International Trade and the Environment

World Bank Discussion Papers

Patrick Low, editor
Recent World Bank Discussion Papers


No. 103  Agricultural Extension for Women Farmers in Africa. Katrine Saito and C. Jean Weidemann

No. 104  Enterprise Reform and Privatization in Socialist Economies. Barbara Lee and John Nellis

No. 105  Redefining the Role of Government in Agriculture for the 1990s. Odin Knudsen, John Nash, and others

No. 106  Social Spending in Latin America: The Story of the 1980s. Margaret E. Grosh


No. 108  Debt Management Systems. Debt and International Finance Division

No. 109  Indian Women: Their Health and Economic Productivity. Meera Chatterjee


No. 111  Household Consequences of High Fertility in Pakistan. Susan Cochrane, Valerie Kozel, and Harold Alderman


No. 113  World Bank Lending for Small and Medium Enterprises. Leila Webster

No. 114  Using Knowledge from Social Science in Development Projects. Michael M. Cernea


No. 117  Developing Financial Institutions for the Poor and Reducing Barriers to Access for Women. Sharon L. Holt and Helena Ribe

No. 118  Improving the Performance of Soviet Enterprises. John Nellis


No. 120  The Information Technology Revolution and Economic Development. Nagy K. Hanna

No. 121  Promoting Rural Cooperatives in Developing Countries: The Case of Sub-Saharan Africa. Avishay Braverman, J. Luis Guasch, Monika Huppi, and Lorenz Pohlmeyer

No. 122  Performance Evaluation for Public Enterprises. Leroy P. Jones

No. 123  Urban Housing Reform in China: An Economic Analysis. George S. Tolley

No. 124  The New Fiscal Federalism in Brazil. Anwar Shah

No. 125  Housing Reform in Socialist Economies. Bertrand Renaud

No. 126  Agricultural Technology in Sub-Saharan Africa: A Workshop on Research Issues. Suzanne Gnaegy and Jock R. Anderson, editors


No. 128  Research on Irrigation and Drainage Technologies: Fifteen Years of World Bank Experience. Raed Safadi and Hervé Plusquellec

No. 129  Rent Control in Developing Countries. Stephen Malpezzi and Gwendolyn Ball

(Continued on the inside back cover.)
International Trade and the Environment

Patrick Low, editor

The World Bank
Washington, D.C.
Foreword

There is widespread consensus that governments must play an important role in preventing environmental degradation. Discussion of the scope and instruments for government action on the environment is therefore timely and important. This volume is primarily concerned with the international aspects of environmental policy and the relationship between environmental concerns and nations' use of the standard tools of international economic policy.

Governments have an obvious interest in each others' policy behavior when dealing with the environment. Whenever one country's pollution or natural resource depletion imposes direct costs on other nations either locally, regionally, or globally, this interest is natural. In the case of these direct jurisdictional spillovers, agreements between governments can potentially benefit all parties. In the case of worldwide problems like global warming or in the case of regional problems like acid rain, there is no viable alternative to international cooperation.

A distinctly different case of demand for intergovernmental action can arise even in the absence of direct spillovers because the world's economies are integrated through trade and capital mobility. This is the main focus of the current volume. There are two sources of pressure for intergovernmental action on differences in policies on local pollution. Industries faced with the costs of environmental regulations frequently complain that imports produced under looser environmental standards are a source of unfair competition. Groups motivated by these concerns urge their governments to oblige their trading partners to implement similar environmental policies or, failing that, to impose trade and investment restrictions. Secondly, there is the frequently voiced fear that the threatened migration of polluting activities will undermine the political will to impose necessary environmental controls on domestic industry. This, in turn, would cause competitive deregulation among trading countries.

What should be done about these concerns? Some argue that nations should be able to protect against products produced according to lower environmental standards than those applied domestically. Yet implementation of this doctrine would run counter to accepted principles of international trade and could lead to substantial new trade restrictions on developing country exports. Similar protectionist arguments based on differences in labor cost, working conditions, domestic nonenvironmental regulations, and tax rules are generally rejected. Given the magnitude of international differences in environmental regulation and the fact that electrical energy is an important input to many exportables, it is likely that many barriers could be justified on the basis of differences in environmental regulation if this were allowed as legitimate grounds for action.

An alternative proposal is for nations to harmonize their environmental standards. How strong is the case for this approach? There are three arguments against blanket harmonization of environmental regulation. First, the damage caused by pollution differs greatly across locations. Local atmospheric, topographic and climate conditions are important determinants of the costs imposed by pollution and are recognized as such in setting local standards for emissions. The harm caused by pollution also differs with conditions of population and existing pollution; within the United States, densely populated California imposes tougher standards than sparsely populated states, and the amount of nontoxic effluent permitted into a river is sensitive to the existing river conditions. Given that environmental legislation within countries recognizes intrinsic differences in absorptive capacities, international harmonization seems problematic.
The second reason for avoiding a focus on international harmonization is the difficulty of securing agreements. In a world of diverse constituencies, harmonization is likely to prove an elusive objective. Even with the best of political will, establishing a meaningful uniform standard is a formidable task. For example, should air emissions standards regulate stocks of pollutants or flows? And even if intergovernmental agreement on standards were reached, individual governments' implementation would still lead to varied regulations facing a given industry in different countries. A forlorn search for interjurisdictional agreement could absorb time and resources that would be much better spent in defining and implementing sound domestic environmental policy. In this sense, the harmonization objective could embody its own anti-environmental dynamic and actually prove counterproductive in reducing pollution, allowing domestic producers to postpone locally appropriate action while waiting for international consensus.

The third argument against international harmonization is that even where societies share the same environmental objectives, there are vast differences in the resources nations can devote to the environment. It cannot be forgotten that there are over one billion people living in absolute poverty, without adequate food, shelter, or health care. Resources devoted to improvements in environmental quality increase more than proportionately with income. The policy challenge is therefore to create conditions favorable to income growth and environmental improvement, not to constrain growth through the imposition of inappropriate environmental standards. The Bruntland Commission's concept of "sustainable development," defined in terms of meeting present needs without compromising future generations, points us in the direction of an appropriate policy mix between environmental protection and development. Identifying that mix in practice will be the cutting edge of the debate, where reasonable people will disagree.

It must also be acknowledged that legitimate differences among countries with respect to environmental standards might cause "dirty" industries to seek out pollution havens. Preliminary evidence reported in this volume, however, suggests that this is unlikely to be a major environmental concern for several reasons. First, costs of compliance with environmental regulations are generally not a sufficiently high fraction of total cost to be a crucial determinant of location. Second, there is very little evidence of footloose polluting industries. In fact, some evidence suggests that more export-oriented economies have attracted greater labor-intensive and hence cleaner industries. Third, concern over liability and home country reputations will weaken any temptation of multinational firms to cut costs by using environmentally inferior capital goods and equipment in a world of rising environmental standards. Fourth, as the capital stock is expanded and renewed in developing countries, there is likely to be a tendency for investors to anticipate more stringent environmental regulation in the future. They will therefore seek to avoid the costs of relatively expensive retrofitting by adopting at the outset top-of-the-line controls developed to meet the industrial countries' standards.

Wherever one stands on the question of the priority of sovereign national governments in setting environmental policy, there is one issue on which policymakers should be able to agree -- in relations between industrial and developing countries, cooperation will lead to better outcomes than coercion. Impatience and strong feelings may make unilateral punitive actions appear attractive as a means of influencing the behavior of other governments. But is the unilateral imposition by a rich country of high standards of environmental quality that divert a poor country's resources from poverty alleviation any more justifiable than forcing a country to accept unwanted polluting industries? Countries coerced into action by threats are unlikely to comply either very thoroughly or for very long, leaving the environmental outcome in doubt.

In international bargaining there may be a presumption that a country asking for concessions should expect to compensate the other. But even if this were not the case, when consumption in the petitioning country is 20 times that of the country asked to bear additional costs for environmental improvement or when countries are asked to forgo the benefits of their natural resources, equity more than
economic logic suggests that threats to reduce poor countries' incomes further by trade restrictions are inappropriate.

These are issues on which passions run high and where dogmatic solutions are an offer in abundance from all sides. But dogma is never less helpful than when delicate and complex balances have to be struck. It is to be hoped that the present volume contributes to our understanding of how environmental problems can be addressed on the international plane. If nothing else, the papers that follow highlight issues that governments and institutions like the World Bank need to be aware of as they wrestle with questions of environmental policy.

Lawrence H. Summers
Vice President and Chief Economist
Development Economics
The World Bank
## Contents

Contributors, Discussants and Panelists  

1. International Trade and the Environment: An Overview  
   Patrick Low  
   1

2. Trade and the Environment: A Survey of the Literature  
   Judith M. Dean  
   15

3. Trade Policy and Pollution  
   Patrick Low and Raed Safadi  
   29

   Discussant’s Comments  
   David Robertson  
   53

4. Trade, Environment and the Pursuit of Sustainable Development  
   Stewart Hudson  
   55

   Discussant’s Comments  
   Charles Pearson  
   65

5. Economic Development, Environmental Regulation and the  
   International Migration of Toxic Industrial Pollution: 1960-1988  
   Robert E.B. Lucas, David Wheeler and Hemamala Hettige  
   67

   Discussant’s Comments  
   Ramon Lopez  
   87

6. Do "Dirty" Industries Migrate?  
   Patrick Low and Alexander Yeats  
   89

7. Trade Measures and Environmental Quality: The Implications  
   for Mexico’s Exports  
   Patrick Low  
   105

8. Economic Growth and Environment  
   Marian Radetzki  
   121

   Discussant’s Comments  
   Charles Blitzer  
   135
9. The Environment as a Factor of Production:
The Economic Growth and Trade Policy Linkages 137
*Ramon Lopez*

*Discussant’s Comments* 157
*Sweeder van Wijnbergen*

10. Trade Policy and Industrial Pollution in Latin America:
Where are the Pollution Havens? 159
*Nancy Birdsall and David Wheeler*

*Discussant’s Comments* 169
*Gunnar Eskeland*

11. Tropical Forests and Trade Policy: The Case of Indonesia
and Brazil 173
*Carlos Alberto Primo Braga*

*Discussant’s Comments* 195
*Judith M. Dean*

12. Prices, Policies and the International Diffusion of Clean Technology:
The Case of Wood Pulp Production 197
*David Wheeler and Paul Martin*

*Discussant’s Comments* 225
*Ishac Diwan*

13. The Political Economy of Trade and the Environment in
the United States 227
*Craig VanGrasstek*

*Discussant’s Comments* 245
*David Vogel*

14. The Political Economy of Trade and the Environment
in Western Europe 247
*Gernot Klepper*

*Discussant’s Comments* 261
*Jim Rollo*

15. Investment, Technology and the Global Environment:
Towards International Agreement in a World of Disparities 263
*Ishac Diwan and Nemat Shafik*

*Discussant’s Comments* 287
*Ravi Kanbur*
16. International Policy Coordination and Environmental Quality 289
Raed Safadi and Patrick Low

Discussant’s Comments 307
Patricia Annez

17. Trade and the Environment: Harmonization and Technical Standards 309
David Robertson

Discussant’s Comments 323
Nemat Shafik

18. GATT and Environment: Basic Issues and Some Developing Country Concerns 325
Piritta Sorsa

Discussant’s Comments 341
J. Michael Finger

Bibliography 345
Contributors

Nancy Birdsall, Director, Country Economics Department
Carlos Alberto Primo Braga, Economist, International Economics Department
Judith M. Dean, SAIS, Johns Hopkins University
Ishac Diwan, Senior Economist, International Economics Department
Hemamala Hettige, Consultant, Industry and Energy Department
Stewart Hudson, National Wildlife Federation
Gernot Klepper, Kiel Institute of World Economics
Ramon Lopez, University of Maryland
Patrick Low, Economist, International Economics Department
Robert E.B. Lucas, Boston University
Paul Martin, Research Assistant, Environment Department
Marian Radetzki, SNS Energy and University of Luleo, Sweden
David Robertson, Australian National University
Raed Safadi, Research Analyst, International Economics Department
Piritta Sorsa, Economist, World Bank Geneva Office
Craig VanGrasstek, VanGrasstek Communications
David Wheeler, Environmental Specialist/Economist, Environment Department
Alexander Yeats, Principal Economist, International Trade Division

Discussants

Patricia Annez, Senior Economist, 1992 World Development Report
Charles Blitzer, Principal Industrial Economist, Technical Department, LAC
Judith M. Dean, SAIS, Johns Hopkins University
Ishac Diwan, Senior Economist, International Economics Department
Gunnar Eskeland, Economist, Country Economics Department
J. Michael Finger, Lead Economist, Country Economics Department
Ravi Kanbur, Editor, World Bank Economic Review and World Bank Research Observer
Ramon Lopez, University of Maryland
Charles Pearson, SAIS, Johns Hopkins University
David Robertson, Australian National University
Jim Rollo, The Royal Institute of International Affairs, London
Sweder van Wijnbergen, Lead Economist, Country Department II, LAC
David Vogel, University of California, Berkeley

Panelists

Charles Arden-Clark, WWF International
Peter M. Emerson, Environmental Defense Fund
Sudhir Shetty, Senior Economist, 1992 World Development Report
Michael B. Smith, SJS Advanced Strategies
Introduction

Public awareness of actual and potential threats to the natural environment has grown rapidly in the last few years. Concerns about deteriorating ambient quality and natural resource depletion have raised the specter of "irreversibility" -- the fear that irreparable damage is being done to the planet through the exhaustion of finite natural resources, the contraction of biodiversity and the cumulative destruction of air, land and water resources. This has resulted in severe pressures on governments, particularly in industrial countries, to develop policies to address environmental degradation. Choices have to be made from among alternative policy approaches, and these alternatives vary greatly as to their costliness and efficacy.

All too often, in the face of public clamor for action to deal with what are perceived as serious environmental threats, governments have omitted to give adequate consideration to the justification for the measures they have adopted, or to the nature of the options available. Bad policy choices carry their own costs in terms of inefficiency, and in addition they may prove to be of limited effectiveness as environmental protection measures.

This monograph focuses upon the links between trade and the environment, and the use of trade policies to address environmental degradation. The relation between international trade and the environment cannot be adequately understood in terms of a simple analysis of when trade measures should or should not be used to deal with environmental problems. A range of other underlying issues must also be considered.

The present paper provides a brief overview of several of these issues, based on the papers that were prepared for this volume. In addition to the papers themselves, the material presented here draws on discussants' comments and the proceedings of the World Bank's trade and environment symposium, at which most of the papers were presented. The symposium proceedings included a final roundtable discussion at which Charles Arden-Clark, Peter Emerson, Sudhir Shetty and Michael B. Smith expressed their views on issues raised during the meeting.

The discussion in this paper is organized around six thematic headings. The first of these covers trade and environmental policy links. The sections that follow analyze the relationship of environmental quality to: industrial location, competitiveness, economic growth and trade liberalization, the political economy of environmental policy making, and international cooperation on the environment. The thematic headings help to order the wide range of issues that are relevant to the relationship between trade and environment, although it will be obvious from the discussion that all these issues are closely linked.

Trade and environment, and environmental issues more generally, may seem to have attracted widespread attention only recently. But this is illusory, since a similar debate raged some twenty years ago, only to die down again in the late 1970s. There are several reasons why these issues came and went, only to come back again more strongly, but what is important for present purposes is that much of the current agenda was debated and analyzed in earlier years. Many of the insights gained through earlier work remain
relevant today. The next paper in this volume, by Judith Dean (Chapter 2), contains a thematic review of previous work on trade and environment issues.\(^1\) It serves as a useful backdrop to the papers presented in the rest of the volume.

**Trade Policy and the Pursuit of Environmental Objectives**

The papers by Patrick Low and Raed Safadi (Chapter 3) and by Stewart Hudson (Chapter 4) contain general discussions of the links between trade and the environment, and they touch on many of the issues addressed in more detail in other papers. To some extent, these two papers contrast the views of economists and environmentalists on this set of issues, even though they cannot hope to encapsulate the broad range of opinions represented in the debate.

The Low/Safadi paper covers three issues. First, it examines the meaning of efficiency in environmental policy making, briefly reviewing the economic literature on this subject, which was mostly written in the 1970s. In the absence of adequately defined property rights, an economically efficient hierarchy of interventions can be established for internalizing environmental externalities. Governments, however, have revealed a strong preference for direct command and control measures, which come far down in the efficiency hierarchy. The paper considers some of the reasons why this may be so.

Second, the paper explores environmental policy in an international setting, and considers whether the efficiency hierarchy developed in a domestic setting still applies. The analysis in this section is based on two underlying propositions -- that pollution absorptive capacities vary by location, including across national frontiers, and that social preferences are likely to differ among countries. Differences in absorptive capacities give rise to a different structure of costs and benefits from pollution abatement and control activities, and may influence optimal resource depletion rates. Different social preferences or discount rates simply reflect the fact that not all societies necessarily embrace identical environmental objectives.

While these two propositions may seem obvious and unexceptionable to economists, who are accustomed to thinking in terms of scarcity, choice and opportunity cost, they are not so obvious to those who are tempted to assign infinite value to the environment. The existence of differing absorptive capacities and social preferences is what allows environment to be treated as an endowment, or factor of production, that represents part of a country's comparative advantage (cf. Dean, Chapter 2). It follows that environmental standards and pollution abatement and control activities will be different among countries and there is no valid presumption in favor of uniformity or harmonization.

This paper also examines various aspects of international cooperation. It argues that attempts at coercing countries into adopting particular environmental policies, on the basis of a unilateral determination of desirable objectives, are unlikely to have beneficial effects on environmental quality. Where punitive trade restrictions are involved, the costs of inefficiency associated with inappropriate interventions must also be considered. The attainment of environmental targets is more likely to be assured through cooperative arrangements that involve incentives rather than threats. The paper notes the concern that countries may "free-ride", which raises the difficulty of distinguishing between an opportunistic concealment of preferences and a true indication of what these are. It is argued that while the problem may be real, it tends to be overplayed. This is especially so in view of the fact that free-riding incentives diminish over time, since such behavior will tend to destabilize the agreement from which a free-rider is benefiting.

\(^1\)Charles Pearson's comments as a discussant on the paper by Stewart Hudson (Chapter 4) also remind us of the work undertaken by the OECD in the early 1970s to define guiding policy principles for dealing with trade and environment issues.
The third issue addressed in the Low/Safadi paper is the circumstances in which trade measures might be justified in pursuit of environmental objectives. A particular concern, from a trade policy perspective, is the appropriation of ecological arguments for protectionist ends. The paper identifies five circumstances in which trade measures could be applied on environmental grounds. It concludes that trade measures are justifiable as environmental policy in very narrowly defined circumstances, and that there is almost always a better way of meeting environmental objectives.

The Hudson paper lays great stress on the need for "sustainable" development. All reasonable people can agree that sustainable development is an entirely proper objective, just as they can that environmentally damaging externalities should not be allowed to persist. The problem is how to translate the pursuit of sustainable development into sensible policy prescriptions. The Hudson paper only gives limited guidance on this crucial point. Hudson clearly does not support the no-trade, no-growth school of environmentalists mentioned by Carlos Primo Braga (Chapter 11) as followers of "deep ecology." He recognizes that some positive level of trade and growth is a prerequisite of good environmental policy. But Hudson also emphasizes his view that growth, buttressed by open trade, is far from a sufficient condition for ensuring that the environment will be adequately protected.

The observation in the paper that trade is environmentally costly, because it involves energy consumption and generates emissions, suggests less than full acceptance of the economist's view that such partial analysis is unhelpful -- economists would want to know how environmentally friendly alternative patterns of resource use would be. While Hudson does not subscribe to the notion that the harmonization of standards is intrinsically virtuous, he does worry about free-riding, about unfair competition, about "dirty" industry migration and about competitive deregulation. If harmonization is not necessarily the appropriate way to deal with these perceived problems, then the question remains as to what would be the best approach. As with the concept of sustainable development, the challenge is to offer clear policy prescriptions around which debate can be focused.

Industrial Location and Environmental Policy

Two papers in the volume, by Robert E. B. Lucas, David Wheeler and Hemamala Hettige (Chapter 5) and by Patrick Low and Alexander Yeats (Chapter 6), directly address the issue of the migration of dirty industries. Both papers are empirical. In addition to addressing the migration issue, Lucas et al. also look at the relationship between income levels and pollution intensity, and between trade policy and pollution (see below).

On the industry migration question, Lucas et al. examine changes in the international distribution of pollution intensity arising from the sectoral composition of industry. The authors note that industrial pollution levels depend on both the size of the industrial base and the pollution intensity of the industries concerned. Moreover, sectoral composition is only one factor influencing pollution intensity. Other factors which the paper does not examine are technology choice, pollution abatement activity and productive efficiency.

The paper relates toxic emissions data from the United States to cross-country manufacturing output, and finds that pollution intensity grew rapidly in developing countries during the 1970s and 1980s. Thus, dirty industries have certainly moved into developing countries, but have they migrated, in the displacement sense? The observed phenomenon of increased toxic intensity in developing countries may merely reflect dispersion, or industry expansion, as opposed to displacement. Indeed, the paper finds that the toxic intensity of output declines as incomes rise only because the share of manufacturing in total output declines beyond a certain level of income. This is a composition effect, so there is no evidence that industry has uprooted from industrial countries. Neither do we know from this analysis whether industries have chosen to locate in developing countries instead of industrial countries because of differential environmental regulation.
The Low/Yeats paper uses trade flow data as a proxy for shifts in the pattern of international industrial location, in order to examine the extent to which dirty industries have migrated to developing countries over the last two decades or so. Forty-three dirty industries are identified, on the assumption that the higher the expenditures on pollution abatement and control, the dirtier an industry. The trade data show that the share of dirty industry trade in total trade declined between 1965 and 1988, largely as a result of trends in industrial countries. Over the same period, the share of dirty industry output in the exports of many developing countries increased.

The trade share analysis was supplemented by an examination of the revealed comparative advantage (RCA) indices of 109 individual countries in the dirty industries. The RCA index used here measures whether the share of a particular product in a country's manufactured exports is proportionately larger than the share of that product in world trade in manufactures. If it is, then the country concerned is said to have a revealed comparative advantage in that product. Applying this index to dirty industries, it transpired that there had been a disproportionately large increase in the number of developing countries with RCAs in most of the polluting industries. The rate at which developing countries acquired RCAs in dirty industries in the period under study was four times as great as that of industrial countries and faster than the developing country average for all industries.

The paper is inconclusive as to why this happened. The results point in the same direction as those of Lucas et al. as regards the dispersion of dirty industries, but that does not necessarily mean displacement. This paper goes no further than Lucas et al. in determining how far location decisions respond to environmental factors. The more rapid growth of dirty industries in lower income countries may relate to several considerations, such as relative labor costs or natural resource endowments. Another possible explanation is that particular kinds of industries, which happen to be relatively dirty, predominate in early stages of industrial development.

Another issue in need of further research is whether firms that locate in low income countries are dirtier than they would be if they located in industrial countries. As discussed in other papers, particularly those by Nancy Birdsall and David Wheeler (Chapter 10) and by David Wheeler and Paul Martin (Chapter 12), there are reasons why firms might wish to eschew this strategy even if it appeared that differential environmental regulation offered a competitive advantage. Such reasons include fear of liability in the event of an environmental accident, the risk to a firm's reputation from an environmental scandal, the costs of unbundling technology, the demands of consumers ("green consumerism") in export markets, anticipation of more stringent local environmental standards in the future, and the relatively high costs of retrofitting ageing capital equipment instead of starting out with "top of the line" technology. All these considerations would act as disincentives where firms were tempted to differentiate production processes and techniques according to location.

On the other hand, if environmental compliance costs go up significantly and differentially among countries in the years to come, environmental policy regimes could become an important determinant of the location decisions of firms. Ishac Diwan and Nemat Shafik (Chapter 15) report that while industrial countries are responsible for 75 percent of world output, they account for 61 percent of world carbon emissions. Capital stock per capita is fourteen times higher in industrial than developing countries, but carbon emissions as a proportion of capital stocks are one third lower. These figures are suggestive of the use of dirtier technologies in developing countries, at least as far as one pollutant is concerned, but further information is required in order to establish how much of the difference in pollution intensity is attributable to industry composition rather than technological differentiation. Whatever the answer to this particular question, the interesting policy issue is what occurs at the margin, in relation to new investments.
Competitiveness, Environmental Policy and Standards

Directly related to the point above is the question of how costly it is for firms to comply with domestic environmental standards. In policy discussion, the charge of "unfairness" is often leveled against countries that derive a competitive advantage from lower environmental standards. How much of an advantage may firms hope to gain from such differences? The paper by Patrick Low (Chapter 7) uses U.S. data to examine the question. Available data suggest that pollution abatement and control costs to U.S. firms are small. The weighted average ratio of such costs to output was only 0.54 percent in 1988. The highest ratio for a single industry, the cement industry, was just over 3 percent.

Based on a legislative proposal before the U.S. Senate, the paper then estimated the trade effect of a "pollution abatement and control equalization tax" on imports entering the United States. The analysis focused on Mexico's exports, and demonstrated that even under the unrealistic assumption that Mexican industry incurred no abatement and control costs at all, and that exports were therefore liable for the full equalization tax, the trade effects of such a measure would be small. The real costs to U.S. industry, however, may be higher than the pollution abatement and control numbers suggest. Even though the data cover a broad range of expenditures, including a depreciation allowance for pollution abatement machinery, certain costs appear to be excluded. The capital costs on which the depreciation figure is based relate to end-of-pipe adjustments to installed capital equipment, and not to new machinery. There may also be certain lower cost production processes and techniques which are prohibited and therefore do not appear in the cost data, but which do impose a hidden cost on affected users. This factor could be important, bearing in mind the degree to which U.S. environmental policy depends on direct regulation.

A more general point is that pollution abatement and control expenditures may not cover the full cost of internalizing environmental externalities. Full internalization could entail significantly higher expenditures. This question runs into the problem mentioned earlier that the identification of an externality, or for that matter the definition of "sustainable" development, inevitably involves a highly politicized and subjective process. And, of course, perceptions about the existence or the degree of an externality are likely to differ among countries.

This line of argument leads to the conclusion that the unilateral imposition of a pollution abatement and control equalization tax, or any similar attempt to "level the competitive playing field," would be strongly suggestive of a protectionist reflex, with little or no environmental justification. This is most obviously the case if local pollution problems are the object of policy interventions, while those involving international spillovers are not. Even in the latter instance, trade restrictions are an economically costly means for one country to use in trying to induce another to internalize pollution externalities, and they do not guarantee success in terms of the environmental outcome. Cooperation is much more likely to offer a worthwhile result. The protectionist intent of many proposals for internationally uniform environmental policies is revealed by the fact that such proposals aim to equalize the costs of pollution abatement and control measures, rather than to achieve the same environmental standards, irrespective of differences in abatement and control costs.

Aside from the protectionist intent of these kinds of uniformity proposals, there is undoubtedly support in the environmental community for the notion that countries should be doing broadly the same thing about the environment. The harmonization of environmental standards would permit direct control of environmental policy internationally, and as Nemat Shafik puts it in her comments on the paper by David Robertson (Chapter 17) "(H)armony in environmental standards allows the imposition of external preferences without the disharmony of gunboat diplomacy." As already noted, differing absorptive capacities and social discount rates provide strong grounds for reservations about uniformity as an international environmental policy objective. There is some discussion of the issue of international harmonization of standards in the Low/Safadi and Hudson papers, but those by Robertson and Piritta Sorsa (Chapter 18) deal with the question in more depth.
Robertson's paper emphasizes the costs of the international harmonization of standards, relating to the suppression of social choice and elimination of competition. He also suspects that in some circles an insistence on the need for international agreement on harmonized standards may be an excuse for policy inaction on the domestic front. Both Robertson and Sorsa address the important distinction between product standards and process standards. The basic point is that product standards (relating to externalities in consumption) need to be enforced in a particular jurisdiction irrespective of the source of the product. This means that harmonization occurs, at least with respect to goods from all sources in a given market, although not necessarily for those particular goods in all markets. Process standards (externalities in production), on the other hand, should generally be location-specific. Calls for the harmonization of process standards are seen as intrinsically protectionist.

Two complications arise in respect of the product/process distinction and the policy prescription associated with it. First, the distinction is not always very clear, and process standards may sometimes serve as a proxy for product standards. Certain process standards can define the nature of a product, as for example, the use of growth hormones in the production of beef. It becomes more difficult in such cases to be dogmatic about the sovereign rights of governments to define process standards.

Secondly, in situations where production processes involve international pollution spillovers, one country finds itself directly affected by production in another. There is then a legitimate environmental case for being concerned about given production techniques. Transfrontier spillovers may be localized in the sense of affecting only a few countries, or they may involve the global commons. The pollution case here is similar to a situation where there is international concern about biodiversity and the preservation of species. The policy question is whether the existence of a spillover provides legitimate grounds for the harmonization of process standards. The answer is that it does not, as long as social preferences or perceptions as to the nature of the externality vary among countries. The most efficient way to address transfrontier spillovers is for those countries seeking higher standards to provide incentives for other countries to adopt them. If one country seeks environmental policy changes in another that require a re-specification of social preferences, then these changes should be paid for, and not imposed through unilateral bullying tactics. This makes sense not only on efficiency and equity grounds, but also in terms of effective environmental policy. The nature of the transfer mechanism to be used is important, as noted below in the discussion of the paper by Ishac Diwan and Nemat Shafik (Chapter 15).

Not all economic arguments militate against harmonization. Differentiated standards can add to the transactions costs of trade, as well as to the costs of production. They can also serve as a protectionist mechanism, as a means of making it more difficult to sell across national frontiers. Obstacles to trade may be embedded in the standards themselves, or they may be introduced through procedures associated with the enforcement of standards. The GATT Standards Code seeks to ensure the maximum transparency and automaticity in standards-related activities, but does not set standards nor provide authority for trade measures in the event that standards are breached. The Code creates a presumption in favor of harmonization, but the objective is clearly to minimize protectionist opportunities associated with the management of standards. There is concern, emphasized by Robertson but not by Sorsa, that the proposed introduction (in the context of the Uruguay Round) of product-related process standards within the purview of the Standards Code will provide greater scope for the protectionist abuse of standards. There could be some substance to this concern, but only to the extent that the harmonization of process standards is uncritically encouraged.

To sum up, issues relating to environmental policy and competitiveness are really about avoidance of the protectionist capture of ecological arguments. More will be said about this below in the section on the political economy of trade and environment issues. It seems that the competitive disadvantage deriving from differential environmental policy may not be great, whether arising from differences in standards or in enforcement capacities, but more research is required. Even if significant cost advantages result from these national differences, this does not justify measures aimed at equalizing costs, nor does it justify uncritical
demands for the harmonization of standards. Moreover, restrictions on investment linked to the kind of
technology issues discussed in the previous section (the relative dirtiness of different technologies) would be
no more defensible on an a priori basis than trade restrictions.

**Growth, Trade Policy and the Environment**

An important question, clearly in need of research, relates to the more dynamic aspects of the
relationship between growth and trade liberalization on the one hand, and environmental quality on the other.
Questions about this relationship are addressed in several of the papers in this volume, most notably those by
Robert E.B. Lucas, David Wheeler and Hemamala Hettige (Chapter 5), Marian Radetzki (Chapter 8), Ramon
Lopez (Chapter 9), Nancy Birdsall and David Wheeler (Chapter 10), Carlos Primo Braga (Chapter 11), and
David Wheeler and Paul Martin (Chapter 12).

Radetzki's piece discusses links between growth and the environment in general terms. The author
argues that increasing levels of economic activity are linked to improved environmental conditions. He
identifies the high income elasticity of demand for environmental quality, compositional shifts towards cleaner
environmental activities at higher income levels, and the extension of property rights combined with the
development of policies to deal with global common externalities in more developed economies as key factors
explaining this relationship. Radetzki presents a variety of empirical evidence to support the observation that
the pollution intensity of economic activity tends to decline as incomes rise. The relationship is encapsulated
in the hypothesis that a graphical representation of environment and growth, with environmental degradation
measured on the vertical axis and income per capita on the horizontal axis, produces an inverted U-shape
curve.

The hypothesis of the inverted U-shape curve is tested by Lucas et al., who find evidence of its
existence. Their results, however, show that the inverted U-shape hypothesis holds when pollution intensity
is related to income per capita, but not when pollution intensity is expressed per unit of manufacturing output.
As noted earlier, however, this analysis examines composition effects and not technology choices or differing
production techniques within industry or over time. Those relationships are in need of more research,
although preliminary evidence on technology transfer for the pulp and paper industry is provided in the
Wheeler/Martin paper discussed below.

Another point to bear in mind about both the Radetzki and Lucas et al. discussions of the relation
between pollution intensity and income growth is, precisely, that intensity and not the absolute pollution level
is subject to scrutiny in the analysis. As Ishac Diwan and Nemat Shafik (Chapter 15) point out in their piece,
global carbon emissions have continued to increase with rising incomes, as increases in the capital stock have
overshadowed improvements in the capital stock. It remains to be seen at what point a cross over might
occur, such that not only pollution intensity but also absolute pollution levels decrease with rising incomes.
The role of technical progress and technology diffusion is clearly crucial, but many complex factors will
influence this relationship, not all of them fully understood. A significant difficulty arises from the
extraordinary variety of variables that go into the definition of environmental quality. Far too often, attention
will become focused on a few variables representing a very partial view of overall environmental quality and
sustainability.

From a policy perspective, however, evidence that the pollution intensity/growth relationship goes
the right way argues strongly against the adoption of anti-growth policies. Policies that internalize pollution
externalities may well raise costs and reduce output in given activities, and this approach is obviously to be
preferred to an uncritical pursuit of growth at any price. But this is a matter of adjusting relative prices to
reflect social costs and benefits, not of inveighing against increased economic activity because it carries
environmental costs and consumes scarce resources. And again, once environmental policy interventions are contemplated, making the choice between more and less efficient alternatives becomes important from a welfare perspective.

The Lopez analysis is less sanguine than that of many other economists about what technical progress can do by way of mitigating the environmental costs of increasing economic activity, including that deriving from trade liberalization which has a positive effect on growth. The author presents a formal model that distinguishes between growth with stock feedback production effects (where pollution or resource depletion affects future production), and growth simply based on factor expansion (where today’s polluting activities do not affect tomorrow’s output). In the former case, there is an incentive to invest in the resource stock to protect its future value, and so resource degradation or pollution may decrease with growth, particularly if appropriate ownership incentives are present. Where growth results simply from factor expansion with no stock feedback production effects and with no allowance made for technological change, the only way pollution can be reduced is through a reduction in output.

Lopez argues that even with the introduction of technological change into the model and with the full internalization of pollution externalities, growth is likely to be associated with environmental degradation in the absence of feedback effects. Given the specifications of the model, the internalization of pollution costs can change the pollution intensity of output, but not growth, and the elasticity of pollution with respect to output remains unity. This is why the only way to reduce pollution is to reduce growth. The possibility that environmentally biased technological progress could save the day and ensure growth without environmental degradation is treated skeptically by the author. This is partly on the grounds that conventional technical progress will contribute to environmental degradation, and this contribution will have to be more than offset by a strong environment saving bias in technical progress before the negative relation between growth and the environment is broken. In addition, Lopez argues that incentives for research and development expenditures in environmentally friendly technology are low because the costs of pollution abatement and control to firms are low.

The extent to which technological innovation and diffusion influence the relationship between growth and environmental quality is ultimately an empirical question. In his comments as discussant on this paper, Sweder van Wijnbergen is critical of the specifications of the Lopez model. He argues, in addition, that increased trade can have positive environmental effects despite the fact that it induces increased growth. Among the reasons for this are that environmental quality may be enhanced in developing countries under more open trading conditions where: i) technology choice and the product mix are expanded; ii) developing countries specialize more in labor-intensive (i.e. cleaner) production and industrial countries with more stringent environmental standards in capital intensive (dirtier) production; and iii) developing countries may be enticed through more intensive economic and trading links to raise their environmental standards. It is also argued by van Wijnbergen that since capital accumulation only explains a fraction of growth as compared to technological innovation, a more adequate specification of the growth model is one that treats the technological factor endogenously. Finally, he suggests that the treatment of physical and human capital separately in the analysis might reveal that increased investments in human capital could offset, or even more than offset, the growth-inhibiting effect of the imposition of pollution abatement and control requirements on physical capital. Many of these issues can be clarified only through empirical investigation. But the debate does emphasize the important distinction to be made between growth and welfare, and helps to highlight the issues that need to be researched further.

The discussion of growth and the environment raises much the same issues as a consideration of trade liberalization and the environment, particularly in view of the large body of evidence associating trade liberalization with increased growth. In the light of the above discussion, it is clear that trade liberalization
can have both positive and negative effects on the environment. The papers by Lucas et al. and by Birdsall and Wheeler both make statistical tests on the relationship between trade openness, growth and environmental quality.

In the Lucas et al. paper, 95 developing countries are ranked according to their income levels, their growth rates and whether they were open or closed. It transpired that fast-growing closed economies became significantly more pollution intensive in the 1970s and 1980s, whereas the opposite was true for more open economies. In fact, fast-growing open economies experienced essentially pollution-neutral structural change in the 1970s and a significant shift towards a less pollution-intensive structure in the 1980s. These findings modify somewhat the picture presented in this paper on the basis of aggregate data, which suggests an increase in pollution intensity for developing countries taken as a whole. In his comments as discussant on this paper, Ramon Lopez speculates whether the observed relation between toxic intensity and the degree of openness is really a dynamic relation, or merely an aggregation of once-off (static) effects arising from successive trade liberalization episodes. If the latter, the relation between openness and environmental quality is perhaps less important than it would seem from taking the results at face value.

The Birdsall/Wheeler paper presents similar data to that in the Lucas et al. paper, but only with respect to Latin America. The results for Latin America show the same trends as the global developing country data. Dirtier industries have tended to go to the less open economies. As noted earlier, these results refer only to the composition of industry, and not to technological choices or relative dirtiness within industry. The Birdsall/Wheeler paper contains a good discussion of the range of factors that might influence the choice of technology when firms make investments in developing countries. These factors were noted above in the discussion on dirty industry migration, and they include fear of liability in relation to environmental accidents, the desire to protect firm reputation, the costs of unbundling technology, "green consumerism" in export markets, anticipation of future environmental regulation, and the relatively high cost of retrofitting capital equipment.

If economies with open trade regimes attract more foreign investment than closed ones, these technological factors are likely to be at work to a greater degree in the former than the latter. Thus, there may be an even stronger case, from an environmental perspective, for promoting liberal trading arrangements in developing countries than that suggested by the industry composition data alone. The Birdsall/Wheeler paper presented some anecdotal evidence from Chile of the positive link between openness and the transfer of environmentally clean technology.

The Wheeler/Martin paper makes a valuable addition to the volume by examining directly, and in detail, the technology transfer question in relation to the wood pulp industry. The paper shows that the adoption of clean pulping technology is affected most importantly by a country's policy orientation and the scale of its existing pulp industry. Thus, the more open an economy, the more rapidly clean technology is adopted and diffused. An additional result, which is perhaps a little counter-intuitive, is that a country's level of development has no independent effect on clean technology adoption.

In his comments on this paper as discussant, Ishac Diwan muses as to whether this is an exceptional result, based on the fact that the cleaner technology in this industry also happens to be the most cost effective. The argument would be that for competitive reasons, developing countries would choose the cheapest technology, which would often be the dirtiest. On the other hand, Diwan notes that the pulp industry result might have fairly general applicability, to the extent that industrial countries dominate technological development, generally for their own needs, so that when industrial country enterprises invest in developing countries, they take their bundled, cleaner technology with them. If this does happen, developing countries may in fact be denied the choice of a lower-cost dirtier technology, which may make them more competitive.
In short, these factors may make developing country industry cleaner than warranted by the local absorptive capacity and social preferences. Again, these are questions in need of further research.

Finally, the paper by Primo Braga examines the use of trade policy as a mechanism of resource management in the forestry sector in Indonesia and Brazil. The author argues that contrary to the mistaken perception of some environmentalists, the use of export restrictions visited additional environmental degradation upon the Indonesian wet tropical forest than a proper resource management program involving a tax on all timber at the logging stage would have done. Primo Braga rightly points out that the welfare costs and benefits of export restrictions have to be calculated from a broader perspective than merely that of the degree to which the forest was compromised. But certainly from an environmental perspective, the discrimination in favor of local wood processors resulting from export restrictions led to a more intensive use of logs in production, as a result of the relative inefficiency of the local industry. The author goes on to argue that the removal of tariff escalation practised by industrial countries along the wood processing chain would further add to an efficient, less environmentally degrading use of tropical wood.

This paper also contains a discussion of proposals in industrial countries for an import embargo on tropical hardwoods. Once again, Primo Braga explains why trade policy makes bad environmental policy. In the first place, an import prohibition would have to be applied by all the large players in the hardwood market to be effective. Such cooperation would prove very difficult to achieve. But even if it were achieved, its environmental effects may well be negative. An import ban would depress the price of the product, thereby assigning a lower value to forests, and encouraging less careful management of the resource and providing greater incentives to convert forest land to other uses. The tropical hardwoods case study is important, since it clearly demonstrates the shortcomings of using trade policy to address socially excessive natural resource depletion rates. This lesson should not be lost on those who are demanding action to restrict trade as an environmental protection measure.

The Political Economy of Trade and the Environment

The papers by Craig VanGrasstek (Chapter 13) and Gernot Klepper (Chapter 14) examine the political economy of trade and the environment in the United States and the European Community. VanGrasstek's paper undertakes an analysis of voting behavior in the U.S. Senate. He establishes that voting behavior on trade issues and on environmental issues can be linked to identifiable constituency interests, and then examines voting behavior on issues involving both trade and environment. The evidence suggest that environmental considerations tend to increase the votes in favor of trade restrictions, so linking trade with environmental issues would seem to make legislators more likely to support trade restrictions.

In his comments as discussant for the VanGrasstek paper, David Vogel characterizes this nexus between environmentalists and protectionists as an alliance between Baptists and bootleggers. The environmentalists are like Baptists, who support prohibition on grounds of religious conviction, and the protectionists are like bootleggers, who support prohibition in order to gain the rents from illegal liquor sales. While it is obvious why protectionists support trade restrictions, the motivation for environmentalists to do so is less clear. Vogel suggests that opposition to trade is a variation on a more broadly-based objection to business activity in general. Another explanation may be that environmentalists know that it is easier to garner support for trade restrictions, which are misleadingly seen as penalizing merely foreigners, than for other kinds of domestically-oriented environmental policies.

It is interesting to note that Vogel believes there are only a limited number of issues on which protectionists and environmentalists can make common cause, and that therefore the trade and environment link will not be used to great effect in increasing protectionism. This may be too optimistic a view,
considering the ease with which trade measures are invoked as a remedy for events and developments that have nothing to do with trade policy. The most obvious example of this is the clamor for trade restrictions witnessed in the 1980s in the United States, as a means of addressing the mounting trade deficit. The obverse case of the same faulty logic has appeared in early 1992, with the United States pressing Japan to import more vehicles and vehicle parts as a means of narrowing the trade deficit.

The European experience, explored in the Klepper paper, does not permit the kind of precise analysis of voting behavior undertaken by VanGrasstek as a means of assessing the significance of the trade-environment link. This is because fewer issues are voted upon in the EC, and also because there is less transparency in decision making than in the United States. These points are made by Jim Rollo in his comments as discussant.

As Klepper notes, the division of powers between the institutions of the EC and national governments has helped to obscure potential links between trade policy and the environment, and has reduced the scope for the protectionist capture of ecological concerns. This is largely because so far, environmentalists have concentrated their activities in a national context, while trade policy is made at the EC level. It is unclear that this situation will remain unchanged. It would also be interesting to know how far the link between trade and the environment has been made in non-EC European countries, but this was beyond the scope of the paper.

In sum, the politics surrounding the decision making process can be unhelpful in terms of the development of sound environmental policy. The misappropriation of trade policy, which masquerades as environmental policy, is one dimension of the problem. Another is the strong preference of most OECD governments for direct environmental controls over market-based approaches, despite well-established propositions about the superior efficiency of the latter. The protectionist capture of ecological arguments will be made easier by environmentalists if they decline to take notice of efficiency arguments and to support least-cost approaches to addressing environmental externalities.

**International Cooperation and the Environment**

There are four papers in this volume which address different aspects of international cooperation on environmental matters, by Ishac Diwan and Nemat Shafik (Chapter 15), Raed Safadi and Patrick Low (Chapter 16), David Robertson (Chapter 17) and Piritta Sorsa (Chapter 18). The paper by Diwan and Shafik analyzes alternative policy approaches to address international environmental externalities. They demonstrate how in a situation of less than perfectly functioning markets for capital and emissions, the opening of one market and not the other may lead to a harmful environmental outcome. This is an application of the theory of the second best.

The analysis also establishes the case for compensation, especially where industrial country and developing country environmental priorities differ, and where developing countries are expected to respond to industrial country concerns. While industrial countries worry about such issues as climate change and biodiversity, developing countries are much more preoccupied with domestic problems such as health and various forms of local pollution. A careful analysis is made of alternative compensatory mechanisms available, including current cash transfers, debt for nature swaps, technology transfers and sanctions for nature (this is retaliatory or conditional rather than compensatory). The only one of these mechanisms that is not accompanied by adverse side effects is the transfer of clean or pollution-reducing technology. Under the assumptions of the model developed by Diwan and Shafik, the negative effects of inappropriate compensatory mechanisms can be significant. This analysis stresses the importance of making efficient choices among options once a policy course has been decided upon.
The paper by Safadi and Low emphasizes the existence of alternative forms of international cooperation, ranging from binding agreements to loose coordinating arrangements. A game theoretic model is developed to derive the conditions under which implicit cooperation may be as efficient in terms of environmental outcomes as a binding agreement. The model only works among countries that can wield a credible threat against one another (assumed in this framework to be trade measures). The reason for being interested in implicit cooperation is that the establishment of binding international agreements may prove costly and elusive. The search for international commitments can distract attention from the possibility of taking domestically-based action, and leave the environment worse off.

In addition to the discussion of harmonization in the Robertson paper, which was referred to earlier, Robertson also expresses similar concerns about excessive emphasis being placed on international commitments on the environment. He describes the search for international agreements as a "popular prevarication" for governments who do not wish to face up to the need for action to deal with local environmental problems. While not denying the existence of environmental externalities with international spillovers, which may require some kind of international cooperation to address effectively, the author does emphasize that all international environmental problems are the sum of national problems. Action to address national environmental issues, therefore, can also have a beneficial effect on the international dimension of a problem.

Finally, the paper by Sorsa undertakes a careful analysis of how the rules of GATT deal with environmental issues. This is an important paper, in view of the strong criticisms that have been made recently of GATT by environmentalists, often based on ignorance of GATT rules and of how the GATT works. The paper explores the GATT rules on border adjustments (nondiscrimination and national treatment), public policy exceptions, the Standards Code, and rules on dumping, subsidies and countervailing duties. The paper concludes that since trade itself is rarely the source of an environmental problem, there is not much sense in using trade policy to address such problems. It seems that the GATT poses little threat to the pursuit of legitimate environmental objectives (in contrast to hidden protection). Where a clash between GATT and an environmental policy arises, there is often a better way of dealing with the environmental issue. At most, the GATT may be in need of a little clarification, as for example in respect of the rules on border adjustments, where the GATT rules provide an incentive for the suboptimal use of environmental taxes. Another area that could benefit from clarification is the relation between the GATT rules and other international agreements containing trade provisions. This could become important if, in lieu of trying to force acceptance of trade actions based on differences in process standards (as opposed to product standards) upon the GATT, issues relating to process standards are dealt with in separate environmental agreements. Consistency should be ensured. Overall, it would be reasonable to argue that the GATT is more in need of protection from poorly reasoned demands for reform based on environmental arguments, than the environment is from the rules of the international trading system.

Conclusions

One of the most important conclusions to emerge from this work is that there is a need for more empirical work on trade and environment issues. This volume plainly demonstrates how much remains to be done in advancing our understanding of the many complex factors that influence the interaction of trade and the environment. In spite of the lack of sufficient information and analysis that was apparent in all of the areas discussed under the six headings above, it is possible to draw a number of conclusions from the papers that follow. Some of these are naturally tentative. It should be noted that the conclusions summarized below are not necessarily shared by the contributors to this volume.
Environmental policy making

- Environmental policy making, like economic policy making, involves the application of limited means to achieve alternative ends. Nothing has infinite value.

- There can be significant differences in terms of welfare costs among alternative environmental policy interventions, so efficiency considerations are of paramount importance when policy choices are being made.

- Trade measures, because they are indirect interventions, hardly ever offer the best means of addressing environmental externalities. They can be shown to be unambiguously inferior to other policies where the environmental objective is to preserve a natural resource. Even where trade measures can be justified, they are generally a manifestation of policy failure.

- Governments in OECD countries have shown an overwhelming preference for direct regulation over market-based policies, although the former are frequently more costly in terms of efficiency.

- Legitimate differences exist among countries in regard to environmental objectives and standards. These reflect different absorptive capacities and different social preferences. There should be no presumption that harmonization is a desirable policy objective.

- The preference of some governments for international environmental agreements serves to defer action or shift blame rather than addressing domestic environmental problems at their source.

- Where environmental problems cannot be adequately addressed in a domestic setting, international cooperation offers better prospects for sound environmental outcomes than punitive unilateral actions based on unilateral determinations of what the environmental policies of other countries should be. Moreover, incentives are likely to work better than penalties in inducing, and then in sustaining, changes in environmental policies. They are also more consonant with equity considerations.

Empirical findings

- Dirty industries have expanded faster in developing countries than the average rate for all industries over the last two decades, and faster than in industrial countries. It is uncertain whether this international pattern merely reflects growth, or industrial migration as well.

- Pollution abatement and control expenditures by firms do not appear to have had a significant effect on competitiveness in most industries, since these expenditures represent a modest share of total costs. This suggests that national differences in environmental regulations have not been a major explanatory factor in the changing international pattern of location of dirty industries. Moreover, rising costs of compliance with environmental standards will tend to affect most countries.

- Pollution intensity per capita appears to fall as income rises, but evidence of the relationship presented in this volume is based on industrial toxic emissions data, which reflect changes in economic structure (compositional effects) and not in the toxic intensity of manufacturing output. Absolute toxic emission levels continue to rise worldwide.

- The effects of growth and trade liberalization on environmental quality are ambiguous. Where appropriate environmental policies are in place, where growth is associated with environmentally friendly
technological change, or where trade liberalization reduces environmentally destructive economic distortions or increases productive efficiency, the effects of increased growth on the environment are likely to be positive.

- Fast-growing economies with liberal trade policies have experienced less pollution-intensive growth than closed economies. Again, this is a composition effect. However, the contrast between open and closed economies may be even more pronounced if relative toxic intensities within industry are taken into account.

- It seems that firms have good reason not to transfer dirtier technologies to lower income countries when they invest in these countries. Evidence from the wood pulp industry shows that the rate of clean technology adoption and diffusion is higher in open than in closed economies.

- There is some evidence from the United States that if interest groups can link demands for protection from import competition to environmental arguments, they will enjoy a higher success rate in securing trade restrictions. The economic consequences of this kind of capture are generally unfavorable, and the environmental effects at best uncertain.
Trade and the Environment: A Survey of the Literature

Judith M. Dean

Introduction

The recent revitalization of concern for environmental quality has generated many questions regarding the interaction between trade and the environment. Most of these questions relate to the impact of environmental regulations on trade patterns and gains from trade. If a trade-off is perceived, it is often argued that some intervention becomes appropriate: either a specific trade policy measure or the establishment of an international environmental standard. Present GATT policy then becomes an issue of debate. Should GATT revise its rules to accommodate the specific trade measures suggested? How can GATT ensure that the environmental objective is not a guise for a trade barrier? Should GATT establish some international environmental standard with procedures to ensure compliance?

The importance given to trade liberalization and exchange rate policy reform as part of adjustment for development has raised another set of questions. Is there a direct link between removal of trade barriers and environmental degradation? If so, how should liberalization strategies incorporate this cost? Should trade policy be used to meet environmental objectives?

This paper surveys the existing literature on the major questions being debated in both these areas.

Environmental Regulation and Comparative Advantage

As long as damage to the environment is not internalized appropriately into the costs of production, a nonoptimal allocation of resources exists. In an open economy, this means that the pattern of trade is also likely to be nonoptimal. How, then, should trade patterns be altered to reflect the opportunity cost of environmental damage?

In theoretical trade literature the environment is most often treated as a "third" factor of production (in addition to the standard labor and capital in the 2x2 model). A country is thought to have an environmental abundance if it has a relatively large assimilative capacity, i.e., a relatively greater ability to tolerate (absorb) pollutants. As Blackhurst (1977) points out, assimilative capacity is influenced not only by the physical ability of water, air and land to absorb waste, but by the level of pollutants the society is willing to tolerate.

Several studies have analyzed the theoretical impact of environmental policy on standard results in trade. See, for example, Siebert (1977, 1985), Pethig (1976), McGuire (1982), Baumol and Oates (1988) and Blackhurst (1977). Siebert (1985) summarizes the main results of many of these studies regarding the impact of environmental policy on comparative advantage.
Assuming that countries have identical production, pollution and abatement functions for a particular good, then in free trade, one would expect the country with relatively larger assimilative capacity to specialize more in the pollution-intensive good. That is, it is assumed that in autarky, the country richly endowed with assimilative capacity will have a price advantage in the pollution-intensive good. However, as long as the costs of pollution are not internalized, the price advantage is overstated. There is too much specialization in this good.

Unilateral imposition of environmental regulations by the environmentally rich country will impose environmental control costs (ECC) on its producers, thus eroding their price advantage relative to the foreign country. This will reduce the location disadvantage of the environmentally scarce country. We should, therefore, expect a shift in specialization, where the environmentally scarce country increases production of the pollution-intensive good. Unilateral regulations not only change the pattern of trade, but increase pollution in the other country -- even when no transnational pollution exists ("pollute thy neighbor via trade").

Siebert discusses unilateral policy only. Suppose, however, that both countries adopt optimal environmental regulation, such that production costs now include the true costs of pollution. Then, one would expect world output of the pollution-intensive good to fall. However, one would still expect the environmentally rich country to retain its comparative advantage in the production of the pollution-intensive good. Optimal regulation of pollution in both countries should alter the pattern of trade to reflect the relative assimilative capacities of the trading partners. It is unclear, then, whether unilateral restrictions move the pattern of trade closer to the optimum pattern.

The Impact of Inter-Country Differences in Environmental Regulation of Production Pollution

From this brief summary of the theoretical literature, there appears to be grounds for concern that countries with more stringent environmental regulations could experience loss in comparative advantage in affected sectors. It is also clear that some shifting of resources out of the pollution-intensive sector is desirable, to the extent that present trade patterns do not accurately reflect relative assimilative capacities. In this paper we examine the extent to which trade patterns have been influenced by inter-country differences in regulations. Then we investigate the degree to which whole industries have relocated to countries with more lenient regulations. In particular, is there evidence that developing countries are becoming havens for pollution-intensive industries? Finally, we analyze the appropriate policy response to these shifts in comparative advantage. Specifically, should the attainment of environmental objectives justify the use of countervailing duties, subsidies or a harmonized system of international standards?

Loss of Competitiveness

Numerous studies have tried to estimate the impact of ECC on industry price and output, and on the trade balance. See, for example: D'Arge (1974), OECD (1978), Magee and Ford (1972), Pasurka (1985), Richardson and Mutter (1976, 1977), Walter (1973), Ugolow (1982), U.S. DOC (1975), Yezer and Phillipson (1974), Chapman (1991), Robison (1988), Tobey (1990). The methodologies are quite varied, making comparisons between studies difficult. However, some generalizations can be drawn. First, estimates of total ECC by industry tend to be very low—abatement costs are a very small portion of industry costs on average. Second, reductions in output caused by ECC are also small and insignificant on average, although they can be significant for some individual sectors. Third, there is little evidence of any significant impact of ECC on the pattern of trade. This section will briefly review several early studies, and then turn to two more recent works, Robison (1988) and Tobey (1990).
In one of the earliest studies, Walter (1973) investigates the pollution content of U.S. trade. If export goods are relatively pollution-intensive compared to import goods, then U.S. environmental regulations are likely to discourage the export sector. Walter calculates direct ECC and overall ECC (direct and indirect) for 83 goods and services in the United States. ECC is defined to include: current R&D expenditure for compliance, depreciation on existing pollution abatement equipment, the capital cost of that equipment, and current operation costs associated with environmental management. The data are from the late 1960s; a 1966 input-output table is used.

Average annual overall ECC for U.S. exports is found to be 1.75 percent of the value of U.S. exports for 1968-70. Since foreign ECC costs are unavailable, U.S. import-competing sectors' ECC are used to calculate the average annual overall ECC of U.S. imports. This is 1.52 percent of the value of U.S. imports. Walter considers this difference insignificant, and concludes that ECC are trade neutral at best and marginally damaging to U.S. export industries at worst. Weighting overall ECC for an industry by its importance in trade, Walter anticipates that some individual industries might be vulnerable to loss of competitiveness, e.g., construction and mining, plastics. No attempt is made to measure the magnitude of such a loss, however.

Both the U.S. DOC (1976) and Yezer and Philipson (1974) studies (as summarized by Ugelow, 1982) look at the effects of ECC on output in a limited number of industries. The U.S. DOC examined the impact of ECC for water pollution control on copper smelting, aluminum, wood pulp and phosphate fertilizer. They concluded that short-term effects would be more than masked by other factors affecting the state of the economy. No changes in trade patterns in these sectors were observed. Yezer and Philipson found that the percentage decrease in output attributable to ECC (direct and indirect) for 14 industrial sectors averaged less than 1 percent (with the exception of petroleum). Ugelow suggests that this underestimates the impact on output, since it only includes incremental costs attributable to federal legislation.

The OECD (1978) study also takes account of inter-industry linkages in calculating ECC effects on output in Japan, the Netherlands, Italy and the United States. Ugelow summarizes the overall results as follows. The increase in prices due to ECC is not terribly significant, but is sufficient to trigger some reduction in output and exports.

Richardson and Mutti (1976) present a general equilibrium analysis. They estimate domestic and import market demand and supply equations for 81 industries, with varying assumptions about domestic elasticity of supply. Again an input-output matrix is used to calculate both direct and indirect ECC. The impact of these ECC on price and output is evaluated under three scenarios: the polluter-pays principle; full subsidization of ECC through a VAT; full subsidization of ECC by a production tax. The three methods of financing do not yield significant differences in outcomes overall. However, subsidization implies that displacement costs are spread more evenly across industries. With subsidization, the range of change in price and output is 1 percent - 1.5 percent (rise and fall, respectively). Under the polluter-pays principle this range increases to up to 5 percent. The individual industries found most susceptible are: livestock, chemicals, plastic, paints, petrol refining, nonferrous metal manufacturing and utilities.

Richardson and Mutti stress that one cannot assess the trade impact of ECC until one can account for: inter-country differences in controls; financing of controls; inter-country differences in macro policy; and exchange rate flexibility. Not surprisingly, in their 1977 study, these authors try to account for some of these other variables. Four schemata for estimating effects of unilateral controls are compared: a partial equilibrium approach which calculates direct ECC only and uses elasticities to estimate output effects; the use of I-O matrices to capture both direct and indirect cost increases due to environmental regulations; a "macro-orthodox" approach which incorporates feedback on industry output through changes in exchange rates, in domestic income, in demand both at home and abroad due to exchange rate changes, and assumes full pass-through of ECC to prices; a "classical general equilibrium" approach in which domestic elasticity
of supply is not infinite, ECC is not fully passed through to prices, and income and exchange rate changes are not included.

A comparison of the first two approaches reveals that the partial equilibrium method tends to underestimate output effects by 50 percent compared with approaches which use I-O matrices to account for inter-industry linkages. Inclusion of general equilibrium refinements, as in the latter two approaches, yields displacement costs which are 30 percent lower and more smoothly spread across firms than those found in the second approach (assuming ECC are subsidized by a VAT tax). This suggests that feedback through other economic variables tends to mitigate the already relatively small impact of ECC on industrial output.

Robison's work (1988) is important for several reasons. First, it updates the study by Walter (1973) on the pollution content of U.S. trade. Estimates are made for 1973, 1977 and 1982, using I-O tables for 1973 and 1977. Secondly, Robison presents estimates of the impact of a 1 percent increase in ECC on the trade balance. He purposely does not include the general equilibrium refinements discussed by Richardson and Mutti (1977), and purposely assumes full pass-through of ECC to prices. In this way he hopes to generate upper-bound estimates of trade impacts.

In calculating the pollution content of U.S. trade, Robison must again assume that U.S. ECC for import-competing industries are equivalent to actual ECC for U.S. imports. Results indicate that the ratio of abatement content of U.S. imports to U.S. exports has risen from 1.151 to 1.389 between 1973 and 1982. Robison concludes that U.S. comparative advantage has shifted away from goods which have high abatement costs in the United States. When the same calculation is done for U.S. trade with Canada, Robison finds no change in this ratio. He hypothesizes that this might be due to similar ECC in the two countries.

Robison constructs the following hypothetical scenario: an increase in abatement costs raises the sectoral price by 1 percent. For 78 sectors (both manufacturing and nonmanufacturing), he calculates the impact on the 1977 sectoral trade balance of this change in relative price (including both direct and indirect effects). The impacts on total U.S. sectoral trade (value) range from -0.12 percent (special industry machinery) to -7.08 percent (copper) for merchandise sectors, with an average impact of -2.69 percent. Omitting all mitigating general equilibrium effects which might come from exchange rate or income changes, the aggregate effect on the U.S. trade balance is calculated. It is not clear what method of aggregation is used here. For 1977, the net reduction is 0.67 percent of the value of U.S. total trade. Robison argues that marginal changes in abatement costs will affect the U.S. balance of trade. However, his figures suggest that the impact would be quite small overall.

Tobey (1990) takes a completely different approach to testing whether or not ECC have any impact on U.S. comparative advantage. Following earlier work on shifting patterns of trade by Leamer (1984) and Bowen (1983), he employs a cross-section "Heckscher-Ohlin-Vanek" (HOV) model. Beginning with 64 agricultural and manufacturing industries, Tobey calculates the total ECC as a percentage of total costs of production. Pollution-intensive industries are those whose ECC/TC exceeds 1.85 percent - 24 industries. Even for these industries, the range is 1.92 percent - 2.89 percent. These sectors are aggregated into five groups: mining, primary nonferrous metals, paper and pulp, primary iron and steel, and chemicals. For each of these five groups, net exports are regressed on U.S. endowments of 11 resources (labor, land, capital, natural resources).

In this type of model, one would include a measure of environmental endowment, to ascertain whether or not environmentally rich countries export more of the pollution-intensive good. Clearly, environmental endowment is difficult to measure. Tobey, however, is interested in the effect of ECC on trade patterns. His first test, therefore, involves including a dummy variable for ECC stringency as an additional explanatory
variable. Presumably, in an HOV model of this type, Tobey is implicitly assuming that more stringent ECC are correlated with environmental scarcity. Thus the dummy variable should have a negative coefficient. In addition to problems with measuring stringency, this taxonomy ignores the fact that countries may be presently pursuing nonoptimal environmental regulation. In that case stringency is a poor indicator of environmental endowment. If the stringency dummy is correlated with ECC, then this may still be a good test of whether relatively high ECC tends to decrease net exports. Tobey finds no significant impact of stringency of ECC on trade patterns.

Tobey's second test is an omitted variable test. If ECC do have an impact on net exports, then countries with stringent regulations (DCs) should have a negative expected sign in the error term, while the opposite is true for countries with lenient regulations (LDCs). The null hypothesis is that there will be no difference in the expected signs of the error terms. Tobey finds that the null hypothesis cannot be rejected.

It has been suggested in a recent work by Chapman (1991) that ECC have been highly underestimated, because, among other things, they have not included workplace health and safety protection costs. There may be room for more work along the lines of Robison and Tobey, but with better estimates of the actual costs imposed on industries due to environmental regulation. However, it is unclear that this would yield a significant impact on trade patterns, unless it implied radically larger ECC across all regulated industries.

Relocation of Industry to "Pollution Havens"

Another fear which has been voiced is that relatively low environmental standards in developing countries compared to industrialized nations will lead "dirty" industries to shift operations to these LDCs (the industrial flight hypothesis). In addition, LDCs may purposely undervalue the environment in order to attract new investment (the pollution haven hypothesis). Both phenomena could lead to nonoptimal (excessive) pollution in LDCs.

As has been argued above, some shift in the production of pollution-intensive goods is optimal, since countries possess different assimilative capacities to absorb pollutants (i.e., different environmental endowments). However, as Pearson (1987) points out, there is no a priori reason to believe that increased output in the environmentally abundant country will be captured by multinationals as opposed to domestic firms. There is also no a priori reason to believe that LDCs are relatively environmentally abundant compared to DCs.

Pearson notes that empirical investigations of this issue must contend with the following difficulties: there is no unambiguous definition of ECC; any observed change in foreign direct investment (FDI) is influenced by many other economic variables other than ECC; no good data on foreign ECC exist, rendering it impossible to really calculate the impact of differentials in ECC.

Walter (1982) looks at trends in FDI by firms from Western Europe, Japan and the United States from approximately 1970 to 1978. He examines trends in FDI both in terms of industry mix and destination. Although there exists a large amount of overseas production in pollution-intensive industries, there is little evidence that it has been influenced by differing ECC. Examination of trends in foreign FDI into the United States also supports this conclusion. There is no evidence that foreign FDI is shifting towards states with more lenient standards.

Pearson (1987) surveys several studies, all of which tend to support the conclusion that there is little evidence of industrial flight to developing countries. Results from three of these are discussed below. Pearson (1976) estimates the increase in exports in 18 manufacturing sectors which LDCs might expect to gain
as a result of differentials in ECC, that is, the potential gains to LDCs from maintaining lower environmental standards. His results for 1973-77 and 1978-82 indicate that LDCs might see an increase over existing levels of export revenues of between 2.1 percent and 4.6 percent. He considers this small relative to the 8 percent annual growth which took place during the period.

Duerksen and Leonard (1980) examine trade and investment data to determine if ECC differentials have led to industrial flight toward LDCs. Among their results are: host countries which received the most overseas investment in pollution-intensive chemicals, paper, metals and petroleum refining were other industrial countries (not LDCs); the percent of U.S. FDI in pollution-intensive industries in LDCs compared to DCs did not increase significantly over time. They conclude that there is no evidence of widespread relocation of U.S. industries to pollution havens. A study by Knodgen (1979) of West German FDI also supports this conclusion.

Leonard (1988) presents case studies of FDI in Ireland, Spain, Mexico and Romania. He argues that the industrial flight and pollution haven hypotheses are based on too static an idea of comparative advantage. His approach to the determination of comparative advantage and therefore industrial location incorporates theoretical work on: the product cycle, the existence of foreign direct investment, industrial location decisions by firms, bargaining processes between multinationals and host countries, and development strategies. Examining aggregate trade and investment statistics, Leonard sees no evidence of large-scale industrial flight as a response to U.S. environmental regulations. In the four countries studied, government officials appeared to behave in conformance with the pollution-haven hypothesis in the 1970s. However, the savings realized from the absence of pollution controls were not substantial enough to alter the locational preferences of multinational firms. Other factors, such as the level of training of labor, infrastructure and stability were much more important in location decisions. In addition, growing concern by these countries for the environment has influenced the bargaining process with multinationals. Leonard argues that these countries could not be called pollution havens in any sense today.

Policy Responses to Loss of Competitiveness

In 1972, OECD countries agreed to a "polluter-pays principle" (PPP) regarding the financing of ECC. Presumably this was to facilitate the efficient allocation of resources through internalizing negative externalities. As argued above, this theoretically implies a loss in comparative advantage in pollution-intensive sectors for the country with relatively high ECC. Empirically, at least some sectors may see significant loss in competitiveness. One proposal has been to subsidize ECC so that industries in countries with "high standards" will not experience this loss in comparative advantage. (Despite the PPP scheme, OECD countries have indeed implemented numerous subsidies to cover ECC.) This would imply that GATT would need to distinguish subsidies for attainment of environmental goals, from other subsidies which ostensibly give firms an "unfair" advantage in trade.

The study of Richardson and Mutti (1977) provides some evidence on this issue. They compare the impact upon U.S. industry output of ECC under the PPP and under a scheme where ECC are subsidized. The subsidy is paid for by levying an identical tax on the value-added of each industry. In several of the models they consider, Richardson and Mutti find that the subsidization scheme makes the distribution of environmental control displacement across industries more equal, as compared to the PPP results. That is, the subsidy scheme reduces the relative disincentives facing industries most severely impacted by ECC.

Government subsidies which compensate firms for the cost of meeting regulations inhibit the optimal shift of resources away from pollution-intensive industries. Thus, on the basis of economic efficiency, there does not seem to be any reason to allow the avoidance of loss of comparative advantage through use of
subsidies to meet ECC. In addition, the economic literature on pollution has long argued that tax schemes or marketable permits are usually a more efficient method of internalizing pollution costs than subsidies. This suggests that subsidies used to attain environmental goals are likely to be guises for avoiding losses in competitiveness, and should not be allowed by GATT.

Another popular policy proposal is to allow countries to levy countervailing duties against imported products whose cost advantage is derived from relatively more lenient environmental standards. Pearson (1987) argues that such duties are not efficient for two reasons. First, it must be recognized that efficient environmental regulations in one country will differ from another precisely because of differences in marginal benefits and marginal costs of abatement (i.e., differences in assimilative capacity). These standards should be determined locally. Only if an exporter were to purposely set standards below what was locally optimal could the ECC differential be viewed as a deliberate export subsidy. Second, existing estimates of ECC show that they are quite small, and indicate that their impact on trade patterns is probably insignificant. Therefore, a tariff to adjust for ECC differentials appears unnecessary.

If there is any role for GATT here, it would be to attempt to discern if a country’s environmental regulations were below those which are locally optimal. Only in such cases might a countervailing duty be justifiable.

Implicit in the argument for countervailing duties is the idea that the more lenient country has the wrong environmental standards. A third proposal is, therefore, that standards regarding production pollution be harmonized internationally. As Pearson (1987) argues, this proposal appears to be based on two misconceptions. First, international ambient, effluent or emissions standards will not equalize ECC. Therefore, countries which are environmentally scarce will find their ECC relatively high and will still experience loss in competitiveness. Second, equalizing pollution abatement costs (ECC) is inefficient. As argued above, ECC should reflect relative assimilative capacity. Thus we should expect both marginal benefits and costs of abatement to differ across countries. Equalizing standards or attempts to equalize abatement costs would interfere with efficient reallocation of pollution-intensive industries toward countries with relatively large environmental endowments.

Transnational Pollution

There are two main issues which link transnational pollution to international trade, and hence to GATT. First, are trade barriers an appropriate way to regulate (and/or diminish) transnational pollution (e.g., acid rain)? If so, in what way must GATT rules be revised to allow for this? Second, how will domestic regulations to control transnational pollution affect trade patterns?

These issues also arose in the analysis of production pollution (above), where the damages from such pollution were within national boundaries. Do the answers change if the external costs generated by production cross national borders?

Baumol and Oates (1988) address the theoretical question of the optimal policy response to transnational externalities. They argue that an internationally optimal tax on emissions is required: one which is equal to the marginal damage generated in all countries taken together. Given national sovereignty, however, this policy is unlikely to be implemented. Consider countries A, B and C, where A is the polluter, and B and C are the victims of transnational pollution. A may establish an emissions tax based on marginal cost/benefit calculations within its own borders. B and C might impose tariffs equal to the marginal damage suffered by their own nationals. The prices and allocation of resources which result will deviate from the optimal outcome. Prices in A are not directly affected by the tariffs of B and C. Therefore, prices in A will
not fully reflect the social costs of A’s production. Similarly, the duties set in B and C will not account for the full social cost of their consumption. In all countries, prices for the polluting good will be too low relative to the outcome with the internationally optimal tax. Baumol and Oates conclude that there is no set of tariffs capable of sustaining the Pareto optimum which would be yielded by the optimal tax.

However, they then go on to explore the role for tariffs as a second-best policy. Is there a case for unilateral tariffs against the polluting country? Baumol and Oates argue that there exists a "quasi-optimal" tariff, provided the importing country is the victim of the pollution and is large in world markets. This tariff is one which incorporates the costs of the damage in the victims’ country into the victims’ domestic price, and, therefore, lowers the world price of the polluting good. When transnational pollution exists, zero tariffs are not generally optimal. However, the tariff which would maximize the importing country’s welfare (given its monopoly power) exceeds the quasi-optimal tariff. Therefore, the narrow interests of the victim country are likely to result in too high a tariff relative to the second-best policy.

Baumol and Oates conclude that, though clearly second-best, there may be a role for tariffs to move the global economy towards a "quasi-optimum," or to be used as a threat to achieve compliance to an internationally agreed upon target.

Merrifield (1989) considers the impact of unilateral action, such as a production tax or an abatement equipment standard in one country, on the level of transnational pollution, the terms of trade and factor rewards. He argues that unilateral action can succeed in reducing the level of emissions, but that free trade in goods and in capital could cause foreign emissions to rise sufficiently to increase the level of emissions on net.

Some interesting empirical work has begun on the impact of regulation of transnational pollution on trade patterns and the gains from trade. Whalley (1991) and Whalley and Wigle (1991), studying carbon taxes, suggest that interregional gains and losses between DCs, LDCs and oil exporters are highly sensitive to the type of tax implemented to reduce emissions, but are not insignificant in size. In light of the theoretical argument above, Whalley and Wigle’s results regarding a global tax on production of greenhouse energy products are particularly interesting. They anticipate a terms of trade loss for the oil exporting region, and an overall gain to the developing non-oil exporting nations if the tax revenues are redistributed proportionately to population.

Product Standards as Nontariff Barriers

Environmentally related product standards (ERS) are applied to products for the purpose of preventing environmental deterioration, or protecting consumers from direct environmental contamination (Pearson 1982). Some common types of ERS relate to: motor vehicle emissions, food products, product radiation emissions, toxic substance controls, product noise and packaging requirements. Again, the main issue linking ERS with trade is the issue of inter-country differences in standards. In the case of production pollution, the country with the more stringent regulations expected a deterioration in its comparative advantage in the regulated sectors. Here the opposite problem arises. The country with more stringent product regulations will find its competitive position enhanced, as imported goods which fail to meet the local standards are prohibited.

In this case, two issues arise. How can GATT ensure that ERS are not being used as a guise for inhibiting trade? Is there a case for an internationally harmonized standard? Two recent events illustrate the contentiousness of these issues. GATT has recently proposed a "Codex Alimentarius" which would internationally harmonize food product standards. Some U.S. groups have asserted that the standards in the Codex are less stringent than FDA or EPA standards, and that the United States should be free to adhere to
its own standards without being accused of being protectionist. This past year, the United States imposed a ban on export of unprocessed logs from U.S. public lands in the Pacific Northwest. Japan contends that this export ban is a thinly disguised nontariff barrier. The ban does not meet the environmental objective, since it does not apply to processed wood products. It will raise the price of unprocessed wood to Japan (the United States is the largest timber supplier to Japan) and encourage ailing U.S. wood processing industries.

**ERS as Nontariff Barriers**

There is virtually no literature which examines the conditions under which ERS can become NTBs, nor the extent to which such NTBs have affected trade patterns. An early study by Pearson (1982) on standards in fish and shellfish is a beginning.

Pearson suggests three circumstances in which an ERS may intentionally or unintentionally become an NTB. First, an ERS may be deliberately used as a trade barrier, for example, when imported goods are subject to different standards from domestic goods, or when the standard does not meet the stated environmental objective. The costs of these barriers are familiar.

Second, inter-country differences in standards can become an NTB when the differences occur for no inherent reason. This is because they can cause foreign producers to incur extra costs compared to domestic sellers. An example would be the nonrecognition of an equivalent foreign testing procedure for radiation or other emissions standards. The foreign exporter may incur: costs in acquiring information on differing standards; direct costs for adaptation of the product; loss in economies of scale due to shorter product runs to meet different export market standards. Such costs may be particularly acute for developing country sellers.

Finally, suppose the differing standards just described exist because of different social preferences, i.e., different assessments of the increase in welfare due to a more stringent standard. To evaluate whether this justifies a difference in standard between countries, one should compare the marginal costs of the more stringent standard with the marginal benefits. The assessment of costs should include the types of costs described above. In cases where marginal costs exceeded marginal benefits, the more stringent standard would not be justified, and would become an NTB.

**Measuring the Impact on Trade**

No literature exists in this area either. Conventional assessment of NTBs seeks to translate them into tariff-equivalents. Along these lines, Pearson makes two suggestions. One could measure the additional costs incurred by the exporter to comply with different standards. One could also measure the number and/or value of shipments denied entry due to failure to meet standards. Pearson measures the value of imports detained in fish, shellfish, fruits and vegetables. He finds that food ERS have a modest impact on trade, but can be significant for individual commodities.

**Policy Response**

Unlike the case of producer pollution, there seem to be strong arguments for harmonization of product standards to avoid protectionism and to reduce the costs described above. The only case in which different standards appear to be economically legitimate are those in which the marginal benefits of incrementally more stringent standards exceed the cost of such standards.
The types of NTBs described above suggest certain policy responses to determine if the ERS is a disguise for protectionism. First, determine if imports are being subject to the same standard as domestic goods. Second, evaluate whether the ERS meets the environmental objective (the Japanese dispute with log exports), and in particular whether it meets it in a least-cost way. Third, determine if differences in national standards are arbitrary. This is a particularly difficult question, since it requires countries to agree on safe levels of emissions of radiation, air pollution from cars, etc. On these issues the scientific community is not in agreement (the food standards debate). However, more stringent ERS should not be accepted without weighing the costs of such a policy. It appears that public debate has focused solely on marginal benefits without assessing marginal cost. Unlike the case of production pollution, it appears that implementation of harmonized product standards may be efficient if more stringent regulations exist for no inherent reason, or if the marginal costs of more stringent regulations exceed the marginal benefits.

Trade in Hazardous Substances

Trade in hazardous substances is related to the issue of product standards. In this case, the question is whether the domestic environmental standards of the exporting country should be imposed on the importing country. For example, if use of a pesticide is prohibited in country A, should country A be allowed to export the product to country B?

Anecdotal evidence of potential or actual damage due to export of goods which are domestically prohibited or severely restricted abounds (Scherr, 1987). Most of the cases cited concern exports of pesticides, pharmaceuticals, consumer goods and food, and hazardous waste. Studies by Scherr (1987) and Azevedo (1982) survey the evolution of U.S. regulation of such trade. The main issues in the United States involve notice of exportation of such goods, prior informed consent of the importing country, explicit bans on drugs which are domestically prohibited, and procedures for alerting importing nations of the export of hazardous substances.

In 1989 GATT established a Working Group on Exports of Domestically Prohibited Goods and Other Hazardous Substances. Broadly speaking, its task is to examine the trade-related aspects of this issue not adequately addressed by other institutions. Sankey (1989) surveys the activity of seven other international bodies attempting to regulate this trade: UNEP, FAO, WHO, ILO, UN Secretariat, UNCTC, OECD. The main concern of these bodies has been to provide information on domestically prohibited goods (DPG) and hazardous substances, and to establish procedures whereby export notification is given in the exporting country, and time and information is given for the importing country to make an informed decision to import or not.

The most active of these has been the UNEP. In 1975 it established an International Register of Potentially Toxic Chemicals. In 1987 it adopted the London Guidelines for Exchange of Information on Chemicals in International Trade. Under these guidelines, 74 countries agreed to notify each other whenever they banned or severely restricted a chemical. The guidelines also provided for exporters to notify importing countries of impending exportation of DPG. UNEP has also developed procedures whereby export of hazardous substances could only occur after informed consent of the importing country. In 1989 UNEP also adopted the Basel Convention on Transboundary Movements of Hazardous Wastes. This extensive measure requires, among other things, States Parties to notify the convention secretariat of movement of hazardous waste and sets up procedures of verification and settlement of disputes. Also in 1989, under UNEP auspices, the Montreal Protocol of Substances that Deplete the Ozone Layer was established. It came into force in 1989, ratified by 36 countries and the EC. This requires participating states to reduce consumption and production of such substances. It also prohibits export of controlled substances to nonparty states, and the importation of such substances from nonparty states.
Efforts to provide exchange of information have also been established by the FAO regarding pesticides, the WHO regarding pharmaceuticals and chemical safety, the ILO regarding occupational safety, and the UN Secretariat. Under the WHO pharmaceutical products certification scheme, the importing country may require the exporter to provide certification of authorization of sale and certification of compliance with WHO production standards.

In 1984 the OECD adopted guiding principles on export of prohibited chemicals. It recommends that exporting countries give necessary information to enable importers to make informed decisions regarding importation of such products.

The main issue now is whether GATT should introduce its own restriction on such trade and if so, how. In particular, should exports be permitted only after importing countries have given official prior informed consent? Given the arguments in the previous section, it appears that inter-country differences in standards for these products (assuming access to full information regarding the degree of hazard involved) would only be justified if marginal benefits from less stringent standards outweighed marginal costs.

Reform of Trade and Exchange Rate Policy: The Implications for Natural Resource Use and Environmental Degradation

The recent emphasis on reform of trade and exchange rate policy as a means to further development has provoked questions concerning the environmental impact of such reforms. At the center of the debate is whether or not these reforms will lead to a nonoptimal rate of depletion of natural resources and increased environmental degradation, i.e., a type of development which is not sustainable. For example, devaluation and/or removal of trade barriers will likely increase output of agricultural exports. Would this imply too rapid a rate of depletion of forests or soil? Would this lead to overcultivation of land? Would this shift production to crops which are more damaging to the environment?

Virtually no analytical work exists in this area. This is not surprising, for two reasons. First, trade liberalization, devaluation and accompanying policies such as fiscal and monetary austerity, elimination of government marketing boards in agriculture, and other policies will undoubtedly have some impact on the use of natural resources and the extent of environmental degradation. However, the type of impact is not predictable a priori. Second, even if one were able to predict that certain trade reforms would increase the export of, say, a natural resource, this would not imply that the reform should not be made. The problems of optimal resource use and optimal rate of degradation lie in appropriately determining the shadow prices of resources, and internalizing externalities. These are domestic problems. Although certain trade policies may help achieve such a domestic objective, they are at best, second-best methods of doing so. Most studies which discuss the issue recognize this: Pearce and Turner (1990), Warford (1989), Barrett (1990a), Muzondo (1990), Markandya and Richardson (1990).

Markandya and Richardson (1990) provides a detailed examination of the way in which specific liberalization policies might be expected to affect the environment. Devaluation should increase the producer price for export goods and for import-competing goods, and cause substitution away from imported products. To the extent that this causes a rise in the output of export crops, it may imply increased land clearing (increased deforestation) or more intensive use of existing lands. It may also imply changes in the use of fertilizers and pesticides and in the choice of crop. There may be an increase in the rate of soil erosion or increase in the incentive to invest in land-improving equipment or techniques. The reaction of the farmer is likely to be heavily influenced by the land tenure system, as this influences the degree to which changes in price incentives actually affect production decisions.
Markandya and Richardson anticipate that removal of tariffs and quantitative restrictions give rise to the same potential impacts as a devaluation, across a more limited number of products. This is also the case for increases in official producer prices of agricultural products. Simultaneous removal of subsidies on agricultural inputs could result in a number of outcomes. Removal of pesticide subsidies, for example, could imply use of more traditional methods which are less environmentally damaging. However, to the degree that they are less effective, productivity falls. To counteract this, farmers may cultivate land more intensively.

Barrett (1990a) actually attempts to analyze how farmers' decisions regarding soil conservation will be affected by liberalization policy. He focuses on the following debate. Suppose particular liberalization policies lead to a rise in farm producer prices. Will this lead farmers to deplete the soil less, because they have financial incentive to invest in conservational farming techniques or equipment? Or will this lead to farmers "mining the soil" for a quick return on larger crop yields now? (The phrase is borrowed from Lipton.) Barrett proposes the following maximization problem for the farmer: choose a soil erosion program to maximize the present value of a stream of future profits, discounted at market interest rates. He then considers the reaction of the farmer to an unanticipated permanent increase in the price of his crop.

The results are provocative. For example, Barrett argues that such a price increase will have no impact on the farmer's choice of optimal soil conservation. This is because the rise in price raises, equally, the benefits to more soil erosion now and the benefits to adopting more conservation now. He finds that the same result holds for the impact of the price rise on the length of the fallow period. The only way the price increase will have an impact is through its effect on the farmer's decision to employ nonsoil inputs. A third result regards fertilizer usage -- used to mitigate erosion-induced productivity loss. Here he finds that the optimal conservation decision remains unaffected as long as the technical rate of substitution between soil loss due to cultivation and soil depth is independent of the use of nonsoil inputs. If this independence does not exist, then the conservation decision will be affected. However, the direction of the effect is impossible to determine without specific information on the production function.

Barrett concludes that a rise in producer prices could improve, worsen, or have no impact on soil depletion--that it depends upon the technical details of the agriculture production function. He also stresses that the concern should not be whether or not policy reforms conserve or do not conserve soil. Rather it should be: to correctly estimate the shadow price of soil use, given that erosion can cause harm downstream; and to incorporate this externality correctly into the farmers' decision process.

Another interesting conclusion can be drawn from Barrett's work. Reform of land tenure systems and access to rural credit markets may be a more appropriate focus for the achieving of appropriate levels of soil erosion. This is because Barrett does show that higher discount rates will lower the optimal level of soil depth in the steady state. To the extent that sharecropping arrangements and very high interest rates from moneylenders produce a very high discount rate for peasant farmers, these would tend to contribute to higher than optimal rates of soil depletion.

In a recent study on industrialized country trade policies and natural resources, Dunmore and Langley (1988) propose that the link between trade policy and demand for agricultural commodities must first be estimated. Then, the resulting adjustments in agricultural production must be assessed: changes in types of crops planted, production techniques, relative amounts of inputs used. Specific assessment of these adjustments should allow for estimates of the derived demand for natural resources use and value, and consequently, for the potential additional damage or benefit to the environment. As Barrett's work shows, there is considerable uncertainty as to the adjustments in agriculture which would result from a change in trade or exchange rate policy, as well as their impact on the environment.
The discussion thus far has ignored the nonagricultural sectors of the economy. Removal of overvalued exchange rates (as a means of subsidizing capital inputs), tariffs and quantitative restrictions is likely to imply reduced incentives to the previously protected import-competing sector. The shrinking of some industries in this sector may imply reductions in certain types of environmental damage. Certainly this must also be weighed in assessing the overall impact of liberalization on the health of the environment.

The study of the links between trade liberalization and environmental damage will be valuable if it pinpoints specific external costs which will be aggravated by liberalization. This may be useful in determining the optimal domestic policy (or policies) to reduce the environmental damage to the appropriate level. It may also indicate necessary reforms in land tenure and credit availability (particularly rural credit) which will be critical in efficiently internalizing the costs of these externalities. However, as trade barriers are an inefficient means of achieving a domestic goal, it is doubtful that such a study would lend support to limitation of liberalization due to its environmental impact. A case for more gradual removal of barriers would need to be based on estimates of the welfare costs of maintaining trade restrictions vs. the gains from delaying environmental damage.

Conclusion

This paper has reviewed the existing literature on the impact of environmental regulation on trade, and the impact of trade policy on the environment. What are the conclusions which can be drawn regarding changes in trade policy and GATT, in light of concern for the environment? On what issues does further work appear necessary?

Inter-Country Differences in Environmental Regulation of Production Pollution

More stringent regulations in one country are thought to result in loss of competitiveness, and perhaps industrial flight and the development of pollution havens. The many empirical studies which have attempted to test these hypotheses have shown no evidence to support them. There may be room here for better estimates of actual environmental control costs incurred by firms, and estimates by industry of actual losses in output due to these costs. It is doubtful that this would yield a significant impact on trade patterns. However, it might provide useful information on individual sectors where adjustment may be significant.

There is no role here for countervailing duties or an international environmental standard. Both concepts ignore the necessary reallocation of resources that must occur if externalities are to be efficiently incorporated into costs. Both also ignore the fact that standards should be based on local calculations of marginal costs and benefits. Only if an exporter’s standards are below what is locally optimal, could a countervailing duty be justified.

Subsidies are likely to be guises for trade barriers, and should in general not be accommodated. They are usually not an efficient means of achieving an environmental objective. In addition, they may hinder the efficient reallocation of resources away from pollution-intensive industries.

Transnational Pollution

When pollution spills over national boundaries, there may be a role for tariffs to move the global economy towards an optimal allocation of resources. However, the tariff will be at best second-best. If it is based on damage to the victim country alone, it will not reduce trade in the polluting product enough. If the tariff is one which maximizes the welfare of the victim, it may reduce trade in the product by too much.
Empirical work thus far suggests that unilateral domestic policy may be ineffective at reducing global emissions, and that a type of global tax may have significant effects on trade patterns. Further empirical work on the effectiveness of various policies and their implications for trade patterns would be useful.

**Product Standards as Nontariff Barriers**

Unlike the case of production pollution, more stringent regulations here are likely to result in gains in competitiveness for domestic industry, as the regulation becomes a barrier to trade. Again, unlike the case of production pollution, there appears to be a case for establishing some international code of product standards to prevent the use of standards as NTBs. This would require discerning whether a standard meets the objective, and whether differences in standards exist for no inherent reason. If disagreement exists in the scientific community over the additional benefits of more stringent standards, it is important to weigh these against the additional costs they generate. This suggests the importance of more empirical work assessing the restrictive impact ("tariff-equivalent") of more stringent regulations on trade in the affected products.

**Trade in Hazardous Substances**

Many international institutions have set up guidelines for their members to follow regarding export of these products. Particular emphasis has been placed on informed consent on the part of the importing nation. To the extent that this is simply a special case of the debate on differences in product standards, the suggestions in the preceding section should apply here as well.

**Reform of Trade and Exchange Rate Policy: The Implications for Natural Resource Use and Environmental Degradation**

Little work has been done to assess the impact of liberalization policies on the environment, largely because the links are indirect and the outcomes in many cases ambiguous. Furthermore, trade barriers will be, at best, a second-best means of reducing environmental damage. However, empirical work linking changes in trade and exchange rate policy to the environment would be useful to: pinpoint the environmental damage likely to be aggravated by the policy change; perhaps speed up the process of implementing an efficient domestic policy to incorporate this damage into production costs; and illuminate other areas where policy change may be required to effectively reduce damage, such as land tenure and rural credit systems. Any case for more gradual liberalization of policy would need to be based on estimates of the costs of maintaining barriers versus the benefits of delayed environmental damage.
Trade Policy and Pollution

Patrick Low and Raed Safadi*

Introduction

It has been about twenty years since the state of the environment first became a significant public policy issue. Much of the early debate focused on the rate of depletion of finite resources and had a distinctly Malthusian hue. A depiction favored by some environmentalists was of a face-off between voracious humankind and an exhausted, abused Planet Earth. It was argued that the absolute physical limits to growth were rapidly approaching and society was showing itself incapable of adapting to the only option available—that of zero growth. Unless a fundamental realignment of attitudes and behavior occurred, the situation would soon become painfully unsustainable.¹

The more depressing of these scenarios were predicated on models that turned out to be very sensitive to small changes in underlying assumptions. The models paid scant attention to the role of productivity growth, technical progress and the price system in determining the dynamic relationship between the rate of resource use and economic growth. The contrast between the pessimism of twenty years ago and views commonly expressed today is stark. The Brundtland Commission, for example, argued explicitly that there are no limits to growth.² Repudiation of the doomster scenarios of the late 1960s and early 1970s was, however, far from an adequate answer to ever-growing concerns about environmental degradation.

Water and air quality, protection of the soil, waste treatment and disposal, noise control, and the management of natural resources have all become mainstream concerns of governments. Interest in the state of the "global commons" has intensified.³ These pressures have provoked the promulgation of numerous

---

¹The authors are grateful to Patricia Annez, Sudhir Shetty and John Whalley for comments on an earlier draft.

²The Club of Rome was prominently associated with these arguments. See, for example, Meadows, et al. (1972).

³World Commission on Environment and Development (1987). The Commission that produced this report was chaired by Gro Harlem Brundtland. The Brundtland Report recognized that economic growth, poverty and the state of the environment are intimately linked, and argued that environmental degradation would not be effectively addressed in the absence of growth and poverty alleviation. It should be emphasized that these views are not universally accepted, as the following declaration of the British Green Party (1989) makes clear: "At the heart of the problem is consumption . . . An ever-expanding consumer economy eats up the planet, spewing out the waste as pollution and denying future generations any share in the earth's rich bounty . . . That's why trees are dying from acid rain, and why our streams and rivers are so dirty" -- quoted in Kay and Silbertson (1991).

³The concerns about the state of the global commons relate mainly to greenhouse gas emissions, ozone depletion, tropical deforestation, pollution of the ocean and the loss of biodiversity.
laws and regulations, especially in industrial countries, as well as a number of attempts at international cooperation. There are perhaps economists who would like to wish externalities and market failure out of the literature, and to dismiss environmental concerns as yet another excuse for interference by the state. There are certainly environmentalists who believe that opportunity costs and less than infinite environmental values are empty concepts invented by economists to justify the pillage of nature. Much has been done since the late 1960s, however, to address the market and policy failures associated with the growing problem of environmental degradation in a populous world.

A fairly extensive literature exists on the economics of the environment. A large part of it deals with the policy options available to governments in the presence of an externality, arising where the market fails to reflect the social cost of environmental degradation or of a particular pattern of resource use. The essence of the problem is that environmental quality is often treated as a public good, when in reality the existence of rival consumption combined with nonexcludability leads to a situation of under-supply (that is, to environmental degradation). Once a government recognizes that an environmental problem exists and merits action in order to align social and private costs and benefits, choices must be made from among a variety of available instruments. Options include regulation, assignment of pollution rights, fiscal measures (taxation or subsidization of polluters), a budgetary commitment involving direct action, or some combination of these.

With increasing frequency, environmental issues involve more than one country. When distinct sovereignties have differing interests in an environmental problem, or when the policy stance of one government is seen by another as inimical to its own objectives, then international action may be required to avoid conflict. In these circumstances, the solution to environmental problems is no longer just a matter of a single authority deciding how to internalize externalities in an optimal manner. International arrangements or undertakings may have to be worked out to engender cooperative behavior among competing sovereignties.

International environmental concerns are pronounced in relation to the global commons, but may also arise where individuals in one country declare an interest in environmental problems or policies in another, in the absence of any direct physical link (spillover effects) between the two countries. Governments can expect these declarations of interest from two principal sources. They may come from environmental groups, whose concern is the promotion of a healthy environment in a global sense or the preservation of biological diversity or cultural heritage. Alternatively, they may come from domestic industry or labor and focus on international cost differentials arising from national pollution abatement and control policies.

Environmental groups and industry/labor interests may perceive a common cause and join forces, as they appear to have done in the debate about a free trade agreement between Mexico and the United States. A coalition of this kind frequently demands trade restricting actions, although the coincidence of interests between these two groups is not as close as might appear from their joint lobbying. What principally distinguishes them is that the basic concern of environmentalists is the effectiveness of pollution control or natural resource preservation measures. For industry/labor groups, on the other hand, the reduction of international competitive differences is the primary if not sole objective. The case made by industry/labor groups on environmental grounds bears a striking resemblance to the demands that have long been made, and found some expression in U.S. policy, for trade action to deal with the abuse of workers' rights in foreign countries.4

4Access to the U.S. Generalized System of Preferences (GSP) scheme has been denied certain countries on the grounds that they do not respect internationally accepted standards with regard to workers' rights. The United States has also tried for several years, unsuccessfully so far, to place workers' rights on the GATT agenda. It does not seem unduly cynical to note that a professed, ostensibly honest concern for the well-being of foreign workers dovetails nicely with another concern - that of the competitive position of domestic industry. If there is disingenuousness, it is occasionally dispensed with, as in the recent demand by an AFL-CIO representative that wage differentials between Mexico and the United States should be addressed in the proposed free trade area negotiations. See International Trade Reporter (April 10, 1991).
The notion that varying standards of pollution control among countries are a source of unfair competition seems to be gaining popularity. Its potential effects on the trading system are far-reaching. Doing different things about the environment, or doing the same things in different ways, is considered sufficient in some circles to justify complaints about unfair competition. What this means is that arguments for remedial trade (or other) action predicated upon the adverse competitive effects of environmental control measures do not necessarily require that there are international spillover effects. In other words, no distinction is made between local and global pollution problems. If this distinction is ignored, the scope for trade-restricting action arising from pollution control and abatement policies is far-reaching. Moreover, even if there are international spillover effects, involving regional problems or the global commons more generally, it is not obvious that trade policy interventions are called for (see below).

Policy discussions about the environment have frequently been conducted at a level of emotion that largely precludes reasoned debate. In popular discussion, trade restrictions have readily been identified as the solution to environmental degradation, and proposals for open trade as the antithesis of what is needed to take care of the environment and of scarce natural resources. Political demands for linking trade and environmental policy more explicitly are strong.

There are numerous examples of writings that are based on the view that trade liberalization is bad for the environment and that additional trade restrictions are the only way to control environmental degradation. Why has the link been so readily, and in many ways uncritically, made between open trade and environmental degradation? One reason may reside in the tradition of direct control that has dominated environmental policy in industrial countries. It is only quite recently that market-based policy alternatives have been regarded as an option. While regulation is applied domestically to deal with environmental problems, it must seem to many almost axiomatic that international trade needs to be regulated as well.

A frequently expressed concern about open trade is that it will lead to competitive deregulation and "least common denominator" environmental standards. Another fear has been that "dirty" industries would migrate to less regulated settings. This is a worry both for environmentalists because of the implications of migrating industries for global environmental quality, and for labor interests because of the loss of jobs that would be implied.

It will be argued in this paper that the case for trade restrictions to support environmental objectives is at best confined to a narrow range of circumstances. Concerns about competitive deregulation and the

---

5A recent example of a less-than-helpful discussion of the issues was the assertion, made by opponents of the U.S. Administration’s request to Congress for extended authority to negotiate foreign trade agreements (including the Uruguay Round and the Mexican free trade agreement), that the free trade agreement with Canada and lax border inspections were responsible for "sharp increases in meat containing metal shavings, pus-filled abscesses and fecal material." See "US fast-track trade debate gathers pace," Financial Times, March 25, 1991.

6For some illustrations, see Brown (1990); Ritchie (1990); Shrybman (1990); Centre for Agriculture and Environment (1990). Blanket antitrade sentiments based on environmental concerns are easy to challenge with examples of where freer trade would involve greater reliance on production that is less damaging to the environment. Increased international competition in agriculture is a case in point.

7For a discussion of this issue, see Leonard (1988). Leonard argues that different environmental standards have had no significant effect on the location of investment, even where countries have tried to attract dirty industries.
If it is accepted that not all pollution is unacceptably bad, a number of important propositions follow. First, it becomes obvious that different countries and different regions within countries have different pollution assimilation capacities. This fact can be used to promote pollution abatement -- the migration of dirty industries might even be a welcome development from an environmental perspective. Second, differences in social preferences as regards the level of pollution that a country wants to live with are no longer to be suppressed through enforced harmonization, although compromises may still need to be made where international spillovers are concerned. Third, there can be readier acceptance of international differences in policy approaches to pollution abatement. Rigid, internationally standardized policies are not justifiable. There are no a priori reasons why levels of pollution control should be identical among countries, unless some polluting products or emissions are considered so bad that there is a universal commitment to their complete elimination. In general, it becomes more feasible to think of ways of addressing environmental problems internationally without threatening the fabric of the trading system by overloading it with a new, somewhat open-ended rationale for restricting trade.

The rest of this paper explores some of these ideas in more detail by focusing on various policy choices involving environmental quality. The paper next discusses environmental policy in an international setting. It then analyzes the relationship between trade policy and environmental policies.

Environmental Policy in an International Setting

Policy Options

Table 3-1 is an abbreviated summary of the costs and benefits associated with different policy options faced by governments, once a decision has been made to internalize an environmental externality, defined as some target level of pollution abatement or rate of resource use. The propositions in the table are well established in the literature on the economics of the environment. Alternative policies carry quite different efficiency implications, with market-based interventions promising lower-cost pollution abatement and control expenditures for a given target than regulations. Efficient, least-cost policies equalize the marginal costs and benefits of meeting environmental targets and introduce incentives for innovations that promote "environmental productivity." Fully efficient interventions are unlikely to be attainable in the real world, once allowance is made for the absence of full information, other forms of uncertainty, imperfect markets, transactions costs, and administrative costs.

---

From a protectionist perspective, presumably there would be greater interest in equalizing the cost rather than the level of pollution control. This makes even less sense in economic terms, falling squarely within the same category as demands for action to address wage differentials between countries (see footnote 3 above).

Empirical evidence of the cost differences is reported in Tietenberg (1990).
### Table 3-1: Policy Options for Pollution Control

<table>
<thead>
<tr>
<th>Policy</th>
<th>Efficiency Costs/Benefits</th>
<th>Market Assumptions and Implementation Costs/Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Assignment of property rights</td>
<td>- Externalities internalized through direct negotiation among affected parties.</td>
<td>- No state intervention required, except to define enforceable property rights that ensure excludability</td>
</tr>
<tr>
<td></td>
<td>- Assume: a) low transaction costs (limited number of interested parties)</td>
<td>- Assume: a) low transaction costs (limited number of interested parties)</td>
</tr>
<tr>
<td></td>
<td>- b) full information on preferences of all parties.</td>
<td>- b) full information on preferences of all parties</td>
</tr>
<tr>
<td>2. Command and control instruments (regulation)</td>
<td>- Target levels of pollution control may be achieved with certainty, but not at least cost nor with any incentive effects for innovation to increase “environmental productivity.”</td>
<td>- Enforcement costs associated with monitoring for compliance and administering regulations</td>
</tr>
<tr>
<td></td>
<td>- Regulations associated with &quot;rights to pollute&quot; may create barriers to entry.</td>
<td>- Higher likelihood of rent-seeking opportunities than market-based instruments</td>
</tr>
<tr>
<td>3. User fees</td>
<td>- Similar to regulation in failure to distinguish between high-cost and low-cost pollution control or to induce innovation, but do generate revenue.</td>
<td>- Compared to regulation:</td>
</tr>
<tr>
<td></td>
<td>- a) lower enforcement costs if standard charges are pre-set</td>
<td>- b) fewer rent-seeking opportunities</td>
</tr>
<tr>
<td></td>
<td>- c) no &quot;barrier-to-entry&quot; problem</td>
<td>-</td>
</tr>
<tr>
<td>4. Price-quality interventions (emission trading)</td>
<td>- Marketability of pollution rights (&quot;quotes&quot;) makes for least-cost control and provides incentives for innovation.</td>
<td>- Requires liquid and competitive markets, low transactions costs and full information</td>
</tr>
<tr>
<td></td>
<td>- Initial distribution of rights does not affect efficiency (an equity issue only).</td>
<td>- May involve enforcement costs comparable to those associated with regulation, and administrative costs of organizing an market</td>
</tr>
<tr>
<td></td>
<td>- Would generate revenue if quotes auctioned.</td>
<td>-</td>
</tr>
<tr>
<td>5. Taxes (Pigouvian)</td>
<td>- Same efficiency benefits as emissions trading, but does not separate efficiency and equity aspects of intervention.</td>
<td>- State of markets less relevant than under emissions trading, but may call for iterative process to set tax at level that achieves required pollution control target</td>
</tr>
<tr>
<td></td>
<td>- Generate revenue.</td>
<td>- Stringent information requirements for public authority</td>
</tr>
<tr>
<td>6. Subsidies</td>
<td>- Equivalent to Pigouvian taxes in the short term, except for distributional implications (do not tax pollution source or raise revenue)</td>
<td>- May create an incentive for entry into a polluting industry</td>
</tr>
</tbody>
</table>

**Sources:** Two good survey sources are Eskeland and Jimenez (1991) and Muzondo and Bovenburg (1990).
Empirical work by the OECD\textsuperscript{10} reveals that there has been an overwhelming preference among governments for direct regulation over market-based interventions. Even where there have been attempts to use a market-based approach, both in the United States and Western Europe, many interventions emphasize revenue collection over economic efficiency. While reliance on regulation may be partly understood in terms of the absence of the necessary underlying conditions to make market-based solutions work effectively, political factors are also doubtless at work.

Pressures on governments to favor regulation can be strong. Regulation generally ensures greater precision in outcomes (assuming adequate compliance/enforcement), enhances the popular perception that governments are seriously committed to environmental quality, and avoids explicit recognition that public policy aims to curb some pollution rather than eradicate it altogether. Regulators may also prefer a nonmarket approach to the extent that administered interventions provide them with discretionary authority. Polluters, in turn, tend to see regulations as imparting controlled rights, in contrast to taxes, which impose charges. Moreover, if these controlled rights are specified in certain ways, they can serve as barriers to entry and be doubly pleasing to incumbents in an industry. A preponderance of nonmarket approaches in the domestic context does raise the question of how successfully efficient solutions to environmental problems with international dimensions can be promoted. An awareness of the alternatives and their associated costs and benefits, however, does allow choices to be made.

International Cooperation

At the international level, environmental issues impinge on distinct sovereignties with nonidentical objectives. The efficacy of environmental policy in an international setting depends to an important degree on the ability and willingness of governments to cooperate. If there is cooperation, two broad sets of issues have to be addressed. First, there is the level of environmental quality or resource conservation to be secured. A decision on this question defines the primary policy objective. It is immediately obvious that countries will not necessarily share a common objective, and the process of determining it is likely to be dominated by political considerations, tempered perhaps by scientific data. The social preferences underlying differences among countries in desired environmental quality are influenced by relative income levels. Varying levels of capacity to assimilate pollution will also play an important role. At a practical level, governmental authorities in developing countries are likely to face greater enforcement constraints and administrative limitations than their industrial country counterparts.

Second, once standards have been defined, agreement is required on how they are to be attained. Any number of different arrangements could be settled upon, each with different efficiency and allocative implications. Just as with the determination of the target level of environmental quality, a successful agreement on the distribution of abatement costs will have to take different welfare functions and pollution carrying capacities into account. It is an easily demonstrable proposition in game theory that in the presence of polluting activities with international spillovers, a failure by competing sovereignties to cooperate in addressing the problem will lead to a suboptimal solution (see Appendix).\textsuperscript{11} This is because each country will ignore the welfare costs on other countries of its own policy actions, or lack of them. In other words, there is a free-rider problem.

\textsuperscript{10}See, in particular, OECD (1989a).

\textsuperscript{11}It should be emphasized that in the discussion that follows it is assumed that the desired level of pollution abatement and control or resource preservation is known and agreed upon. Differences in preferences and absorptive capacities among countries are assumed to have been accommodated, although this is likely to be a crucial aspect of any negotiation.
It is shown formally in the Appendix that in a situation where a pollution externality affects two countries of different size, and where there is no explicit cooperation between the countries, welfare can be improved beyond the noncooperative situation if the large country is prepared to make an initial binding commitment to which the small country responds (in the face of a credible retaliatory threat). While this is superior to noncooperation, it is not as desirable from a welfare standpoint as cooperation. The important point is that in the absence of cooperation, a large country still has an incentive to act unilaterally and derive additional benefits both for itself and for the small country.

Returning to the cooperative scenario, the form that international cooperative efforts take is of considerable importance. From a trade policy perspective, there is a risk that in the absence of workable international arrangements, governments will submit to pressures for unilateral measures of trade control, which in many instances can be shown to be suboptimal and unnecessarily disruptive of international trading arrangements.

The presentation in Table 3-1 of efficiency criteria for interventions to address environmental problems was mainly developed in a domestic policy context, but applies in broadly the same manner at the international level. The two central concerns are equalization at the margin of the costs of pollution abatement and the benefits of a cleaner environment, and the creation of market incentives that lead to least-cost abatement. Regulation remains the least promising approach from an efficiency perspective, with various market-based alternatives promising more, provided that the underlying assumptions yielding the optimality results are not too seriously violated. Hybrids containing a mixture of regulation and price-based intervention can also produce efficient solutions.

**The International Distribution of Pollution Abatement and Control Costs**

There is, however, one important difference in the international context. This relates to the allocation of abatement and control costs. As suggested in Table 3-1, the equivalence between a tax and a subsidy as a means of internalizing an environmental externality breaks down in the long run unless entry is controlled in a way that avoids creating an incentive to pollute in order to be subsidized for abatement. At the international level, this problem is obviated by the existence of separate jurisdictions, such that transfers between governments analogous to subsidies can be made without creating an incentive to pollute in order to benefit from subsidized abatement. The key to avoiding the problem is that the government receiving the transfer does not pass it on as an abatement subsidy to its industries, but rather ensures that pollution is taxed.

Much of this discussion has been conducted in the context of the polluter-pays principle (PPP). The OECD sponsored PPP in the early 1970s when environmental issues first found their way onto the international agenda. The PPP is an allocation principle designed to ensure that the cost of goods and services that cause pollution reflect abatement and control costs. No shifting assumptions are necessary for the application of the principle -- it is sufficient that the pollution tax is paid by the polluter in the first instance. OECD documents have occasionally referred to PPP as an efficient principle for least-cost pollution abatement and control. This is a partial representation of the principle, since PPP is consistent with efficient

---

12Strictly, this result depends on the existence of a leader and a follower, and not in the characterization of countries as small or large.

13Recommendations on PPP were adopted by OECD member states in 1972 and 1974. These are reproduced in OECD (1975). This book also includes some analysis of PPP. Other useful OECD sources are OECD (1981) and OECD (1976).
polution abatement and control but is far from a sufficient condition of optimal intervention. The principle can be applied to direct regulatory approaches just as well as it can to market-based policies.

The polluter-pays principle was developed in a domestic policy context, and is regarded as having several advantages in addition to being consistent with efficient intervention. First, it emphasizes prevention over compensation for damage done. Second, it infuses a sense of fairness into policy, since the cause of a problem is seen directly to assume liability for it. Third, incorporating the internalization of environmental externalities into the costs of production avoids trade friction that would be more likely to occur if abatement were subsidized.

While the OECD has emphasized the virtues of PPP in the domestic policy context, and sanctioned departures from it only on an exceptional and temporary basis (for equity reasons or to hasten action on abatement), there has been recognition that compensation may be necessary to secure international cooperation. Compensation, or the use of side payments, transforms PPP into the victim-pays principle (VPP). As noted above, interposing multiple jurisdictions establishes an equivalence between PPP and VPP that, unlike tax and subsidy equivalence under a single authority, carries over beyond the short term. Reliance on VPP to address transfrontier environmental problems is in conformity with theory in this area. It is formally shown in the Appendix that the distribution of pollution abatement and control costs does not have any efficiency implications.

Theoretical treatments of international environmental problems distinguish various kinds of international spillover effects, the most important of which analytically are unidirectional externalities (upstream/downstream problems) and regional or global reciprocal externalities involving many countries. A well-established proposition is that feasible solutions to problems of environmental degradation with international repercussions may require side payments. This is most obviously the case with unidirectional externalities, where side payments induce cooperation. In the absence of the inducement, a polluting country has no incentive to cooperate in an efficient solution. Side payments may also be required in the case of reciprocal externalities where agreement is needed on a target level of pollution abatement and the distribution of the costs of abatement. When governments have different views about the appropriate level of environmental quality, or where there are significant differences in the capacity of countries to pay abatement costs, side payments may play a useful persuasive role.

Despite the lack of ambiguity in the proposition that side payments are necessary for international cooperation, it seems that there are many examples of international agreements that have not relied on such payments. Among the few examples of agreements that contemplate side payments of one kind or another are the Convention for the Protection of the World Cultural and National Heritage and the Montreal Protocol.


For a readable treatment of the issues, see Mäler (1991). Another interesting paper that deals with these problems is Newbery (1990).

An example of a unidirectional externality is where one country pollutes a river that flows into another. Examples of reciprocal externalities involving many countries are ozone layer depletion and the production of greenhouse gases.

For an analysis of 170 global and regional environmental agreements in which the United States participates or has an interest, see United States International Trade Commission (USITC), 1991.
on Substances that Deplete the Ozone Layer. Under the first of these agreements, the World Heritage Fund has been established on the basis of compulsory and voluntary contributions for the protection of world cultural and national heritage. Under the Montreal Protocol, agreement was reached recently concerning assistance to developing countries to meet their commitments on the control of ozone depleting chlorofluorocarbons (CFCs).

Mäler\textsuperscript{18} has argued that the apparent absence of side payments in international agreements might partly be because countries have not wished to innovate in this direction for fear of creating a presumption that international negotiations about the environment necessarily entail compensatory transfers. To the extent that this is the case, the problem would be lessened if explicit understandings were reached about whether compensation was appropriate in particular instances. A second explanation for the infrequency of observed side payments in the exercise of cooperative transborder environmental policy is that these side payments take a form other than financial transfers. There is much fungibility in international dealings. Transfer payments may be difficult to detect, and may not even be made explicit. If this is correct, observance of VPP is merely hidden, not absent.

In situations where cooperation is required between more than two jurisdictions, problems may arise from the existence of an incentive to free-ride. In effect, the incentive to free-ride exists for all potential signatories to an agreement, so countries may weigh a willingness to participate in the agreement in question against the likelihood that the agreement will come into being without their participation. If an agreement is already in place, or is imminent, it may pay third parties to refrain from joining the agreement while free-riding on its benefits. Participants in an agreement on which nonsignatories are free-riding may wish to estimate the extent to which nonparticipation by particular countries leads to the underproduction of a public good, in this case improved environmental quality. Side payments are obviously one way of reducing free-riding incentives where externalities are reciprocal. The case for them would again depend on how important nonparticipation by one or more countries is to the integrity and objectives of an agreement and whether other forms of persuasion would be more appropriate.

Mäler\textsuperscript{19} argues that the incentive to free-ride is likely to be a short-run incentive. In the longer run, cooperation begins to look more attractive because the long-run costs of a poorly functioning or failing agreement may exceed the short-term advantage of free-riding. This point would be more important for large countries whose behavior affects other parties in a significant manner. If this consideration is taken into account, and the real effects of nonparticipation by a country are also properly evaluated, then there may be reciprocal externality situations where side payments or some form of coercive action do not make sense. In other words, it is debatable that universal participation in agreements involving reciprocal externalities is a sensible objective. Transaction costs increase with the number of parties to a negotiation.

There are two other factors to be considered in a decision about the coverage of an international cooperative agreement. First, when an agreement is drawn up, there is likely to be some pressure for the harmonization of pollution abatement and control measures among signatories. For all the reasons discussed earlier, harmonization does not lend itself to least-cost pollution abatement and control. For developing countries with significantly different utility functions from those of industrial countries, harmonization at or near the level of industrial country standards could prove costly in terms of growth and development. This is clearly an argument against insistence on the universality of agreements, or at the very least against the uniformity of adopted standards. The second point to be made here has to do with the implementation of international commitments on pollution abatement and control. Considering the pervasiveness of regulation in domestic environmental policies, it is probably realistic to assume that regulation will play a prominent role

\textsuperscript{18}Mäler, op. cit.

\textsuperscript{19}Ibid.
at the international level as well. Effective regulation needs enforcement, which may be costly. An adequate enforcement apparatus is required to make international commitments credible. Many developing countries would probably encounter considerable enforcement difficulties. Even if a partial solution to the problem is found through the design of policies which economize on enforcement costs, it would remain open to question whether this does not provide an additional reason for accepting a phased application of environmental commitments over time.

The question whether agreements involving the preservation of the global commons should encompass all affected parties or only some is controversial. One reason for preferring a universal approach is the concern that negotiations among a restricted group will result in an agreement whose requirements are inimical to outsiders. An equity consideration could also be relevant if an agreement involves side payments or a distribution of tradeable rights to pollute. Just as with emissions trading in a domestic context, countries could agree on abatement targets and then allocate pollution rights among themselves. If these rights can be freely exchanged, the efficiency of the outcome is unaffected by the initial allocation, and the initial allocation can serve as a form of side payment. International agreement along these lines might not be easy to secure, but the point here is that any arrangements involving side payments may be problematic from an equity point of view if they are not universal. There is a practical and logically consistent way of dealing with the question whether international agreements that aim to internalize environmental externalities should be committed to by all countries that are affected by the externality. It is to establish in principle the universality of such agreements by making them open-ended and nondiscriminatory, with provision for delayed participation on the part of countries whose current involvement in the problem is peripheral.

Trade and the Environment

The Interaction between Trade and Environment Policy

Five distinct kinds of interaction between trade and environmental policy are analyzed here. These are i) protectionist uses of environmental arguments; ii) the reliance on trade policies as a means of changing the environmental policies of another country; iii) the application of trade policy to give force to domestic environmental standards; iv) the use of trade policy as a means of enforcing existing international agreements; and v) trade policy interventions deemed necessary to the viability of environmental agreements. These categories are not always mutually exclusive, and they bear the analytical weakness of having to ascribe motives for intervention in some instances. However, the distinctions do help to determine the legitimacy or otherwise of the use of trade policies in an environmental context.

Protectionism and Environmental Policy

The environmentalist concern that open trade is hostile to the promotion and maintenance of improved environmental quality has been taken up with some enthusiasm by interest groups that are more concerned about international economic spillovers (competition from foreign sources of supply) than environmental spillovers. As noted earlier, there is no valid argument from first principles that freer trade is associated with increased environmental degradation. The problem of environmental degradation cannot be convincingly linked to specialization through trade. On the contrary, open trade may be beneficial to the environment through its effects on resource allocation and income levels. Environmental degradation may be a problem at any level of trade and international specialization -- it depends on other policies.

The argument that the cost of pollution abatement and control measures in one country imposes a competitive disadvantage on the industry of that country if the industries of its trading partners do not face the same cost schedule is protectionist. A more sophisticated presentation of the case is the demand for
uniformity of regulations rather than identical costs of compliance, since this allows for the fact that the costs of achieving identical levels of environmental quality may differ according to location.

There are several examples from the United States of legislative proposals aiming at the equalization of compliance costs or something approaching it. A resolution before the House of Representatives in the 101st Congress, for instance, states the following:

"... it should be the policy of the United States to seek in trade negotiations the adoption and enforcement of effective and equivalent environmental standards and controls among the nations of the world; ... the President should seek, through the Uruguay Round and the next GATT round, agreement on mechanisms under which the United States and its trading partners can eliminate or reduce competitive disadvantages resulting from differential national environmental standards and controls; ... such agreement should not impair the implementation of the Clean Air Act or any other U.S. environmental protection laws."²⁰

Protectionist environmental arguments that seek to reduce competitive differentials are not sensitive to the question whether international environmental spillovers exist, or in other words, whether the environmental degradation associated with given activities is crossing frontiers. As noted earlier, there are some environmentalists who would argue that all environmental degradation involves international spillovers because environmental questions can only be addressed in terms of the global ecosystem. Even if this were accepted, for example in relation to the global commons, it would be to force the point greatly to argue that identical policy responses are required from all countries to address environmental externalities. This is because of all the arguments made above about: i) different preferences regarding environmental quality, or in other words differing definitions of the environmental externality to be internalized; ii) different assimilative capacities between countries and regions; iii) the different benefits that accrue to different groups from pollution abatement and control; and iv) the requirements for effective international cooperation, relating to incentives, the ability to pay and equity considerations more generally.

In sum, the satisfaction of protectionist economic demands predicated on environmental considerations by no means guarantees effective action to safeguard the environment. Under standard assumptions, the welfare costs of trade restrictions represent a net national loss. Even if a convincing link could be made with environmental policy and the internalization of an externality, there would be costs associated with the use of trade restrictions as the chosen intervention. It is the absence of a clear link between the objectives of inhibiting competition and of preserving the environment that explains why coalitions between protectionist and environmentalist interests that call for trade restrictions may serve the former but not the latter. Demands for the equalization of environmental quality expenditures or for the standardization of environmental norms as a matter of economic justice should be recognized for what they are -- the appropriation of environmental arguments to blunt international competition.

Trade Policy as Inducement and Punishment

Trade policies may be harnessed as a means of encouraging countries to participate in international agreements that they would otherwise prefer to abstain from. They may also be applied by one country to impose its own environmental standards upon others. The use of trade policies to influence outsider behavior, in the sense of encouraging a commitment by a country to particular environmental policies or to an agreement, is more likely to involve punishment than a reward. In general, the more remote international consensus is on an issue, the more disruptive will this particular use of trade policy become.

²⁰House Resolution 371 (Swift), quoted in USITC, op. cit.
In the most extreme case, an individual country may unilaterally define a standard and then apply trade sanctions or the threat of them to enforce compliance with those standards. There are precedents for this approach in U.S. trade policy, involving Section 301 of the Trade Act of 1974. This statute provides for retaliation against the trade of other countries where particular policies are considered unfair. In some of its more recent versions, Section 301 has involved a process whereby countries are identified for unfair trade practices, and required under the threat of trade retaliation to modify those practices. One of the strong criticisms of this approach has been that it skirts due multilateral process and can involve the imposition of trade restrictions that would be illegal under the GATT.\footnote{For a discussion of unilateral trade policy in the United States, see Bhagwati and Patrick (1990).} Legislative proposals have been made in the United States Senate to extend Section 301 remedies to address differential environmental standards.

In the context of environmental policy, an important distinction must be made between product standards and process standards. Product standards are to do with consumption externalities and will be considered below in relation to domestic environmental preferences. Process standards are an altogether different matter, as they relate to production processes and methods (PPMs). What this means in practice is that if PPMs are considered a legitimate source of concern between countries, then governments become answerable to one another for how, and by how much, environmental externalities are internalized in the production process.

It is not difficult to see how extending the reach of international commitments on standards can play into the hands of protectionist interests. Moreover, from an efficiency perspective, it has already been shown why the internalization of environmental externalities is not an argument for harmonized PPMs. Harmonization is a policy objective that can make sense among countries with similar production functions, incomes and tastes, since it reduces the transactions costs of international cooperation. Among dissimilar countries, however, harmonization becomes more intrusive and inefficient.

It may be noted that there are some quite widely supported proposals before the Uruguay Round for extending the GATT Standards Code to cover PPMs. There are similar moves afoot to include PPMs in an agreement on sanitary and phytosanitary measures in the sphere of agriculture. The application of trade restrictions by one country to oblige another to adopt specified PPMs may be expected to gain wider acceptance over time, particularly when the case is argued on health or consumer protection grounds. If this trend is inevitable, emphasis should be given to the development of agreed standards. Moreover, considering the protectionist risks associated with the demand for harmonization, and the efficiency costs of harmonization, clear distinctions are needed between legitimate health and safety concerns on the one hand, and environmental concerns as these relate to pollution abatement and control and to resource conservation on the other.

Discrimination is inherent in trade restrictions designed to make governments adopt new policies. There are a number of examples of international agreements where discriminatory trade sanctions are applied against outsiders. Perhaps the two most prominent of these are the Montreal Protocol and the 1989 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal. Under Article 4 of the Montreal Protocol, there is provision for the prohibition of trade in CFC-containing products with nonsignatories, and exhortatory discouragement of the export to nonsignatories of technologies that produce or use chemicals controlled under the Protocol. Similarly, under the Basel Convention, which has yet to come into force, signatories are obliged to prohibit all trade in hazardous waste with nonsignatories.

A legitimate question in the case of both the Montreal Protocol and the Basel Convention is whether these discriminatory trade provisions are designed to encourage countries to sign the agreements, or are necessary to their objectives (as discussed below). The answer to this question is uncertain, and the
discrimination could in effect serve both purposes. To the extent that differential treatment of nonsignatories is a matter of manipulation rather than necessity, there is no good defense of it on political or economic grounds. It represents policy failure and the "realpolitik" of power-based international relations. In economic terms, it means that one country imposes its social welfare function upon another. As noted earlier, this is not an efficient outcome, since it does not lead to cooperative welfare maximization.

Trade Policy for the Enforcement of Domestic Standards

The distinction between product standards and PPMs clarifies the difference between i) protecting domestically defined and enforced standards that address environmental externalities in consumption, and ii) imposing uniform production processes upon competing foreign producers that purportedly address environmental externalities in production. There does not seem to be any serious difference of view about the right of governments to set and enforce domestic standards. Effective enforcement of domestic standards requires, as a minimum, the threat of trade restrictions. Such restrictions would only be applied where imports do not meet specified standards. Emission standards for motor vehicles provide a good example of where domestic standards can only be made effective if they are supported by the threat of restrictions, in this case on imports of vehicles that do not meet the same emission standards.

The GATT recognizes the legitimacy of import restrictions to enforce standards, and has developed the Agreement on Technical Barriers to Trade (Standards Code) in an attempt to ensure that standards do not operate as an unwarranted trade restriction. Cooperative agreements on procedures for establishing standards and for their implementation are essential to the maintenance of open trade. The GATT agreement goes a little further, however, since it creates a presumption that the international harmonization of standards is virtuous. It is explicitly understood that the GATT is not involved in standard setting activities, but the encouragement of harmonization may create problems, especially if the reach of the GATT Code is extended to PPMs. The efficiency trade-off between the costs of harmonization and the benefits of lower transactions costs has already been discussed.

Although in theory the definition of standards and the formal distinction between product and process standards may be clear enough, in practice the situation is not always so straightforward. This problem has been well illustrated recently by the hormone in beef dispute between the EC and the United States. The EC prohibited imports of U.S. beef produced with certain growth hormones, on the grounds that European beef was not produced with these hormones, which were claimed to represent a health hazard. The United States complained that the restrictions were purely protectionist, since the standard they were supposed to defend was spurious and not based on a reasonable scientific norm. The EC insisted that the measure responded to domestic consumer preferences and gave force to domestic standards. Apart from demonstrating the difficulty that can arise in determining the intent of a standard, this dispute also shows why a clean operational distinction between a product standard and a PPM may be hard to make in specific instances.

Trade Policy for the Enforcement of International Agreements

Most international agreements require convincing enforcement provisions, involving a retaliatory or punishment mechanism. This becomes more important the greater the influence of an international commitment is on the policy of governments, and the greater the incentive that exists to be less than fully cooperative under the terms of an agreement. In a game theoretic framework, the sustainability of an agreement may be seen as a series of repeated games, where retaliation or the withdrawal of cooperation is a credible threat.

Efficient implementation is very important to the avoidance of a protectionist use of standards, relating to such issues as mutual recognition of technical inspections and prompt inspection procedures.
The question of interest here is whether trade restrictions offer an efficient retaliatory mechanism. Theory is not very helpful, because it is assumed that a credible threat does not need to be exercised. If an international environmental agreement is properly structured and stable, non-compliance by a party to the agreement would be irrational, in the face of the severity of the retaliatory consequences of such action. Countries are assumed to have entered into an agreement because they consider it to be in their interests to do so. In this framework, the withdrawal of market access, or in other words the imposition of trade restrictions, may be an effective threat.

The case for trade restrictions as an enforcement mechanism under an international agreement must be distinguished clearly from the case of the use of trade policy to induce (punish) cooperation (noncooperation) in the absence of international agreement that was discussed above. The GATT dispute between Mexico and the United States over tuna fish offers a good illustration of the distinction. In October, 1990, the United States prohibited imports of yellowfin tuna and yellowfin tuna products from Mexico (and Venezuela) on the grounds that these fish were caught by purse seine fishing (nets with floats at the top and weights at the bottom that encircle fish) without adequate regard for certain standards. The contention is that these fishing methods kill dolphins in unacceptable numbers.

The trade restrictions applied here would seem to fall into the category of measures designed to influence the willingness of a country to comply with certain production or process standards, where the standards have not been jointly defined through an international agreement. In other words, this appeared to be a case of the imposition by one country of the arguments of its social welfare function upon another. The GATT ruling on the matter was that the U.S. tuna embargo represented a GATT-inconsistent application of extraterritorial trade policy. If, on the other hand, there had been an international agreement to which the countries concerned were party, trade policy action may well have constituted an efficient enforcement mechanism, although it is not entirely clear what a GATT ruling would have been in this case.

**Trade Policy for Efficient Agreements**

The final case referred to above of interaction between trade policy and environmental policy is that where trade policy action is an intrinsic part of the effectiveness of an agreement, or in other words where trade measures are functionally necessary. A clear-cut case of such an agreement is the Basel Convention on hazardous wastes, which imposes strict controls on trade. Other examples include agreements entered into by the United States and a number of other countries regarding the recovery and return of stolen archaeological, historical and cultural properties. These kinds of agreements do not raise efficiency issues. On the other hand, it was noted earlier that the feature of the Basel Convention requiring discriminatory trade action, and the comparable provisions in the Montreal Protocol, do raise the question whether trade policy is being used efficiently or as a means of persuasion.

There are several examples of the use of trade actions to give force to environmental objectives that have been discussed in terms of their efficiency. One of these concerns the use of export restrictions on tropical woods justified on environmental grounds. It is not difficult to show that an export restriction is not an efficient measure, since it only affects export sales and not offtake or the domestic production of tropical wood products. Another interesting case is the trade embargo on ivory, supported by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). It has been persuasively argued that a ban on ivory trade has created economic rents that have contributed to the further decimation of African elephant herds rather than to their preservation. The argument is that appropriate resource management and property right assignments would be more effective in preserving the scarce resource than the much blunter trade policy instrument. These kinds of considerations are circumstance and resource specific, but they do demonstrate why a seemingly rational and well-intentioned application of trade policy may turn out to be suboptimal.
To sum up, of the five categories of interaction between trade policy and environmental policy, there is only one instance where trade policy might be the best intervention. This is the case just discussed, where an international agreement can only be given effect through trade policy. In all other cases, trade measures are either inappropriate, second best, or a reflection of an underlying policy failure. Table 3-2 summarizes these propositions. What they mean from an environmental perspective is that many arguments for trade measures justified on ecological grounds will have uncertain and possibly negative effects on environmental quality or finite resource management.

**Summary and Conclusions**

Policy responses to environmental concerns can have important implications for the trading system. Considerable scope exists for disrupting international trade in gratuitous ways that serve neither the environment nor cooperation among nations. The apparent community of interest between environmental groups and labor/industry lobbies is largely illusory. This grouping coalesces around an emphasis on trade restrictions and controls which admirably serves protectionist interests, but presses for policies whose consequences from an ecological perspective may be random, or in many cases can actually reduce the chances of achieving improvements in environmental quality.

A constructive approach to the environment entails recognition that environmental quality does not have infinite value, and the nature of the trade-offs that are made is crucial to the attainment of environmental objectives. At the international level, cooperation promises far greater returns than confrontation, even where larger countries can seemingly choose to impose their objectives upon smaller ones.

Effective international cooperation needs to build on a number of basic points. First, underlying the idea that there is an environmental externality that needs to be internalized is the implicit notion that the nature of the externality can be specified and agreed upon. Policymakers have to determine what the environmental target is. This in itself is a negotiation, since it must take place in a world of varying social preferences. Secondly, there is the question of how to go about internalizing the externality. Choices must be made between instruments and approaches. Third, there is the related question of who will pay for pollution abatement and control, or for resource management programs.

Formal analysis shows that efficiency considerations are independent of the distribution of environmental expenditures. Game theory shows how the absence of cooperation leads to a suboptimal outcome of the prisoners' dilemma variety. Taken together, these two points may well argue for cooperative arrangements involving side payments. The extent to which side payments are called for will depend on a number of factors, including the degree of difference in the utility functions of the implicated parties and relative capacities to pay for pollution abatement and control. Countries should not expect effective and stable environmental abatement and control policies to result from unilateral approaches under which the objectives and priorities of one country are imposed upon another.

Similarly, harmonization as a policy objective needs to be treated with caution. It was noted that arguments for the harmonization of the costs of abatement and control between countries are protectionist and have no basis in sound environmental policy. The harmonization of policies is also problematic, because a uniform approach cannot arbitrate differences in social preferences, environmental assimilative capacities and cost and benefit structures. The difficulties are likely to be accentuated by differences in the economic circumstances facing countries. There are, however, arguments in favor of harmonization in terms of the reduction of transactions costs, so a trade-off is called for. If the trade-off involves the establishment of international agreements among a reduced number of countries, adequate provision must be made against discrimination and for the gradual participation of nonsignatories to international agreements. In this
<table>
<thead>
<tr>
<th>Reason for Imposing Trade Restrictions</th>
<th>Costs/Benefits of Using Trade Restrictions</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. To redress competitive effects of differences in environmental standards or costs of pollution abatement and control between countries</td>
<td>- This is a protectionist use of environmental arguments with uncertain environmental effects (could lead to further environmental degradation) - Involves standard welfare costs of trade restrictions</td>
<td>- No trade policy justification</td>
</tr>
<tr>
<td>2. To induce behavioral changes or punish countries for pursuing environmental policies different from those identified as appropriate by the restricting country (production externalities)</td>
<td>- Unilateral attempt by one country to impose its social welfare function upon another, with uncertain environmental effects (could lead to further environmental degradation) - Involves standard welfare costs of trade restrictions</td>
<td>- Policy failure - If international coordination is justifiable, cooperation around agreed objectives superior to unilateral action</td>
</tr>
<tr>
<td>3. To enforce domestic standards applied in the restricting country (consumption externalities)</td>
<td>- Enforcement mechanism that may be necessary to defend domestic product standards - Involves standard welfare costs of trade restrictions</td>
<td>- Policy failure in the sense that countries do not agree on the application of domestic product standards</td>
</tr>
<tr>
<td>4. To enforce international agreements in the face of violations</td>
<td>- Enforcement mechanism that may be necessary to address violations of internationally accepted commitments - Involves standard welfare costs of trade restrictions</td>
<td>- Policy failure arising from an unstable international agreement; likely to reflect lack of adequate definition or a perceived imbalance in rights and obligations under the agreement</td>
</tr>
<tr>
<td>5. To give effect to international agreements</td>
<td>- Measures necessary under the terms of an agreement (e.g., trade in hazardous waste, rare species or cultural artefacts) - Trade restrictions may not be the most effective way of giving effect to environmental objectives (e.g., preservation of tropical woods or elephant herds)</td>
<td>- Trade measures may be justified, but may not always be the most efficient instrument</td>
</tr>
</tbody>
</table>
connection, the free-riding problem can be exaggerated as a justification for discriminatory actions or for imposing conformity upon third parties.

As to the most appropriate kinds of intervention, the existence of a formal efficiency hierarchy of preferred policies does not seem to have influenced policy decisions to any significant degree, considering the overwhelming and easily observable revealed preference for direct regulation over market-based interventions. While this might have something to do with the assumptions that underlie the efficiency arguments, vested interests also play an important part. Industries tend to prefer regulation to market-based interventions, and governments might be expected to as well, both in terms of the attractiveness of the control function and because regulation is likely to sit better with environmental pressure groups. There should be no presumption that the inefficiencies of chosen domestic options need to be carried over into international agreements. Rather, the efficiency costs of domestic arrangements should be borne in mind in the design of such agreements.

Trade policy interventions have a limited role in addressing environmental problems. Five cases were analyzed in the paper where trade policy might be applied. The analysis could not be fully formalized because the distinctions used depend to a degree on the identification of underlying motives for action, and they are not mutually exclusive. The approach does, however, help to shed light on the circumstances in which trade policy interventions are inappropriate for the attainment of environmental objectives.

The use of ecological arguments as a plea for the reduction of competitive differences among countries was characterized as protectionist. The protectionist intent becomes clearer where the case is made in the context of local pollution problems in foreign countries that involve little or no international spillovers. It was argued that trade policy may be misused as a means of trying to force countries to adopt new policies or process standards that are not appropriate in terms of their cost or efficiency. Where trade policy is used as a means of enforcing domestic product standards, or of retaliating within the framework of an international agreement, it is functionally justified but also represents the breakdown of cooperation that carries economic costs and is in this sense a policy failure. Finally, on occasion trade policy interventions may be necessary to an agreement in a pure efficiency sense, for example in the case of transborder trade in hazardous waste.
Appendix

The Gains From International Cooperation in Environmental Policy

Using a game theoretic framework, this appendix shows: i) the welfare gains from efficient cooperation between two countries in the face of environmental externality; ii) the potential (less than fully efficient) gains from leader/follower behavior in the absence of international agreement; and iii) the welfare neutrality of side payments between parties to an international agreement.

Assume two countries (home and foreign) that share in the benefit of an international public good—the control of international pollution. Assume also that an interior solution holds, such that both countries contribute something towards the control of international pollution. The home country contributes \( g \), and foreign country \( g^* \). Asterisks denote foreign country variables. The total supply of the public good is given by:

1. \[ G = g + g^* \]

Citizens of the home (foreign) country consume a domestically produced private good \( x (x^*) \).

Given the world price of the private good, \( p \), and home (foreign) country national income at world prices \( y (y^*) \), home and foreign budgets are given by:

2. \[ px + g = y \]
3. \[ px^* + g^* = y^* \]

Assume quadratic utility functions for the two countries:

4. \[ U = \frac{1}{2} [\alpha x^2 + \beta G^2] \]
5. \[ U^* = \frac{1}{2} [\gamma x^{*2} + \sigma G^2] \]

where all the parameters are assumed to be non-negative.

Utility is maximized subject to budget constraints as follows:

6. \[ \max_x \quad U = \frac{1}{2} \left\{ \alpha \left( \frac{y - G}{p} \right)^2 + \beta (g + g^*)^2 \right\} \]
Each country obtains the Nash noncooperative equilibrium by maximizing its own welfare and taking as given the level of expenditure on international pollution by the other country. Thus the Nash reaction functions for the two countries are:

8. \[ g = \frac{\alpha}{\alpha + \beta p^2} y - \frac{\beta p^2}{\alpha + \beta p^2} g^* \]

9. \[ g^* = \frac{\gamma}{\gamma + \sigma p^2} y^* - \frac{\sigma p^2}{\gamma + \sigma p^2} g \]

Equations (8) and (9) may be expressed as functions of home and foreign incomes:

10. \[ g = \frac{1}{\gamma (\alpha + \beta p^2) + \alpha \sigma p^2} \{ \alpha (\gamma + \sigma p^2) y - \gamma \beta p^2 y^* \} \]

11. \[ g^* = \frac{1}{\gamma (\alpha + \beta p^2) + \alpha \sigma p^2} \{ \gamma (\alpha + \beta p^2) y^* - \alpha \sigma p^2 y \} \]

Equations (10) and (11) show that each country's expenditures on the control of international pollution are positively related to its own income, and negatively related to that of the other country. Intuitively, this result arises from the expectation, in a one-shot game, that higher incomes will be associated with higher expenditures on pollution control.

Case of Identical Countries with Identical Tastes

Assume now for simplicity that both countries are of the same size and have identical tastes. This implies \( \alpha = \gamma, \beta = \sigma \) and \( y = y^* \).

The Nash Noncooperative Equilibrium

The Nash noncooperative equilibrium is shown at \( N \) in Figure (a) below. The solution is obtained by setting \( g = g^* \) in either equation (8) or (9) \(^{23}\):
The Efficient Equilibrium and Cooperation

In order to obtain an efficient outcome, the two countries must cooperate in the internalization of their externalities. The efficient level of international pollution control is determined by maximizing welfare subject to $g = g^*$, or
14. 
\[ g^E = g^{*E} = \frac{\alpha}{\alpha + \beta p^2} y \]

and the corresponding utilities are equal to:

15. 
\[ U^E = U^{*E} = \frac{\alpha \beta \left(4\alpha + \beta p^2\right)}{2 \left(\alpha + \beta p^2\right)^2} y^2 \]

It is immediately evident that at the Nash noncooperative equilibrium the control of international pollution is undersupplied, i.e., \( g^N < g^E \) and \( U^N < U^E \). Each country tries to free-ride on the benefits of the public good supplied by the other country.

The efficient equilibrium \( E \) can only be attained in this one-shot game if countries pre-commit to the policies \( g^E \) and \( g^{*E} \) in a binding agreement, because these levels (i.e., the efficient levels) of control of international pollution are not on their reaction functions. If the home country believes that the foreign country will play \( g^{*E} \), it will be tempted to cheat and play \( g^C \) to obtain \( U^C \). \( g^C \) is obtained by inserting \( g^{*E} \) into the home country reaction function (equation (8)); thus:

16. 
\[ g^C = \left[ \frac{\alpha}{\alpha + \beta p^2} \right]^2 y \]

It can be readily seen that

17. 
\[ g^C < g^N < g^E \]

The home country's level of expenditure on the international control of pollution is lower at \( C \) than at \( N \) or \( E \), and its welfare is higher. The foreign country knows that the home country will be so tempted and will not play \( g^{*E} \) in the absence of a binding agreement.

The Stackelberg Equilibrium and Commitments

One equilibrium involving a commitment that has frequently been studied is the Stackelberg leadership equilibrium. In this equilibrium, one country would commit to deliver a particular level of expenditure on the control of environmental pollution. This country is called the Stackelberg leader. The other country optimizes given the leader's level of expenditure. This country is called the Stackelberg follower. The leader chooses a level of expenditure, taking into account how the follower will react to that choice.
If the home country is a Stackelberg leader, welfare will be maximized welfare subject to the reaction function of the foreign country. Assume that home country is the Stackelberg leader. The Stackelberg levels of expenditure on international pollution control are given by:

18. \[ \frac{\partial v}{\partial g} + \left[ \frac{\partial v}{\partial g^*} \right] \{ \frac{dg^*}{dg} \} = 0 \]

where the third term in brackets in the first equation (18) is the slope of the foreign reaction function with respect to the g axis.

The solutions to the first order conditions are given by:

19. \[ g^s = \frac{1}{\alpha (\gamma + \alpha p^2)^2 + \gamma \beta p^2} \{ \alpha (\gamma + \alpha p^2)^2 y - \gamma^2 \beta p^2 y^* \} \]

20. \[ g^{*s} = \frac{\gamma (y^* - \alpha p^2)}{\gamma + \alpha p^2} g^s \]

and

21. \[ g^s = g^s + g^{*s} = \frac{\alpha (\alpha + \alpha p^2)}{(\alpha + \alpha p^2)^2 + \alpha \beta p^2} \{ y + y^* \} \]

Assume for simplicity that \( \alpha = \gamma \) (i.e. that both countries place equal weights on the consumption of the private good). In this case, subtracting equation (10) from equation (19) yields:

22. \[ g^s - g^n = -\frac{\alpha \beta p^4 (\alpha + \alpha p^2) (y + y^*)}{[(\alpha + \alpha p^2)^2 + \alpha \beta p^2][(\alpha + \alpha p^2) + \beta p^2]} > 0 \]

Equation (21) shows that the Stackelberg leadership solution depends on the combined income of both countries (we will have more to say about this point in the next section). Moreover, when the leader spends
more on the control of international pollution, the follower ends up spending less, as can be seen from
equation (20) \( g^s > g^m \). The net result can be seen by comparing \( G^s \) which is given by equation (21) and
\( G^N \) which is given by the sum of equations (10) and (11),

\[
G^N = g^N + g^{*N} = \frac{\alpha}{(\alpha + \sigma p^2) + \beta p^2} \left[ y + y^* \right]
\]

and

\[
G^s - G^N = \frac{\alpha \beta p^4}{((\alpha + \sigma p^2)^2 + \alpha \beta p^2)(\alpha + \sigma p^2 + \beta p^2)} \left[ y + y^* \right] > 0
\]

In this equilibrium, where one country assumes leadership and the other follows, total expenditure
on the control of international pollution is higher than that associated with the Nash solution.

**On the Issue of Transfers Between Countries**

Suppose now that transfers between countries are possible. We continue to assume an interior
solution. Add equations (2) and (3) together:

\[
Y = y + y^* = p (x + x^*) + (g^N + g^{*N})
\]

or

\[
G^N = Y - p (x + x^*)
\]

and express the consumption of the private good as a function of the Nash levels of expenditure on
international control of pollution:

\[
x = \frac{2}{\alpha} g^N
\]

and
Equations (26), (27) and (28) contain the result. The quantity of public and private goods consumed within each country (which by definition is equal to the total amount available) depends only on aggregate income, not on each country’s income. Hence, a transfer of income from one country to another does not change total consumption. A transfer results in the donor offering less towards public good supply and the recipient offering more; these two effects exactly cancel each other.

An interior solution assumption was crucial to this result. If a country were sufficiently poor, it might contribute nothing towards public good provision. Then a change in the distribution of income across countries could induce a country formerly not contributing to begin to do so.
Discussant's Comments

David Robertson

This paper provides an excellent tour d'horizon with which to begin this symposium. It contains a comprehensive survey of controversies that are developing between environmental policies and trade policies, and indicates some dangers inherent in advocating that trade policy instruments should be used in the pursuit of environmental objectives.

Most demands for such actions show a serious lack of understanding of trade policy and the General Agreement on Tariffs and Trade (GATT), the relevant international institution. Attempts to draw trade policy into the debates over environmental policies suggest that environmental lobbies see trade as an easy target, because governments find more directly relevant policy alternatives, such as taxes and subsidies and other measures consistent with OECD's polluter-pays principles, more difficult to accept because of their unpopularity.

Trade policy is an economic instrument; a "means" to increase economic growth (efficiency gains from exploiting comparative advantage) and to achieve income redistribution (among domestic producers and consumers); in only very restricted conditions can trade policy measures improve a country's terms of trade at the expense of other countries. Environmental objectives (pollution abatement, natural resource conservation, etc.) are very clearly "ends." These involve trade-offs against growth and other economic objectives, something that environmental groups do not mention when they explain the benefits of environmental improvements.

The real question, therefore, is whether trade policy instruments are "efficient" in achieving environmental objectives, or whether there are more efficient alternatives. Since economists agree that trade policy instruments are second-best instruments in dealing with economic distortions, it seems doubtful that trade policy instruments are efficient as environmental instruments. Internalizing externalities and incorporating environmental costs fully into market prices is evidently the best approach to reducing environmental degradation, as the OECD established in 1973.

Why then are environmental groups giving so much attention to trade policy and the GATT? Probably because they do not understand trade policy or the GATT, and because the popular view is that trade policy only affects foreigners. Trade policy is often confused with national defense and strategic issues. Even the language of trade economists encourages this view:

- "tariff dismantling" is easily associated with "disarmament";
- references to raising tariff walls and to trade fortresses promotes the idea of "defenses";
- tariff reductions are referred to as "concessions" in GATT negotiations, even though the main benefits accrue to the tariff-cutting country.

---


[26] The optimum tariff case; see Johnson (1953-54).

Introduction

During 1991, the issue of trade and environment came to the forefront, not only in the international conservation community, but in international trade circles as well. In Geneva, the General Agreement on Tariffs and Trade (GATT) reconvened its Working Group on Trade and the Environment. In Paris, the Organisation for Economic Cooperation and Development (OECD) began to develop a set of principles for the integration of trade and environmental concerns. The United Nations decided that the issue of trade and environment would be a prominent one at the UN Conference on Environment and Development (UNCED) to be held in Rio de Janeiro in June 1992. For the United States, Canada and Mexico, it became apparent the environment would be a critical element in securing domestic support for a North American Free Trade Agreement (NAFTA).

Unfortunately, despite heightened interest in trade and the environment, most of the attention was dedicated to proving one of two things. The international trade community expended a lot of effort in seeking to demonstrate that environmental concerns are not related to trade, or that they merely serve as a convenient cover for economic protectionism. Some in the environmental community sought to portray the current trend toward more liberalized trade as designed specifically to undermine protection of the environment. Environmentalists in general did not hesitate to describe the negative environmental impacts of free trade.

Largely ignored was the need to integrate trade and environmental concerns in the service of a higher goal: the promotion of sustainable development. Though often unwieldy, and certainly ill-defined, the concept of sustainable development offers an intellectual framework for understanding the need for, and the benefits obtained from, uniting trade and environmental concerns.

This is the central message of this paper. As such, the paper does not pretend to serve as an economic or legal argument, but is more philosophical in tone and, hopefully, can help guide ensuing empirical and legal studies.

Trade and Environment: Philosophical Underpinnings

During the 20 years since the first Earth Day, in 1970, the world lost nearly 200 million hectares of tree cover, an area roughly the size of the United States east of the Mississippi River. Deserts expanded by some 120 million hectares, claiming more land than is currently planted to crops in China. Thousands of plant and animal species with which we shared the planet in 1970 no longer exist. Over two decades, some 1.6 billion people were added to the world's population -- more than inhabited the planet in 1900. And the world's farmers lost...
an estimated 480 billion tons of topsoil, roughly equivalent to the amount on India's cropland.\textsuperscript{1}

The painful litany of problems cited above has lead to a great deal of soul-searching in the environmental community. This soul-searching has centered largely around the question of why there has been relatively little success in resolving these problems, despite the significant increase in environmental awareness over the past two decades.

While numerous explanations have been offered, one is particularly compelling. It originates in what has been, at least historically, an isolationist approach to environmental issues by the environmental community. This can be exemplified in the philosophy that natural resources can be protected simply by locking them up and insulating them from the predatory practices of humankind. Today, global environmental trends such as global climate change and the necessity for meeting basic human needs, particularly in the developing countries, have made this philosophy obsolete and have led to a more holistic and integrated approach to achieving environmental objectives.

This approach is reflected in the concept of sustainable development. To be sure, exact definitions of sustainable development are still hard to come by, but the essence of the concept is that economic and environmental concerns cannot be treated separately. To achieve the objectives of environmental protection, attention must be paid to development needs. Development, at the same time, will not be sustainable if attention is not paid to the environment. To satisfy the objectives of sustainability and development, and to preserve options for future generations (itself a central goal of sustainable development), economic and environmental considerations must be integrated.\textsuperscript{2}

Throughout the 1980s, the concept of sustainable development was refined still further and there evolved a greater understanding that environmental problems derive from particular models of development and patterns of economic activity, and not from discrete actions taken by individuals, corporations, governments or multilateral development agencies. The focus on trade issues in the 1990s can be seen as a natural step in the evolution of critical thinking within the environmental community.\textsuperscript{3}

Trade is an increasingly important factor in national economies and plays a central role in determining the patterns of economic behavior between nations. The expanded definition of trade, which now includes issues such as investment and intellectual property, has helped shape the nature of development within and between nations. World trade, which totals over $3.5 trillion annually, has played a significant role in determining how, and in what manner, the natural resources of our planet are utilized. This is not to say that trade patterns are the sole determinant of resource use, since most of the economic activity taking place on this planet is domestic and not international. Nevertheless, as more nations engage in steadily liberalized world trade, the role of trade in determining resource use will expand.

\textsuperscript{1}Brown, et al. (1991).

\textsuperscript{2}Dixon and Fallon (1989).

\textsuperscript{3}The finest and most expansive works on the relationship of trade and environment to sustainable development are from Zarsky (1991a,b). Another important work on this subject is MacNeill (1991). An intriguing proposal on trade, environment and sustainable development can be found in World Resources Institute (1991).
If understood in the context of sustainable development, environmental concerns and trade activities are not necessarily at odds, and should be dealt with in an integrated fashion. It is clear that trade policy which does not consider environmental impacts can undermine the natural resource base on which continued, or future, development depends. At the same time, it is obvious that environmental policy, framed without regard to development needs, can be equally shortsighted.

Within the context of sustainable development, trade and environmental policy become means by which to achieve a higher goal. The implications of this approach are captured in an excerpt from the OECD’s recent "Joint Report on Trade and Environment" which concludes that:

It is, therefore, important that trade policies are sensitive to environmental concerns and that environmental policies take account of effects on trade...Unlike sustainable development, free trade is not an end in itself...4

One of the most important keys to understanding the environmental perspective on trade issues is to recognize its basis in the concept of sustainable development. Therefore, it is necessary to correct two misconceptions this perspective seems to have generated. First, the environmental perspective on trade should not be construed as antitrade, since trade can be an important instrument by which to achieve development that is economically and environmentally sustainable. Second, this approach is not an attempt to extort from trade practices the means to cure all of the world’s environmental ills. What is critical is the intersection of trade and environmental concerns.

Why Free Trade Is Not a Panacea (and Neither is Protectionism)

The dynamic relationship between economic activity and the health of the environment, and the implications of this relationship for sustainable development, are now widely accepted, as is the recognition that change is needed in the patterns of global economic activity in order to better address environmental concerns.

One of the most active prescriptions for addressing these concerns, however, is a strong dose of free trade. In response to environmental criticism of the NAFTA negotiations, for example, the Bush Administration argued that the agreement, which would further liberalize trade between the United States, Mexico and Canada, was deserving of support because it would increase the financial resources available for environmental protection, particularly in Mexico.5

Unfortunately, while free trade agreements can lead to greater economic growth and a greater pool of funds targeted for environmental protection, there is no guarantee that this will necessarily occur. Further, while acknowledging that environmental protection cannot occur in the absence of some level of economic growth, promoting free trade as a panacea for resolving environmental ills ignores some of the very real costs that it entails. As Patrick Low and Raed Safadi of the World Bank have noted, "This proposition is contentious, as many environmentalists would argue that wear and tear is positively correlated with income, especially in relation to the global commons."6

---


5This argument was advanced in many public fora, but for the record can be found in Los Angeles Times (1991).

An awareness of the wear and tear associated with liberalized trade begins with an understanding of the higher energy costs associated with an increased transportation of tradable goods. Environmental impacts are felt in both the production and the use of energy associated with the transportation of goods (e.g. oil development in ecologically sensitive areas, and increased air emissions from trucks.) Second, the transportation of these goods can, and often does, increase the possibility of environmental accidents, the most obvious example of which is the recent Exxon Valdez oil spill in Alaska. 7

Export-led growth resulting from free trade agreements can also promote a rapid and unsustainable extraction of natural resources. The unsustainable harvesting of tropical timber to gain foreign exchange is but one example of this process. 8

Another potential impact of free trade is the chilling effect that it can have on the ability of federal, state and local governments to establish the highest environmental standards they deem appropriate. Provisions of the United States-Canada free trade agreement have already been used to attack U.S. domestic environmental regulations on asbestos. 9

Finally, it is possible that free trade agreements can undermine international efforts to protect the global commons. Korea, which is a party to the GATT, but is not a signatory to the Montreal Protocols on the production and use of chlorofluorocarbons, is expected to challenge this international environmental agreement as illegal under GATT articles. 10

The limitations of free trade as an instrument for sustainable development are also evident on theoretical grounds. Economists like to argue, for example, that one of the principle benefits of free trade is that it leads to a more efficient allocation of the earth’s resources. Unfortunately, in terms of natural resources, this theory only holds true if externalized environmental costs are internalized. Though some mechanisms are available for doing so (for instance, taxes and tradable pollution permits) they are not utilized in any current trade agreements, neither are they being actively considered in any current trade negotiations.

A related critique of free trade suggests that comparative advantage is not defined solely in terms of efficiency, but also in terms of lower cost factors of production. Countries with lower environmental standards, or more lax enforcement of environmental standards, can avoid the environmental costs associated with unsustainable natural resource use. In so doing, they can gain an advantage over goods that are produced in countries with higher standards, or more strict enforcement of environmental measures. Countries may not actively pursue policies of this nature to gain trade advantage, but investment may nevertheless flow to

7Zarsky, op. cit., describes the environmental costs (and benefits) associated with liberalized trade in greater detail.

8Though several examples of this process are at hand, a particularly well-researched treatment of the subject is contained in Nectoux and Kuroda (1989).


10Speculation regarding Korea, GATT and the Montreal Protocol on chlorofluorocarbons has been raised at several meetings of the U.S. Environmental Protection Agency’s National Advisory Council on Environmental Policy and Technology (NACEPT), International Trade and Environment Working Groups, by a variety of different trade experts, as well as environmentalists.
countries where such advantages exist, assisted in no small measure by the investment liberalization provisions of free trade agreements.¹¹

Having outlined some of the limitations in applying free trade as the antidote for environmental distress, it is imperative to immediately point out that this does not make the case for using protectionism as a means for achieving sustainable development. Indeed, there is an emerging body of literature that suggests that protectionism, or at the very least closed economies, can have an even greater negative impact on the environment.

Protectionism rewards an inefficient use of resources, and its most direct impact is felt in developing countries, i.e., those least able to afford continued obstacles to their own development. While protectionism might be justified for some industries, at certain stages in a nation’s development, the application of protectionism is rarely the most effective policy. Free trade can increase competitiveness and, in so doing, can make a significant contribution to industry employing new, and less polluting, production methods.¹²

Emerging Issues Related to Trade, Environmental Policy and Sustainable Development

Much of the debate on trade and environment has centered on demonstrating the relative merits of free trade or protectionism, or open or closed economies, in dealing with environmental problems. If these problems are discussed in the context of sustainable development, a more optimal use of collective brainpower would be spent in identifying the emerging issues of trade and environment, and raising the questions that need to be resolved in order for world trade to promote sustainable development. This section of the paper is dedicated to that effort.

Standards

One of the most obvious issues involving trade and the environment is how to deal with the differences in environmental standards that exist between nations. On the one hand, there is a concern that exporters in countries with lower environmental standards will have a competitive advantage over exporters in countries with higher standards. Some have proposed creating an environmental code which would treat the lower standards as "subsidies" subject to the imposition of countervailing duties to correct their perceived impact on trade.¹³

On the other hand, many recognize that a scarcity of technical and financial resources may make it difficult, particularly for the developing countries, to both establish and enforce the same level of

¹¹The most challenging theoretical critique of free trade as an engine for promoting sustainable development is found in Daly and Cobb (1989).

¹²A counterattack to environmental criticisms of free trade was launched by the International Trade Division of the World Bank as part of its symposium on "Trade and Environment," held in Washington, D.C., on November 21-22, 1991. The majority of the papers presented at the symposium make forceful arguments that protectionism, or closed economies, are more damaging to the environment than free or liberalized trade. Non-symposium papers, of historical significance, include Pearson (1974) and Pearson (1982).

¹³Information on the concept of an Environmental Code to the GATT is derived from personal communication with members of the staff of U.S. Senator Max Baucus. A fuller treatment of "ecological dumping," and inadmissible subsidies, is contained in Clarke (1991).
environmental standards that exist in the more industrialized countries. If exports from these countries face trade sanctions based on their lower standards, then they will be at a competitive disadvantage vis-a-vis countries with higher environmental standards. In dealing with the issue of differential environmental standards, it will be necessary to discuss technical and financial resources necessary for environmental standards to be raised worldwide.

A discussion of standards should also address three other issues of critical interest to the international trade and environmental communities. The first would be an analysis of proposals to "harmonize" international standards. The environmental community is concerned with the process to be followed in setting these standards, and the use of the standards themselves. We would prefer to see international standards serve as a floor, rather than a ceiling. We would like to have a role in defining the situations where it is even appropriate to set international standards. Finally, we are extremely concerned that state and local governments maintain the right to set the highest environmental standards they deem appropriate for their needs.

A second important issue relates to the use of "sound science" as the basis for evaluating the validity of national or subnational standards. The current argument in trade circles seems to be that standards higher than a harmonized international norm would be allowable if such standards are based on sound science. While this might offer some relief to those concerned about protecting the rights of national and subnational governments, it ignores the relevance of risk assessment to the question of what is or is not a legitimate standard. Science can help determine the probability of impact of a given occurrence, but standards also incorporate a society's determination of tolerable risk.

Finally, the August 1991 ruling on the tuna-dolphin dispute seems to suggest that the GATT will only recognize standards that apply to goods and services in trade, and not the process by which these goods or services are produced. This is a head-in-the-sand attitude that runs counter to the political reality that, worldwide, countries are moving to adopt process standards, with related trade measures, that affect both natural resources as well as manufactured goods. Environmentalists are increasingly concerned about the life cycle of a product, beginning with the extraction of natural resources in the production process, but also including a consideration of the environmental ramifications of transport, marketing, packaging, consumption and disposal. Rather than arguing that process standards and trade do not mix, a better use of time would be spent in the development of principles by which to avoid the use of process standards as protectionist devices.14

Transparency and Public Participation

Transparency is a word with two entirely different applications depending on whether one is primarily concerned with environmental protection or the promotion of free trade. To the international trade community, the term transparency generally applies to the promulgation of environmental policies, laws and regulations. The complaint is often heard that these measures are difficult to understand, and that their development and implementation are not transparent. Greater transparency for the international trade community is usually a battle cry for greater openness in the development and implementation of environmental policies, laws and regulations which can affect trade.

To the environmental community, greater transparency is a battle cry for increased openness and accountability in the formation, negotiation and implementation of trade policies and accords. A closely related need is to increase public participation in these activities. In comparison to the deliberations and operations of other multilateral economic institutions, such as the World Bank and the International Monetary Fund, multilateral trade policy, particularly as it relates to the GATT, is shrouded in an even greater veil of secrecy. Increased transparency and public participation means increased access to trade documents, and increased openness of the decision-making process within institutions like the GATT. As the negotiations surrounding the UN Conference on Environment and Development have demonstrated, this new openness can be accomplished without undermining the negotiating positions of individual governments.15

Dispute Resolution

The issue of how to resolve trade and environmental disputes is closely related to the issue of standards, and has been affected in the extreme by the aforementioned GATT ruling in the tuna-dolphin dispute. Any discussion of how to formulate more effective dispute resolution mechanisms must incorporate the concerns expressed above with regard to transparency and standards, as well as issues that may overlap with a discussion of international environmental treaties and the GATT, and issues of protection of the global commons.

Other concerns related to dispute resolution have to do with the perceived lack of expertise of trade panels in dealing with environmental issues. Some suggestions are to include at least one environmental expert on any panel that is dealing with these disputes, and to allow amicus curiae briefs to be filed by interested parties. Principles should be developed which can help identify disputes that are not appropriate for resolution by trade panels.

Another question relevant to the establishment of more effective dispute resolution mechanisms is where the burden of proof should lie in resolving trade and environmental disputes, and the role of sound science. Current policy seems to place the burden on the governmental entity establishing the policy or standard in question. Further, the extent to which environmental measures are based on sound science seems to be the litmus test by which departures from a common standard will be judged.

Most in the environmental community feel that the burden should be placed on those challenging environmental measures to prove that these measures are not legitimate. Moreover, as discussed earlier, the environmental community is extremely suspicious of what the test of sound science will mean in practice, especially when the role of risk assessment in setting standards is ignored.16

Institutional Reform

One of the first questions raised in discussing trade and environment is the extent to which institutional reform is necessary for addressing this issue. One obvious target for reform is the GATT, and even its own panel ruling on the tuna-dolphin dispute seems to suggest the need for changes to better address trade and environmental concerns. At the same time, the question of the need to integrate other UN-family agencies, such as the United Nations Environment Programme (UNEP) and the United Nations Commission on Trade and Environment (UNCTAD), has been raised. Institutional reform of these agencies, and a

15A cogent analysis of the benefits of increased public participation in the negotiations regarding the North American Free Trade Agreement (NAFTA) can be found in Thorup (1991).

reevaluation of the relationship between them, is necessary to more adequately address trade and environmental concerns. Within individual governments, trade and environmental agencies will have to find ways to work more closely together.\(^{17}\)

**Subsidies**

The treatment of subsidies under free trade agreements raises several issues related to the environment. The elimination of some subsidies, such as those that promote unsustainable agricultural production, can have a positive impact. Moreover, it might make sense to interpret lower environmental standards, and lax enforcement, as an indirect subsidy rewarding unsustainable economic activity. Groups have argued that such subsidies should also be eliminated.

Eliminating subsidies that are designed to be environmentally beneficial, however, can have a negative impact on the environment. The reflexive response on the part of the environmental community is that all such subsidies should be protected. Yet, we know that in certain circumstances these subsidies can have perverse effects, such as reforestation subsidies that encourage timber companies to engage in unsustainable forestry practices. A common definition of "subsidy" is needed, as are principles by which to identify those that should be reformed or eliminated.\(^{18}\)

**International Environmental Agreements/Protection of the Global Commons**

As trade liberalization and increased environmental agreements are pursued, disputes will arise as to whether international trade rules, or international environmental agreements, take precedence. Clearly, the environmental community will argue that international environmental agreements should have precedence, especially given those elements of the recent GATT ruling on the tuna-dolphin dispute that suggest that multilateral environmental agreements are the preferred course of action. Nevertheless, what about situations where countries are GATT signatories, but not signatories to a given international environmental agreement? The environmental community is extremely concerned that the GATT lacks the capacity to effectively resolve these disputes, though there is little consensus on what other UN agencies should be involved.

Closely linked to the consideration of how international environmental treaties relate to international trade rules, is the question of how protection of the global commons relates to trade. In the case of the tuna-dolphin dispute, the United States took action to preserve the global commons by restraining its own domestic fleet. To prevent a free-rider problem, it also restricted imports from other countries not meeting U.S. standards of conduct. This has been criticized by the GATT as a trade-illegal, extraterritorial application of U.S. law. Others characterize it as a "unilateral action" with the implicit message being that the measure should, based on its "unilateral" nature, be considered trade illegal.

If such measures are trade illegal, then how are countries to protect the global commons, keeping in mind the free-rider problem? The need to protect the global commons is undeniable, and in an increasingly economically interdependent world, trade measures will be necessary to achieve this societal goal. Protection of the global commons should not be at issue, rather the focus should be on how trade measures can most appropriately be used to further this goal, and how conflicts between protection of the global commons and

\(^{17}\)GATT (1991c), *op. cit.*, and Arden-Clarke (1991), *op. cit.* The Arden-Clarke paper is, to date, the most detailed blueprint for environmental reform of the GATT. The definitive background source concerning the inner-workings of the GATT is Jackson (1989).

\(^{18}\)An initial cut at categorizing environmental subsidies is contained in GATT (1991a).
international trade agreements can be minimized. Clarification of the relationship between international trade and international environmental agreements should be part of this effort.¹⁹

North-South Issues

Perhaps the most difficult subject within those related to trade and environment is that which is collectively referred to as "North-South Issues." Admittedly, lumping issues together under this theme is seriously flawed, as there are several instances (agricultural policy is a good example) where common positions of countries of the North and South are possible. It is also true that North-South issues cut across all elements of the trade and environment debate, and treating the subject apart from other aspects of the debate has its shortcomings.

Nevertheless, there are some very different perspectives on trade and environment depending on whether one approaches the issue from the point of view of a developed country, or a developing country. (For the record, the differences in perspective between nongovernmental and governmental representatives can also be quite marked.)

Essentially, what is considered under this topic are the special needs of the developing countries in their relationship to the more "developed" North. With respect to trade, these needs will become particularly apparent as pressure is brought to bear on countries to raise their environmental standards. In the developing countries, while the failure of political will in seeking higher standards is an important factor, the lack of financial and technical resources sometimes plays a more prominent role.

In addressing trade and environmental concerns, special attention should be given to the developing countries. This should involve a consideration of how best to facilitate the flow of environmentally beneficial technology to these countries, as well as an exploration of more direct compensation necessary for them to better protect the environment. The most effective approach would be reform of world trade so as to create better economic incentives for developing countries to manage their resources sustainably.²⁰

The Political Economy of Trade, Environment and Sustainable Development

To date, analyses of the political economy of trade and environment have focused almost entirely on the perceived antagonistic nature of these sometimes competing concerns. Free trade advocates in particular, seeking to preserve the core principles of a liberalized world trading system, have sought to reduce environmental concerns to a mere cover for protectionism, irrelevant (or parallel) to the process of negotiating and implementing trade accords. At times, environmentalists have characterized the free trade agenda as a cover for gutting environmental laws and agreements.

To be sure, there is a great deal of validity to the concerns of both environmentalists and free trade advocates. Environmental regulation can be used as a cover for protectionism and, at the same time, free trade can undermine environmental policy measures, and cause natural resource degradation. Nevertheless, a more complete analysis of the political economy of trade and environment would devote greater attention

¹⁹Konrad Von Moltke, a Senior Fellow with the World Wildlife Fund in Washington, D.C., is a member of the EPA-NACEPT International Trade and Environment Committee and, as of December 1991, is completing a paper on the subject of international environmental treaties and international trade. Much of the information in these paragraphs is derived from private communication with him.

²⁰Though there are several critiques of free trade from a developing country perspective, two of the most interesting are Gómez-Lobo (1991) and Gudynas (1991). A Northern perspective on this issue is a paper by Porter (1991).
to the areas where these dual concerns are not at odds, and address the question of why trade and environmental policy are not being integrated in the pursuit of sustainable development. Studies of the political economy of trade and environment should identify the obstacles preventing the integration of these concerns, and examine the reasons why governments and international trade organizations, such as the GATT, seem reluctant to embrace the concept of sustainable development in practice as well as theory.

In the long run, environmental protection will not be successful if it ignores the development needs of the world's population. Conversely, the benefits of a more liberalized trading system cannot be sustained over the long term if environmental and natural resource considerations are not taken into account. To be sure, conflicts between some of the core values of liberalized trade and environmental protection do exist. Nevertheless, an awareness of the mutual benefits of an approach to trade and environmental concerns, based on sustainable development, can help overcome the anxiety that this new type of thinking seems to have generated in both the trade and environmental communities.

One thing is for certain. If, over the next 20 years, we are going to reverse the negative environmental trends that affect our planet and our fellow human beings, we must move toward a path of development that is both economically and environmentally sustainable. As an important part of this effort, we must dedicate ourselves to the identification and creation of elements of a world trading system that reflect a desire to move in this direction.


Discussant’s Comments

Charles Pearson

Mr. Hudson has provided a paper that is deliberately "philosophical" and reflective in tone. He proposes "sustainable development" as an overarching construct and object, within which trade and environmental policies are means, not ends. This seems a sensible and productive approach to reconciling policy differences, even if "sustainable development" is more than a bit vague.

However, the points of conflict between a liberal trade system and sound environmental policy are not, perhaps, as numerous and profound as Mr. Hudson suggests. Both sets of policies aim at improving welfare through efficient allocation of resources, including natural and environmental resources. Both agree on the desirability of internalizing external costs in product price, but they necessarily have different starting points. The rules of a liberal trade system (i.e., GATT) are designed in large measure to keep governments from distorting prices, for example through GATT disciplines on the use of subsidies, and tariff and nontariff barriers. Environmental policies are in large part an effort to correct price and market failures arising from externalities. Both trade and environment policies, however, work toward greater efficiency through improving the price mechanism. Moreover, some of the apparent conflict is simply because governments still fall short of liberal trade. Pervasive agricultural subsidies are a good example, and their removal would serve both liberal trade and environmental objectives.

The analysis of trade and environment certainly has a longer history than Mr. Hudson suggests. The OECD is not, in 1991, just beginning "to evolve a set of principles related to the integration of trade and environmental concerns." This was in fact first done in 1972, with OECD members agreeing to "Guiding Principles Concerning International Economic Aspects of Environmental Policy." The current effort at the OECD builds on a 20-year analytical and policy base.

It is instructive to review the Guiding Principles, to see how well they have held up. The first and best known is a cost allocation principle known as the polluter-pays principle (PPP). In simple terms the PPP requires that environmental control (EC) costs incurred in the private sector be paid for in the private sector, rather than through government subsidy. The PPP serves two purposes. First, it brings market prices closer to full social cost of production, a requirement for efficient allocation of environmental resources. Second, it prevents a trade distortion from arising if one government subsidizes environmentally related production costs. Thus it contributes to sound environmental and trade policy. It could be argued that strict adherence to the PPP might discourage a country from introducing new environmental protection, but, wisely, the PPP allows for exceptions, especially in transition periods. A strong case can be made that extending the PPP, in particular to Eastern Europe and the NICs, is now appropriate, although transitional government assistance and remedial assistance for cleanup of past pollution may still be needed.

The second of the Guiding Principles addresses environmentally related product standards. It was (and is) feared that in the absence of international harmonization, such product standards could be used as covert trade barriers (NTBs); at the same time the OECD recognized that internationally uniform product standards would not respect legitimate differences among countries in assimilative capacity, economic structure, income levels and social preferences, and might lead to least-common-denominator solutions. The pragmatic solution was to urge international harmonization of product standards where no valid reasons for

---

21The term PPP is perhaps unfortunate. The polluter is free to pass on EC costs to the consumer in product price. Also, under the PPP, the polluter is not obligated to pay for residual environmental damages after meeting abatement requirements.
differences exist, and to limit covert NTBs through the application of national treatment and nondiscrimination. Neither the product standards as NTBs issue, nor the least-common-denominator issue, has disappeared, but the relevant principle survives rather well.

The third and last of the Guiding Principles requires governments to avoid using border adjustments (export rebates and import taxes) to offset international differences in environmental control costs. The OECD spelled out the theoretical rationale quite clearly—countries will have legitimate differences in environmental control policies and costs, and border adjustments would nullify a source of comparative advantage and gains from trade. The OECD was undoubtedly aware of the severe administrative costs and the invitation to protectionist actions that a border adjustment scheme would entail. The consensus of empirical studies over the past twenty years suggest that there has been little need for border adjustments to deal with trade problems. It would appear that the case for border adjustments, if there is one, would have to be argued on environmental grounds.

While the Guiding Principles still serve, there is a need to update, clarify and extend them in light of changing conditions. Mr. Hudson correctly draws our attention to recent developments that cast new light on the nexus of trade and environmental policies. Both economic integration, as exemplified by EC-92 and the proposed North American Free Trade Agreement (NAFTA), and trade liberalization through the Uruguay Round, increase the saliency of environmentally related product standards and EC cost differences. At a minimum, the environmental consequences of trade liberalization should be analyzed for planning and management purposes. The broadening of environmental concerns beyond industrial pollution to include natural resource management under the construct of sustainable development helps illuminate the shortcomings of both trade and environmental policy in internalizing environmental protection costs in natural resource-based products. Perhaps most importantly, the increased attention to international externalities and global environmental threats makes quite clear that some new criteria or principle for the appropriate use of trade measures to secure international environmental objectives is badly needed.

---


Economic Development, Environmental Regulation and the International Migration of Toxic Industrial Pollution: 1960-88

Robert E.B. Lucas, David Wheeler and Hemamala Hettige

Introduction

This paper is largely empirical. It examines how the structure of manufacturing production varies, both across countries and through time, in relation to the toxic emissions of the component industries. Evidence is also presented on the connection between these variations and trade policy liberalization.

Industrial emissions may be thought of as output multiplied by the pollution intensity of that output. In turn the pollution intensity of output derives from the mix of industrial products, the processes used to produce each of these goods, and treatment of the resultant waste from these processes. It is important to establish at the outset that the present investigation addresses only the first of these elements in pollution intensity -- the effect of product (or industrial) mix. This scope of analysis is dictated by the nature of the data available, described later. Yet this evidence does offer some interesting insights, for little systematic prior evidence exists in this sphere.¹

Meanwhile the next section discusses, in broad terms, some of the elements likely to affect the pollution intensity of industrial production, before turning to the results.

Sources of Change in Pollution Intensity

Development and Private Comparative Advantage

In the absence of any binding controls on the generation of environmental bads -- including failure of private contractual arrangements to contain damaging effects -- there will be over production and over consumption of environmentally harmful commodities. Free trade in such an unregulated context results in a distribution of production across countries founded on comparative private cost advantages without regard to environmental costs: the capacity or willingness of nations to withstand or accept environmental damage does not enter the trade calculus.

As nations develop, the range of commodities in which they have a private comparative cost advantage in trade obviously shifts. These shifts may arise from accumulating capital available per worker, from improvements in the state of know-how and worker skills, or from enhanced identification or ability to exploit natural resources. Even if there were no environmental regulation in wealthier economies, free trade under these conditions might well lead to disproportionately rapid growth of industrial pollution in developing countries. Rising manufacturing emission intensity with income might simply reflect a shift toward comparative advantage in manufacturing generally, and of more capital intensive (smokestack) industries, which also happen to be pollution intensive, in particular.

Environmental Regulation

The standards required by environmental regulations vary substantially across countries for several reasons:

(a) **World income inequality**: The desire for a cleaner environment is presumably a normal good, in the sense that demands for tighter standards rise with income. The lower income countries would then be less concerned to avoid local environmental damage, as were the advanced nations at an earlier stage in their growth.

(b) **Environmental absorptive capacity**: Being able to locate industries with emissions harmful to humans far from densely populated areas presumably has its attractions. On the other hand, some sparsely populated regions exhibit particularly fragile ecosystems, diminishing their capacity to withstand toxic releases.

(c) **Regulatory capability**: Differences in the ability to enforce regulations may explain part of the observable gaps in legislated norms and in the strictness of enforcement.

Regulating environmental damage and taxing emissions can, in principle, be used to internalize the external costs stemming from various forms of pollution. Such instruments, if effective, must alter the costs of production and hence comparative cost advantage in trade. If the externalities inherent in environmental damage are appropriately contained then trade will take place according to the social comparative advantage of nations, an advantage defined by a balance of environmental and other costs. But since both private costs and environmental costs differ from country to country one would not expect to see an even spatial distribution of toxic emissions in an optimally regulated world. Indeed, rising incomes may well first give rise to worse emission levels, as cost advantage shifts toward pollution intensive industries. This trend may then be overtaken at higher income levels by electoral demands for a cleaner environment and perhaps enhanced capacity for enforcement.

Economic Policy Regime

Industrial development has traditionally been viewed as damaging to the environment. Since environmentalists have joined most economists in associating liberal economic regimes with more rapid industrial growth, they have tended to look askance at openness. However, this view neglects the possibility that more open economies follow a less pollution-intensive industrial development path. If openness decreases pollution intensity, then its negative environmental impact via aggregate growth is certainly mitigated and may even be reversed.

The labor cost advantage of developing economies, if allowed free rein in the market, will enhance the prospects of many light assembly activities whose environmental impact is modest. Protection, on the other hand, is often focused on relatively capital- and pollution-intensive sectors such as chemicals and steel.

**Summing Up: Towards Testable Hypotheses**

The previous discussion has identified three forces which may have significantly affected the worldwide incidence of industrial pollution: development-related changes in private comparative advantage; environmental regulation in the wealthier economies; and differences in economic policy regimes. From this we distill three lines of analysis to be pursued.
(i) Development and sectoral composition: The patterns of pollution intensity of manufacturing production in relation to level of economic development, as measured by income per capita, are explored. In particular, it is frequently asserted that pollution exhibits an inverse U-shaped relationship with per capita income: in other words, pollution is believed to first rise faster than output at low levels of income then to rise more slowly than output after some critical income threshold.  

(ii) OECD environmental regulation and displacement: Since it is difficult to proxy for the strictures and implementation of OECD environmental regulations, direct tests of any resultant production relocation are difficult to undertake. Nonetheless, at least broad differences in trends across differing time periods may be examined to ascertain whether production relocation of dirtier industries has been more rapid during episodes of enhanced OECD environmental regulation.

(iii) LDC economic policy and pollution intensity: Has actual import protection among the developing countries promoted or discouraged production of the dirtier industrial products? This is examined here by posing the question: Have periods of trade liberalization led to more or less rapid growth in the pollution-intensive industries among the LDCs?

Data: Sources and Issues

Data Sources

Three primary data sources are drawn upon to derive a measure of pollution intensity of manufacturing output in some 80 countries from 1960 to 1988 for the purposes of this study.  

The first data source is a sample of 15,000 plants, drawn from the U.S. Environmental Protection Agency's (EPA's) Toxic Release Inventory (TRI) for 1987. First mandated by amendments to U.S. Superfund legislation in 1986, the TRI records air, water, underground and solid waste releases of 320 toxic substances by each reporting plant.

As the second data source, the U.S. Census Bureau provided the output data, drawn from the 1987 Census of Manufactures, for each of the 15,000 EPA sample plants. After matching plant-level observations and translating from U.S. five digit SIC identifiers to the ISIC codes, the aggregate toxic releases per unit of output are calculated for each of 37 ISIC industry categories.

In fact, three toxic intensity measures per unit of output are considered in this analysis. The first is total pounds of all 320 toxic releases -- whether atmospheric, effluent or solid -- per dollar's worth of output. In Table 5-1, this measure is labeled Total Release Intensity. However, such a measure neglects the fact that some emissions are obviously of greater concern than others. However, the EPA's Human Health and Ecotoxicity Database (HHED) contains several measures of toxicological and carcinogenic potency of specific emissions. Based upon these the EPA reports an ordinal measure of human toxicity risk associated with each chemical emitted, ranging from category 1 (mild) through 4 (very serious). The second measure of toxic

\[2\] Although there are many assertions that such a pattern prevails there is little systematic evidence either to support or refute this presumption. See, however, Grossman and Krueger (1991) who indeed find such an inverse-U pattern in a cross-country study of urban air pollution.

\[3\] For full technical details, see Martin, Wheeler, Hettige and Stengren (1991).
Table 5-1: Toxic Release Intensities by Manufacturing Industries

<table>
<thead>
<tr>
<th>Industry</th>
<th>ISIC Code</th>
<th>Total lbs. per Million 1987 US Dollars</th>
<th>Total lbs. per Weighted ISIC Million 1987 US Dollars</th>
<th>Risk Factor Weighted Linear</th>
<th>Risk Factor Weighted Exponential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Products</td>
<td>3110</td>
<td>781.6</td>
<td>1418.0</td>
<td>20776.7</td>
<td>4647.5</td>
</tr>
<tr>
<td>Beverages</td>
<td>3130</td>
<td>205.1</td>
<td>387.1</td>
<td>5308.9</td>
<td>51086.7</td>
</tr>
<tr>
<td>Tobacco</td>
<td>3140</td>
<td>489.0</td>
<td>977.9</td>
<td>154381.3</td>
<td>17515.8</td>
</tr>
<tr>
<td>Other Textile Production</td>
<td>3210</td>
<td>3502.2</td>
<td>6289.7</td>
<td>10056.8</td>
<td>61291.0</td>
</tr>
<tr>
<td>Spinning, Weaving</td>
<td>3211</td>
<td>3106.7</td>
<td>7400.0</td>
<td>16897.6</td>
<td>98109.5</td>
</tr>
<tr>
<td>Wearing Apparel</td>
<td>3220</td>
<td>1744.8</td>
<td>3341.8</td>
<td>116899.8</td>
<td>109252.0</td>
</tr>
<tr>
<td>Leather &amp; Products</td>
<td>3230</td>
<td>15380.7</td>
<td>25762.0</td>
<td>268922.3</td>
<td>966600.0</td>
</tr>
<tr>
<td>Footwear</td>
<td>3240</td>
<td>2277.7</td>
<td>3324.0</td>
<td>11695.0</td>
<td>10056.8</td>
</tr>
<tr>
<td>Wood Products</td>
<td>3310</td>
<td>4399.4</td>
<td>9247.0</td>
<td>137294.6</td>
<td>544602.8</td>
</tr>
<tr>
<td>Furniture, Fixtures</td>
<td>3320</td>
<td>5366.8</td>
<td>10056.8</td>
<td>58049.0</td>
<td>42819.7</td>
</tr>
<tr>
<td>Other Paper Prods.</td>
<td>3410</td>
<td>8741.7</td>
<td>16897.6</td>
<td>61291.0</td>
<td>42819.7</td>
</tr>
<tr>
<td>Pulp, Paper</td>
<td>3411</td>
<td>6225.9</td>
<td>11720.6</td>
<td>116899.8</td>
<td>109252.0</td>
</tr>
<tr>
<td>Printing, Publishing</td>
<td>3420</td>
<td>7513.9</td>
<td>14931.6</td>
<td>966600.0</td>
<td>966600.0</td>
</tr>
<tr>
<td>Other Industrial Chem.</td>
<td>3510</td>
<td>52260.3</td>
<td>105302.7</td>
<td>29444.3</td>
<td>29444.3</td>
</tr>
<tr>
<td>Basic Ind. Chem.</td>
<td>3511</td>
<td>32254.6</td>
<td>54922.9</td>
<td>609770.9</td>
<td>609770.9</td>
</tr>
<tr>
<td>Synthetic Resins</td>
<td>3513</td>
<td>14002.9</td>
<td>26436.7</td>
<td>544602.8</td>
<td>544602.8</td>
</tr>
<tr>
<td>Other Chemical Prods.</td>
<td>3520</td>
<td>3563.8</td>
<td>6582.8</td>
<td>58049.0</td>
<td>58049.0</td>
</tr>
<tr>
<td>Drugs and Medicines</td>
<td>3522</td>
<td>3966.7</td>
<td>7416.5</td>
<td>42819.7</td>
<td>42819.7</td>
</tr>
<tr>
<td>Petroleum Refineries</td>
<td>3530</td>
<td>3757.9</td>
<td>7669.5</td>
<td>78634.6</td>
<td>78634.6</td>
</tr>
<tr>
<td>Petroleum &amp; Coal Prods.</td>
<td>3540</td>
<td>2544.1</td>
<td>4777.4</td>
<td>29444.3</td>
<td>29444.3</td>
</tr>
<tr>
<td>Rubber Products</td>
<td>3550</td>
<td>2934.2</td>
<td>5385.5</td>
<td>26305.2</td>
<td>26305.2</td>
</tr>
<tr>
<td>Plastic Products n.e.c.</td>
<td>3560</td>
<td>9335.0</td>
<td>17510.5</td>
<td>175559.9</td>
<td>175559.9</td>
</tr>
<tr>
<td>Pottery, China, etc.</td>
<td>3610</td>
<td>3614.5</td>
<td>5479.4</td>
<td>29164.7</td>
<td>29164.7</td>
</tr>
<tr>
<td>Glass &amp; Products</td>
<td>3620</td>
<td>1481.2</td>
<td>2893.2</td>
<td>43583.8</td>
<td>43583.8</td>
</tr>
<tr>
<td>Non-Metal Prods. n.e.c.</td>
<td>3690</td>
<td>3853.8</td>
<td>5920.2</td>
<td>44194.1</td>
<td>44194.1</td>
</tr>
<tr>
<td>Iron and Steel</td>
<td>3710</td>
<td>7642.8</td>
<td>12931.9</td>
<td>349897.7</td>
<td>349897.7</td>
</tr>
<tr>
<td>Non-Ferrous Metals</td>
<td>3720</td>
<td>9334.3</td>
<td>13234.7</td>
<td>151219.2</td>
<td>151219.2</td>
</tr>
<tr>
<td>Metal Products</td>
<td>3810</td>
<td>4592.5</td>
<td>9103.6</td>
<td>166930.2</td>
<td>166930.2</td>
</tr>
<tr>
<td>Other Machinery n.e.c.</td>
<td>3820</td>
<td>1596.2</td>
<td>2840.5</td>
<td>39165.8</td>
<td>39165.8</td>
</tr>
<tr>
<td>Office &amp; Computing Mach.</td>
<td>3825</td>
<td>303.3</td>
<td>452.4</td>
<td>3163.4</td>
<td>3163.4</td>
</tr>
<tr>
<td>Other Electrical Mach.</td>
<td>3830</td>
<td>1797.3</td>
<td>3195.2</td>
<td>38967.4</td>
<td>38967.4</td>
</tr>
<tr>
<td>Radio, Television, etc.</td>
<td>3832</td>
<td>1808.3</td>
<td>3137.4</td>
<td>29207.4</td>
<td>29207.4</td>
</tr>
<tr>
<td>Transport Equipment</td>
<td>3840</td>
<td>1007.8</td>
<td>2085.8</td>
<td>28055.7</td>
<td>28055.7</td>
</tr>
<tr>
<td>Shipbuilding, Repair</td>
<td>3841</td>
<td>2546.5</td>
<td>3743.2</td>
<td>17426.9</td>
<td>17426.9</td>
</tr>
<tr>
<td>Motor Vehicles</td>
<td>3843</td>
<td>666.9</td>
<td>1188.4</td>
<td>15733.1</td>
<td>15733.1</td>
</tr>
<tr>
<td>Professional goods</td>
<td>3850</td>
<td>887.6</td>
<td>1576.5</td>
<td>16127.0</td>
<td>16127.0</td>
</tr>
<tr>
<td>Other Industries</td>
<td>3900</td>
<td>2706.8</td>
<td>4679.0</td>
<td>42682.7</td>
<td>42682.7</td>
</tr>
</tbody>
</table>
intensity is then a linear weighted sum of toxic releases per dollar's worth of output, using these risk factors 1 through 4 as weights. The implicit assumption inherent in this second measure is that the HHED risk scale is inherently linear, with one pound of emission with risk factor 4 as damaging as four pounds of releases with risk factor 1. This may not be a reasonable approximation. In consequence a third measure of toxic intensity is derived, assuming that the HHED risk weights are exponential (1, 10, 100, 1000) instead of linear. In Table 5-1, the latter two measures are labeled Linear and Exponential Intensities.

One feature of the three intensity measures in Table 5-1 is particularly significant for our analysis: their simple (unweighted) correlation is very high across the 37 ISIC categories. (See Table 5-2). Little is thus lost by focusing on one index, and we have chosen to work with the total (unweighted) toxic intensity.

Table 5-2: Correlation Coefficients: Industry Toxic Intensity

<table>
<thead>
<tr>
<th></th>
<th>Linear Weights</th>
<th>Exponential Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>0.995</td>
<td>0.944</td>
</tr>
<tr>
<td>Linear Weights</td>
<td>0.941</td>
<td></td>
</tr>
</tbody>
</table>

The third data source are the UN annual sectoral output data for each reporting country during the period 1960-1988.\(^4\) To create annual toxic intensity estimates for each sample country, the Total Toxicity Intensity measures from Table 5-1 are applied to ISIC sector shares. These national intensity estimates form the basis for the analysis of the sources and probable environmental consequences of changing sectoral composition in the next section of this paper.

**The Assumption of Constant Sectoral Intensities**

As noted in the introduction, this paper does not attempt a comprehensive analysis of changes in international industrial pollution. Constant, U.S.-based, output intensities are adopted because there is no choice -- international data on within-sector process mix and abatement choices have not yet been collected. Nevertheless, the following estimates will have first-order validity if there is rough stability in the relative pollution intensity of sectors across countries and over time.

Such an assumption of fixed toxic intensity embodies at least three elements:

To apply observed U.S. emission intensities to other countries assumes similar technologies and enforcement standards across countries. For instance, to the extent that lower income countries have more pollution-intensive techniques for given industries than does the United States (whether because

\(^4\) A part of these data are published in the United Nations Industrial Statistics Yearbook.
of the state of know-how, from differing regulations, of from greater difficulty in enforcement) the measures generated here would understate toxic outputs from the lower income nations. On the other hand, if emissions per unit of output are roughly similar no matter where the product is produced the measures here will provide a reasonable approximation.

Closely related to the first point is an issue arising from the level of disaggregation available in the industrial data. To apply the U.S. intensities to other countries requires an assumption either that the pollution intensity of various products within an industry group are not too dissimilar or that the mix of products within each industry is essentially the same across countries.

Third, there is an assumption that emissions are related to output by an industry rather than, for instance, to value added. It is not obvious that this is an unreasonable assumption, though limitations on international data on value added prevent exploring sensitivity with respect to this assumption.

In fact most existing empirical work assumes rough constancy in relative cross-sectoral pollution intensity, invariably identifying the same sets of "heavy polluters" (e.g. metals, cement, pulp and paper, chemicals) and "light polluters" (e.g. most light assembly, food products, instruments). This has been largely based on two sources: (a) case-oriented engineering estimates of intensities in the few air and water pollutants which have been conventionally regulated in the OECD economies since 1975; and (b) reported annual total output- or investment-based intensities of expenditure on pollution abatement and control. In an appendix to this paper some partial evidence is reviewed on the plausibility of rough constancy in sectoral intensities. This evidence suggests that this assumption may not be too misleading, at least as a first approximation, and so the following analysis retains the assumption of fixed toxicity intensity common to almost all prior work.

Toxic Intensity of Industrial Production

Economic Development, Time Trends and Trade Policies

In this section some proximate determinants of variations in industrial toxic intensity are explored. The results are presented in two parts, first looking at the pattern with respect to income per capita and through time, then turning to the role of trade policy.

Levels of Development and Time Trends

The visual evidence in Figures 1.A and 1.B brings out two important points:

(i) Across countries, an inverse U relationship does indeed hold between GDP per capita and the total estimated toxic releases from manufacturing relative to GDP. This is shown in Figure 1.A (and is confirmed in unreported regression analysis). This does not, of course, necessarily imply that every country must follow a pattern of rising toxic intensity of production at first, as development proceeds, followed by declining intensity at more advanced stages of development: the time path for individual countries need not follow the cross-country pattern. It should also be emphasized that this pattern does not necessarily imply a decline in aggregate toxic releases at higher levels of GDP, only that toxic releases per unit of production fall among higher income countries.

The measure on the vertical axis in Figure 1.A is pounds of toxic emissions per 1987 US$1000 of GDP in each country.
(ii) However, Figure 1.B exhibits no such tendency for intensity of manufacturing toxicity per unit of manufacturing output to decline among the high income countries. In other words, the declining portion in the inverse U relationship just noted is a result of the declining fraction of GDP accounted for by industrial output and not a result of any shift toward a less toxic mix of industries within manufacturing.
A more detailed regression analysis is also conducted for pooled cross-section time-series data, based on the following equation:

$$\ln N_t = a_0 + (b_1 + b_2 Y_t) t + (b_3 + b_4 Y_t) Y_t$$

where $N_t$ = Toxic Intensity (country i, period t)

$Y_t$ = Real income per capita (US 1987$)

$t$ = Time

This specification allows for possible variations of trend intensity growth ($b_1$), both with income ($b_2$) and over different periods: 1960-73; 1974-79; and 1980-88. The latter permits one test of the possibility that stricter OECD environmental regulation in the mid-late 1970's had a significant overall impact on the sectoral composition of international manufacturing. The responsiveness of toxic intensity with respect to income ($b_3$) is also permitted, in this specification, to vary with income itself ($b_4$).

Table 5-3 reports fixed-effects estimates of this equation for the period 1960-1988, with one dummy variable included per country. When intensity is defined as industrial emissions divided by GDP, the rise in intensity with respect to rising income at least tapers off at higher income levels. On the other hand, when intensity
Table 5-3: Pooled Annual Data Across Countries: Fixed Effects Regressions

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Toxic Emissions Relative to</th>
<th>Manufacturing Output</th>
<th>GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logarithm (Toxic Emissions/Manufacturing Output or GDP)</td>
<td>(1) (2) (3) (4) (5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time trend</td>
<td>9.206 9.901 27.396</td>
<td>(12.15) (12.21) (17.94)</td>
<td></td>
</tr>
<tr>
<td>Trend: 1960-73</td>
<td>4.598 17.895</td>
<td>(3.04) (6.03)</td>
<td></td>
</tr>
<tr>
<td>1974-79</td>
<td>4.629 17.982</td>
<td>(3.07) (6.08)</td>
<td></td>
</tr>
<tr>
<td>1980-88</td>
<td>4.637 17.973</td>
<td>(3.09) (6.10)</td>
<td></td>
</tr>
<tr>
<td>Income per capita</td>
<td>0.886 0.666 0.870 2.483 2.310</td>
<td>(4.06) (2.82) (3.99) (5.76) (5.38)</td>
<td></td>
</tr>
<tr>
<td>Income squared</td>
<td>0.001 -0.001 -0.001</td>
<td>(2.39) (2.66) (2.50)</td>
<td></td>
</tr>
<tr>
<td>Income* Trend</td>
<td>-0.450 -0.350 -0.442 -1.260 -1.173</td>
<td>(4.11) (2.98) (4.03) (5.89) (5.51)</td>
<td></td>
</tr>
<tr>
<td>No. country dummies</td>
<td>80 80 80 73 73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. observations</td>
<td>1517 1517 1517 1395 1395</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R squared</td>
<td>0.79 0.79 0.80 0.93 0.93</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: T-statistics in parentheses.
is defined as pollutants per unit of manufacturing output this is definitely not the case (indeed, the relationship in equation (2) goes the other way).

To summarize, these results imply:

- that there is no transition to lower toxic intensity in manufacturing at high incomes. The toxic intensity of GDP declines only because the manufacturing share in GDP declines beyond a certain level of income.
- that growth in toxic intensity has been far more rapid in the developing countries.

**Trade Liberalization and Toxic Intensity of Manufacturing**

In order to explore the consequences of alternative trade regimes upon local toxic intensity of manufacturing production, a price level distortion index, recently developed by David Dollar (1990) for the period 1973-1985, is adopted. For present purposes, Dollar's sample of 95 developing countries is divided into seven rank groups: rank 1 LDCs exhibit the least distortion from international price norms; rank 7 are the most highly distorted. The OECD economies are not included in Dollar's sample. Two approaches are therefore adopted to the OECD countries: (a) assigning a Dollar rank of 0 to these cases; (b) omitting the OECD countries from the sample.

The average annual rate of growth in total toxic intensity relative to manufacturing output within each country is regressed upon Dollar's index of trade openness. More precisely, the country growth rates in toxic intensity are regressed upon the growth rate in per capita income within the country over the relevant time interval, the logarithm of the initial per capita income at the beginning of each interval, and the Dollar index interacted with the growth in per capita income. The estimated equations also incorporated a measure of the share of export earnings derived from fuel exports (in an attempt to capture any impact of related toxic-intensive sectors) but in the balance this has no apparent effect.

One interpretation of any differences between the three decades is as follows: the 1960s provide a pre-environmentalist control, while the 1970s and 1980s may provide evidence about short- and long-run adjustments in the wake of stricter OECD regulation. The estimated results are presented for the three decades in Table 5-4.

---

6 Briefly, Dollar's index uses the Summers and Heston price index for a constant basket of commodities across countries. Under free trade, such a basket of tradable goods ought to have the same price everywhere. Departures from unity may then be interpreted as a consequence of some form of trade barrier. In practice some nontradables enter the basket of commodities. Dollar attempts to control for this latter difficulty by regressing the raw index on measures of factor endowments (presumed to affect relative prices of nontradables across countries). The residual from these regressions is then adopted to form the purged index.

7 The annual growth rates are first estimated by fitting a regression of intensity upon time within each of three time intervals: 1960-69; 1970-79; 1980-88. The trend growth rate is estimated this way only for countries with at least five observations available within each time period, so the sample size varies slightly from decade to decade.
Table 5-4: Impact of Income Growth, Level of Development Openness to Trade and Fuel Status on the Growth Rate of Toxic Intensity (by decade)

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Including OECD Countries</th>
<th>Excluding OECD Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60s</td>
<td>70s</td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.071</td>
<td>0.053</td>
</tr>
<tr>
<td></td>
<td>(0.78)</td>
<td>(2.39)</td>
</tr>
<tr>
<td>Growth in per capita income</td>
<td>0.096</td>
<td>-0.596</td>
</tr>
<tr>
<td></td>
<td>(0.19)</td>
<td>(1.63)</td>
</tr>
<tr>
<td>Ln (initial per capita income)</td>
<td>0.008</td>
<td>-0.005</td>
</tr>
<tr>
<td></td>
<td>(0.60)</td>
<td>(1.80)</td>
</tr>
<tr>
<td>Fuel share in exports</td>
<td>-0.046</td>
<td>-0.021</td>
</tr>
<tr>
<td></td>
<td>(0.32)</td>
<td>(0.834)</td>
</tr>
<tr>
<td>Dollar’s index interacted with income growth</td>
<td>-</td>
<td>0.223</td>
</tr>
<tr>
<td></td>
<td>(1.92)</td>
<td>(0.10)</td>
</tr>
<tr>
<td>No. observations</td>
<td>25</td>
<td>56</td>
</tr>
<tr>
<td>R squared</td>
<td>0.03</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Note: T-statistics in parentheses
For the 1960s, when almost no environmental regulations had yet been imposed by the various countries, our regression has no explanatory power: from these data we are unable to detect any significant general trend in toxic intensity change; no impact for either initial income or income growth during the 1960s.

In the 1970s and 80s, however, the situation changes sharply. The implications of the results for these two decades are perhaps most readily seen from the tableau marked as Table 5-5. This tableau has three dimensions:

Three income levels are represented:
- Low ($150)
- Middle ($1,800)
- High ($22,000)

Two annual growth rates are shown:
- Slow (1%)
- Fast (6%)

And two level's of Dollar's index are depicted:
- Open (1)
- Closed (6)

The fundamental importance of policy emerges strikingly in these results. Fast-growing closed economies had very rapid change toward toxic-intensive structures in both the 1970s and 1980s, with acceleration in the latter decade for both low- and middle-income developing countries. In contrast, fast-growing open economies had essentially toxic-neutral structural change in the 1970s and a strong shift toward less-toxic structure in the 1980s. The same trends are evident in slower-growing economies, but less pronounced.

This evidence leads us to a strong qualification of our earlier conclusions:

While developing countries as a whole had greater toxic intensity growth in the 1970s and 1980s, trends for individual countries depended heavily on the growth rate of income and the policy regime. The story of "toxic displacement" seems to have been focused in relatively closed, fast-growing economies.

Summary and Conclusions

Several previous studies have asked whether environmental controls imposed in the industrialized economies are diverting investments in pollution-intensive activities offshore. In broad terms these studies reach a negative conclusion: direct investment does not appear to be stimulated by such regulations, in part because the cost of emission controls is generally a tiny fraction of operating costs. Yet direct investment reflects only a portion of what may be happening to world production patterns; technology transfers may occur with no simultaneous direct investment and production may readily shift toward a different global distribution without either direct investment or technology transfer.

Dean (1991) offers a very useful survey of this material.
Table 5-5: Percent Change in Total Toxic Intensity Relative to Manufacturing Output

<table>
<thead>
<tr>
<th>Country</th>
<th>Policy Regime</th>
<th>Per Capita Income Growth</th>
<th>70s</th>
<th>80s</th>
<th>70s</th>
<th>80s</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LOW INCOME COUNTRIES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Open</td>
<td>2.4</td>
<td>-1.2</td>
<td>3.5</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Closed</td>
<td>0.6</td>
<td>-6.7</td>
<td>7.2</td>
<td>10.9</td>
<td></td>
</tr>
<tr>
<td><strong>MIDDLE INCOME COUNTRIES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Open</td>
<td>1.2</td>
<td>0.4</td>
<td>2.3</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Closed</td>
<td>-0.1</td>
<td>-5.2</td>
<td>6.0</td>
<td>12.4</td>
<td></td>
</tr>
<tr>
<td><strong>HIGH INCOME COUNTRIES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Slow</td>
<td>-0.1</td>
<td>1.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fast</td>
<td>-1.9</td>
<td>-3.7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In this paper, a very general test of the displacement hypothesis has been attempted. Time series estimates of manufacturing pollution intensity for a large sample of developed and developing countries during the period 1960-1988 have been developed. The results derived from these data may be summarized in terms of the three lines of analysis set out earlier in this paper.

**Development and sectoral composition**

(a) As a result of industrial composition shifts, total manufacturing emissions relative to GDP grow faster than GDP at lower levels of income per capita, then grow less quickly at higher levels of income. In other words an inverse U-shape is confirmed between industrial pollution intensity and income.

(b) The decline which is observed in total industrial emissions relative to GDP at higher income levels is a result of the declining share of manufacturing in GDP rather than a result of any shift toward a cleaner mix of manufacturing activities. The pooled cross-country time series estimates reveal no tendency for toxic intensity of manufacturing itself to exhibit an inverse U-shape. On the other hand, the data do indicate that the more rapidly-growing high income countries have actually enjoyed a negative growth in toxic intensity of their manufacturing mix. To what extent the latter result is a reflection of more rapid introduction of cleaner technologies in more rapidly-growing economies cannot be discerned, but it is certainly a potential explanation.

**OECD environmental regulation and displacement**

It is frequently asserted that stricter regulation of pollution-intensive production in the OECD countries has led to significant locational displacement, with consequent acceleration of industrial pollution intensity in developing countries. All our results are consistent with this hypothesis. Both sets of estimates suggest that the poorest economies have the highest toxic-intensity growth. The estimated toxic-intensity elasticity of income growth for a typical (midrange-distortion) LDC economy was apparently negligible in the 1960s, positive in the 1970s, and even higher in the 1980s. Of course, one cannot be certain of a causal connection between these decade patterns and the roughly concurrent shifts in OECD environmental policies. Yet the results are nonetheless suggestive of a potential contributory effect.

**LDC economic policy and pollution intensity**

Pollution intensity has grown most rapidly in developing economies which are relatively closed to world market forces. Relatively closed, fast-growing economies experienced very rapid structural transitions toward greater toxic-intensity. The opposite seems to have been true, however, for more open economies.

More work on this issue clearly needs to be done, but the results in this paper suggest that net toxic displacement toward the LDCs may not have been inevitable during the past two decades. Restrictive trade policies imposed by the developing countries themselves may even have been the main stimulus to toxic industrial migration, rather than regulatory cost differences between the North and South.

It is hoped that these results will prove suggestive for future directions for analysis: much remains to be done. For instance, although the present results suggest that more liberal trade policies among the developing countries have focused manufacturing production on a cleaner mix of industries, we still lack evidence on the effects of freer trade policies upon the choice of production technique, upon waste disposal, on toxicity of consumption activities and environmental harm from changes in agriculture. Moreover, this paper has focused upon the global distribution of toxic emissions rather than upon changes in the global aggregate. It is too early to draw any sweeping conclusions about the connections between protectionist trade policies and environmental effects, but it is hoped that this paper has shown that at least this debate can be enjoined founded upon empirical evidence.
This appendix presents four types of evidence relating to the constancy of toxic intensity emissions for given industries.

1. Constancy Across Measures of Pollution Intensity

The analysis in the text uses the U.S. Environmental Protection Agency's Toxic Release Inventory (TRI) data. Since these data are not available before 1987 (and then only for the United States), no international or intertemporal series is available for cross checking. Useful indirect evidence can be obtained, however, by checking the intersectoral correlation between the TRI data and the U.S. data on Pollution Abatement and Control Expenditures (PACE). Figure A.1 shows the rank of 19 2-digit industries according to: (a) the percentage of new plant and equipment expenditures absorbed by pollution abatement and control; (b) the linear weighted toxic pollution intensity of the industry. In this graph there is a clear outlier -- SIC 27 (printing and publishing) -- which exhibits high emissions according to the TRI data but very low pollution abatement expenditures. If this exception is excluded, then pollution intensity (whether total, linear or exponentially weighted) is quite highly correlated with pollution abatement expenditures. (See Table A.1).

<table>
<thead>
<tr>
<th>Toxic Intensity</th>
<th>Excluded</th>
<th>Included</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unweighted</td>
<td>0.72</td>
<td>0.55</td>
</tr>
<tr>
<td>Linear Human</td>
<td>0.76</td>
<td>0.55</td>
</tr>
<tr>
<td>Exponential Human</td>
<td>0.74</td>
<td>0.64</td>
</tr>
</tbody>
</table>
Figure A.1

**PACE Expenditure Intensity Rank (1986)**

vs. **Linear Weighted Toxic Pollution Intensity Rank (1987)**

(19 2-Digit SIC Sectors)

---

**PACE Rank**

19 +
18 +
17 +
16 +
15 +
14 +
13 +
12 +
11 +
10 +
 9 +
 8 +
 7 +
 6 +
 5 +
 4 +
 3 +
 2 +
 1 +

<table>
<thead>
<tr>
<th>(SIC 27)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

**Toxic Intensity Rank**
2. Constancy Across Countries in the OECD

Figure A.2 plots the rank of 13 industries in West Germany during the mid-1970s and the United States for 1975, according to pollution abatement expenditures relative to new investments in plant and equipment. The raw data underlying this graph are presented in Table A.2. There is a clear positive association in sectoral ranking across the two countries, and in fact the rank correlation is 0.8. Comparable data for other countries (and especially for the LDCs) are not available. However, this two-country comparison suggests that industries needing substantial abatement controls in one country also require expensive controls in another, despite differences in emphasis on the various pollutants and media of release in the two countries.

Table A.2

Percent of New Plant and Equipment Expenditures on Pollution Control, mid-1970s

<table>
<thead>
<tr>
<th>Industry</th>
<th>United States</th>
<th>West Germany*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonferrous metals</td>
<td>24.1</td>
<td>8.4</td>
</tr>
<tr>
<td>Paper</td>
<td>16.8</td>
<td>9.6</td>
</tr>
<tr>
<td>Stone, clay, glass</td>
<td>14.3</td>
<td>--</td>
</tr>
<tr>
<td>Iron, Steel</td>
<td>13.5</td>
<td>10.7</td>
</tr>
<tr>
<td>Petroleum</td>
<td>11.8</td>
<td>19.9</td>
</tr>
<tr>
<td>Chemicals</td>
<td>10.9</td>
<td>11.1</td>
</tr>
<tr>
<td>Electric power</td>
<td>9.7</td>
<td>--</td>
</tr>
<tr>
<td>Electrical machinery</td>
<td>5.8</td>
<td>1.9</td>
</tr>
<tr>
<td>Lumber, furniture, instruments, misc.</td>
<td>5.3</td>
<td>2.4</td>
</tr>
<tr>
<td>Food, beverages</td>
<td>5.2</td>
<td>3.2</td>
</tr>
<tr>
<td>Textiles</td>
<td>4.6</td>
<td>1.5</td>
</tr>
<tr>
<td>Rubber</td>
<td>4.0</td>
<td>1.9</td>
</tr>
<tr>
<td>Motor vehicles</td>
<td>3.9</td>
<td>2.0</td>
</tr>
<tr>
<td>Apparel, leather, tobacco, printing/publishing</td>
<td>2.8</td>
<td>1.5</td>
</tr>
<tr>
<td>Machinery, except electrical</td>
<td>1.8</td>
<td>1.3</td>
</tr>
<tr>
<td>Fabricated metals</td>
<td>--</td>
<td>0.5</td>
</tr>
</tbody>
</table>

*West German data are averages for the period 1971-77
Figure A.2

Sectoral Pollution Abatement Expenditure Intensity Rankings
West Germany vs. United States

West Germany Sectoral Rank

14 +
13 +
12 +
11 +
10 +
9 +
8 +
7 +
6 +
5 +
4 +
3 +
2 +
1 +

U.S. Sectoral Rank

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
3. Constancy Over Time in the United States

In the United States, sectoral Pollution Abatement Control Expenditure data have been collected since the 1970s. Table A.3 presents correlations for PACE expenditure intensities (PACE divided by total shipment value) in 1974, 1980, and 1986. The correlations are very high and show no sign of decreasing over time. We conclude that, in the United States at least, sectoral "heavy polluters" have retained their identity since 1970.

Table A.3
Correlations:
Sectoral PACE Expenditure Intensities
(19 2-Digit SIC Sectors)

<table>
<thead>
<tr>
<th></th>
<th>1974</th>
<th>1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>0.94</td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>0.94</td>
<td>0.94</td>
</tr>
</tbody>
</table>

4. Process and Abatement Considerations

Economists generally assume that sectoral technology mix will be different in developing countries, and that pollution abatement equipment will not be installed in the absence of formal regulation. Empirical work on the technology question from an environmental perspective has only recently begun, and survey evidence on abatement choices is practically nonexistent. A few recent studies, however, raise some doubts about the conventional wisdom.

A twenty-five year analysis of international diffusion for wood pulping technology by Wheeler and Martin (1991) finds that developing countries with open trade policies exhibit no lag in adoption of the newest and cleanest technology. Huq and Wheeler (1991, forthcoming) report survey results for a small sample of pulp and fertilizer plants in Bangladesh. The combination of public ownership and aid dependency in this extremely poor economy has led to technology adoption which is largely dictated by prevailing norms in donor countries. Although formal regulation is almost entirely lacking, many large, polluting Bangladeshi enterprises have already instituted monetary compensation and first-level effluent treatment in response to strong pressure from neighboring communities.

There is at present no strongly persuasive evidence about the environmentally relevant direction of departures from typical OECD technology mix in developing countries. Wheeler and Huq (1991, forthcoming) find rapid adoption of the newest, least polluting (electric arc) steel technology in many developing countries. This, coupled with newcomer avoidance of the highly-polluting open hearth process, which remained important in many OECD countries during the 1970s, implies average pollution intensities which may be quite close to typical OECD intensities, even allowing for significant differences in abatement. Thus Wheeler and Martin (1992, forthcoming) find that slower average adoption of new clean pulping technology by developing countries is almost exactly counterbalanced by slower average decline in the oldest technology (mechanical pulping), which is also quite clean.

---

9 Our thanks to Hamid Alavi for generously making these data available to us.
5. Summing Up

This evidence, although admittedly sparse, nonetheless suggests that an assumption of constant relative toxic intensities within industries, both across countries and through time, may not be too egregious: the adopted measures of toxic intensity is highly correlated with PACE expenditure intensity; for the United States and West Germany aggregate sectoral PACE expenditure intensities are highly correlated; within the United States, PACE expenditure intensities have very high intertemporal correlations; and case study evidence suggests a number of reasons why LDC technologies are not necessarily more pollutant intensive as often presumed.
Discussant's Comments

Ramon Lopez

This paper makes a significant contribution to our understanding of the relationships between economic growth and air pollution. A major finding of the paper that comes across in practically all regressions is the following: Although toxic intensity may increase or decrease with income depending on the country sample used, the period considered and the way in which the dependent variable is defined, the absolute level of pollution emission invariably increases with income. If manufacturing toxic intensity is defined relative to manufacturing output, not only absolute emissions but even the relative intensity increases with income and if intensity is measured relative to GDP, intensity declines at high income levels but absolute emissions continue to increase. In the regressions that consider policy variables this pattern remains. Even for the most open countries, which appear to exhibit the lowest pollution to income elasticity, this elasticity is still positive.

This important finding is not highlighted at all in the paper. Yet it has potentially very significant implications. Given the data used, the regression analysis captures the effects of changes in the composition of manufacturing output at a four-digit level of disaggregation on toxic emissions. Therefore, what the regression shows is that simple changes in the composition of output that economic growth induces are not sufficient to revert the tendencies toward increasing toxic emissions. The only way of achieving this is via technological change that permanently decreases the pollution intensity of individual industries.

Another finding is that the effect of economic growth on pollution changes is significantly smaller in open economies than in closed economies. That is, the elasticity of pollution change with respect to economic growth is substantially smaller in open than in closed economies. This is quite surprising because one could expect that a policy change may cause a once-and-for-all effect in pollution intensity rather than a dynamic effect that would alter the pollution income relationship as the results seem to suggest. It is feasible that these static effects are distributed through a period of time and then in periods when countries increase their openness, the data would appear to reflect a permanent relation between growth changes and pollution changes, but after a few years such seemingly dynamic effect would disappear. This is probably the case in the sample used. This is consistent with the fact that the seemingly "dynamic" effect of openness is more than twice as large in the eighties as in the seventies. In the eighties there were many more trade liberalization episodes in LDCs (and deeper ones) than in the seventies, and hence, one would expect exactly this pattern. In any case the extent to which policies can have a dynamic impact in the pollution/income relationship has important policy implications and deserves a closer theoretical and empirical consideration. The effectiveness of policies (including policies to internalize the effects of the externalities) would be substantially enhanced if such dynamic effects are present.

Finally, a point about the relevance of the output composition effect on pollution generation from a global point of view. The paper considers how income changes and policies can affect toxic emission exclusively via changes in output composition. From the point of view of global pollution this is not very important, however, to the extent that a change in output composition by one country in one direction is likely to be matched by changes in the opposite direction by other(s).

Consider for example a world comprised of two countries and two industries. Assume that initially there is no trade and that each country produces both goods. Suppose the countries decide to open their economies to trade and as a consequence of trade, country one increases production of the least pollution-intensive industry and reduces production of the more pollution-intensive industry. Trade opening for country one is, therefore, good for the environment; pollution intensity declines as a consequence of more open policy.
For country two, however, the opening to trade caused an increase in pollution. For the two countries together ("the world"), total pollution did not change (assuming equal consumer preferences) at all!

Thus, to focus exclusively on output composition effects does not bring us very far in the analysis of the effect of openness on pollution. Using a world sample, one should get the result that the effect of trade policies is pollution decreasing for some and pollution increasing for others and on average would be pollution neutral. The only reason why one would obtain an effect on balance is if the country sample is biased towards one or other type of country. The key issue, therefore, is not the effect of trade policy on the composition of output but on the pollution intensity of the individual industries. Only if trade policies have an effect on the technology of production of individual industries can one expect an effect that does not cancel out across countries.
Do "Dirty" Industries Migrate?

Patrick Low and Alexander Yeats*

Introduction

As the public policy debate in many countries has focused more closely on the issue of environmental quality, concerns have been expressed about how differences in national environmental control measures might influence industry location decisions and patterns of international trade. In view of a long-term tendency for industrial countries to adopt increasingly stringent environmental control measures that impose costs of compliance on polluting industries, the question is to what degree more stringent standards will induce investors to shift the location of their production to countries with lower standards. For environmentalists, dirty industry migration puts global environmental quality at greater risk than it would be if factors of production were unable to relocate in response to variations in environmental standards. For labor interests, dirty industry migration might be considered the product of an unfair situation in which conscientious governments make workers in their jurisdictions pay for the neglect of other governments.

The views of most economists on the virtues, or otherwise, of dirty industry migration would be rather different. Two propositions underlying an economic analysis are, first, that pollution assimilative capacities are likely to be different among countries and second, so too are social preferences regarding environmental quality. Any attempt, therefore, uncritically to impose identical environmental objectives and policies on different countries is unjustifiable in economic terms. There may well be increasing convergence in environmental objectives over time, as incomes, tastes and pollution assimilation capacities become more similar internationally, but this is no argument for enforced uniformity. From this perspective, dirty industry migration may well be an efficient and appropriate response to different economic, physical and social conditions among countries.

Very little work has been done to determine how far international shifts in industrial location have been prompted by differential environmental standards. Leonard (1988), however, examined the issue in some detail and concluded that variations in environmental standards have not had significant effects on investment decisions, even where countries have tried to attract dirty industries. A less direct indicator of how far differential pollution abatement and control costs assumed by the same industries in different countries might induce migration is provided by an examination of the level of costs actually incurred. Studies of the implication of pollution abatement and control expenditures on U.S. industry have been undertaken by Kalt (1985), Tobey (1990), Low (1991) and Grossman and Krueger (1991). These studies use differing methodologies and focus on slightly different questions, but the weight of the evidence suggests that environmental expenditures have remained at modest levels.

*Economists, International Trade Division, World Bank.

1For an economic analysis of these issues, see Siebert (1981).

2For an excellent survey of these issues, and the way they have been addressed in different studies, see Dean (1991).
In light of the growing debate on this issue, and the paucity of empirical research, the present paper seeks to determine if a locational pull of dirty industries toward developing countries exists and, if so, to assess its magnitude. Our analytical approach focuses on secular changes that occurred in developed and developing countries' actual trade and revealed comparative advantage in heavily polluting industries, and also evaluates the locational influence of these industries' production characteristics. The latter aspect is intended to determine if the dirty industries have special characteristics like high labor intensity or natural resource requirements that also work toward (or against) their migration to developing countries.

The Methodological Approach

The analytical approach employed in this paper utilizes actual trade flows and a modification of Balassa's (1965)(1979) revealed comparative advantage (RCA) model. Stated simply, a country's revealed comparative advantage in a specific industry has been measured by the share of that industry in the country's total exports relative to the industry's share in total world exports of manufactures.\(^3\) If this ratio (index) is less than unity this is generally interpreted to mean that the country is at a comparative disadvantage in the trade of the product. However, if the RCA index exceeds unity (which occurs when the industry's share in the country's exports exceeds its share in world trade) this is taken to indicate that the country has revealed comparative advantage in the sector.\(^4\)

While previous RCA studies have generally examined the pattern of a specific country's revealed comparative advantage in different industries, the present investigation utilizes a model developed by Yeats (1985) for analyzing the pattern of different countries' RCAs within a specific industry. Since this analysis covers a period of two decades it shows how the composition of countries with a revealed comparative advantage is

\[^3\] Specifically, if \(x_{ij}\) is the value of country i’s exports of j and \(X_{it}\) is the country's total exports of manufactures its revealed comparative advantage is,

\[
\text{RCA}_{ij} = \frac{x_{ij}/X_{it}}{(x_{ij}/X_{tw})}
\]

where the \(w\) subscripts refer to world trade totals. See UNCTAD (1983) or UNIDO (1982) for examples of policy studies that employed this approach. A somewhat different measure of revealed comparative advantage was developed by Donges and Riedel (1977).

\[^4\] Several basic assumptions of the model may be at odds with existing institutional realities. For example, the RCA model requires that trade barriers do not discriminate among alternative suppliers of the same product. However, "voluntary" export restraints, preferential versus most-favored-nation tariffs on the same item, or provisions of the Multifibre Arrangement (MFA) clearly have such discriminatory effects. Furthermore, the model is generally not applied to agricultural trade due to the major distortions associated with national export incentives (like direct subsidies) and high levels of tariff and NTB protection given specific products.
advantage in dirty industries was changing. The present study computed RCA indices for some 109 countries and provides an almost complete profile of changing national comparative advantage profiles within polluting industries.

Environmentally dirty industries were identified as those incurring the highest level of pollution abatement and control expenditures in the United States. Forty three-digit SITC industries were selected.

Perspectives on Trade in Environmentally Dirty Industries

Given the focus of this paper, there are two key questions concerning trade in environmentally dirty goods. The first relates to the share of such goods in international trade and trends in that share over time. The second, deals with the geographic and economic characteristics of countries in which this trade originates. Table 6-1 address the first by examining the relative importance of dirty goods in global trade. The table shows, for selected years over 1965 to 1988, total imports of major trading countries as well as imports of environmentally dirty products. The latter is further disaggregated into five major subgroups, namely; iron and steel; nonferrous metals; refined petroleum; metal manufactures; and paper and paper manufactures. To

Expressed algebraically this modification of the revealed comparative advantage concept is,

\[ \text{RCA}_{ji} = \frac{x_{ji}}{X_{ji}} / \left( \frac{x_{ji}}{X_{iw}} \right) \]

where RCA\(_{ji}\) gives country i's revealed comparative advantage within industry j. In the present exercise we computed RCA indices using average three year export data (i.e., 1966-68 and 1986-88) in order to reduce the influence of any irregular variation associated with a single year's statistics. For brevity we may refer to these results as 1967 or 1987 data. All trade data were compiled directly from individual countries' United Nations Series D trade tapes. The world totals were compiled from all individual country statistics that were available as of May 1991. We estimate that the available data accounted for more than 90 percent of world trade in both the 1966-68 and 1986-88 periods.

For a fuller discussion of this approach see Low (1991). The data used are reported in Bureau of Census publications: Manufacturers' Pollution Abatement Capital Expenditures and Operating Costs (1988) and Annual Survey of Manufacturers (1988). Forty three-digit SITC industries were selected on the basis of this information. They include all three-digit products in SITC 67 (ferrous metals), SITC 68 (nonferrous metals) and SITC 69 (metal manufactures). Also included were: pulp and paper products (251); organic chemicals (512); inorganic chemicals (513, 514); radioactive materials (519), mineral tars and petroleum chemicals (521), manufactured fertilizers (561), paper and board (641); paper articles (642); plywood and improved wood (631); wood manufactures (632); refined petroleum (332); agricultural chemicals (599); and cement (661). These industries incurred pollution abatement and control expenditures of approximately 1 percent or more of the value of their total sales (1988 data). The highest expenditure/output ratio in 1988 was just over 3 percent (cement) and the weighted average for all U.S. industry was 0.54 percent.

The trade statistics have been drawn from United Nations Series D trade tapes and are based on SITC Revision 1 records. The United Nations records cover all of the OECD countries as well as the major developing countries (see the notes to Table 1). Two important exclusions are the Peoples Republic of China and the former socialist countries of Eastern Europe. As such, Table 1 does not include intra-trade between these countries. Also missing are records on some of the least developed countries -- many of which are in Africa. However, when the figures in Table 6-1 are compared with estimates in UNCTAD Handbook of Trade and Development Statistics, (various years) it appears that the United Nations Series D records cover about 90 percent of world trade.
Table 6-1: The Relative Importance of Environmentally Dirty Products in World Trade: Selected Years 1965 to 1988

<table>
<thead>
<tr>
<th>Year</th>
<th>Reported global trade of all goods¹</th>
<th>All Items</th>
<th>Iron and steel (67)</th>
<th>Nonferrous Metals (68)</th>
<th>Refined Petroleum (332)</th>
<th>Metal Manufactures (69)</th>
<th>Paper and Articles (641)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(value of trade expressed in US$ billions)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1965</td>
<td>127.7</td>
<td>32.7</td>
<td>8.5</td>
<td>6.6</td>
<td>4.9</td>
<td>3.4</td>
<td>2.9</td>
</tr>
<tr>
<td>1975</td>
<td>801.4</td>
<td>138.6</td>
<td>39.3</td>
<td>17.8</td>
<td>27.6</td>
<td>16.2</td>
<td>10.1</td>
</tr>
<tr>
<td>1985</td>
<td>1,738.0</td>
<td>287.7</td>
<td>54.5</td>
<td>35.8</td>
<td>84.6</td>
<td>32.3</td>
<td>23.1</td>
</tr>
<tr>
<td>1986</td>
<td>1,910.2</td>
<td>292.2</td>
<td>59.6</td>
<td>39.7</td>
<td>60.1</td>
<td>38.0</td>
<td>28.0</td>
</tr>
<tr>
<td>1987</td>
<td>2,219.4</td>
<td>337.6</td>
<td>65.0</td>
<td>46.8</td>
<td>66.3</td>
<td>44.6</td>
<td>34.6</td>
</tr>
<tr>
<td>1988</td>
<td>2,444.5</td>
<td>384.2</td>
<td>81.5</td>
<td>63.2</td>
<td>59.6</td>
<td>49.3</td>
<td>40.5</td>
</tr>
</tbody>
</table>

(share in world trade - percent)

<table>
<thead>
<tr>
<th>Year</th>
<th>Reported global trade of all goods¹</th>
<th>All Items</th>
<th>Iron and steel (67)</th>
<th>Nonferrous Metals (68)</th>
<th>Refined Petroleum (332)</th>
<th>Metal Manufactures (69)</th>
<th>Paper and Articles (641)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>100.0</td>
<td>18.9</td>
<td>4.9</td>
<td>3.8</td>
<td>2.9</td>
<td>2.0</td>
<td>1.7</td>
</tr>
<tr>
<td>1975</td>
<td>100.0</td>
<td>17.3</td>
<td>4.9</td>
<td>2.2</td>
<td>3.4</td>
<td>2.0</td>
<td>1.3</td>
</tr>
<tr>
<td>1985</td>
<td>100.0</td>
<td>16.6</td>
<td>3.1</td>
<td>2.1</td>
<td>4.9</td>
<td>1.9</td>
<td>1.3</td>
</tr>
<tr>
<td>1986</td>
<td>100.0</td>
<td>15.3</td>
<td>3.1</td>
<td>2.1</td>
<td>3.1</td>
<td>2.0</td>
<td>1.5</td>
</tr>
<tr>
<td>1987</td>
<td>100.0</td>
<td>15.2</td>
<td>2.9</td>
<td>2.1</td>
<td>3.0</td>
<td>2.0</td>
<td>1.6</td>
</tr>
<tr>
<td>1988</td>
<td>100.0</td>
<td>15.7</td>
<td>3.3</td>
<td>2.6</td>
<td>2.4</td>
<td>2.0</td>
<td>1.7</td>
</tr>
</tbody>
</table>

¹Reported imports of the following countries for which complete 1965-1988 trade data are available: All OECD countries; Algeria; Argentina; Bolivia; Brazil; Chile; Colombia; Costa Rica; Ecuador; Egypt; Ethiopia; French Guiana; Guadeloupe; Guatemala; Honduras; Hong Kong; Hungary; India; Indonesia; Israel; Jordan; Rep. of Korea; Malaysia; Malta; Martinique; Mexico; Morocco; Taiwan (China); Pakistan; Panama; Paraguay; Peru; Philippines; Reunion; Singapore; Sri Lanka; Thailand; Togo; Trinidad and Tobago; Tunisia; Turkey; Venezuela and Yugoslavia.

²SITC Revision 1 numbers are shown in parentheses. See footnote 1 for a list of reporting countries.
assist in evaluating this information the lower half of the table shows the share of these products in world trade.

In 1988, the environmentally dirty products accounted for almost $385 billion or about 16 percent of world trade and the relative importance of these items declined by about 3 points (from 18.9 percent) over the 1965-88 period. The ferrous and nonferrous metal groups combined accounted for almost 40 percent of trade in these goods and also are the source of over three quarters of the total decline in their world trade share. The share of paper and metal manufactures remained virtually static over the 23-year period, fluctuating between 1.3 to 2.0 percent, while refined petroleum share fluctuated (between 2.4 to 4.9 percent), in line with crude oil prices.

Table 6-2 attempts to determine if there are important differences in the geographic origins of these goods, or in the characteristics of the countries from which these shipments originate. The top third of the table shows shipments of environmentally dirty goods originating in both industrial and other countries (the latter group includes Eastern Europe) and also provides a further breakdown for the developing countries of Latin America and the Caribbean, South and South-East Asia, and West Asia. To assist in evaluating this information, the middle third of the table shows the share of all environmentally dirty goods' trade originating in the region.

In 1988, industrial countries accounted for approximately $285 billion, or three quarters of all shipment of these products, with almost 40 percent of world exports coming from the EEC(10). The latter is almost three times the value of trade in environmentally dirty goods originating in Canada and the United States combined. In contrast, nonindustrial countries account for only about one quarter (by value) of global exports of dirty goods, with about one third of these shipments ($32 billion) originating in South-East Asia.

Table 6-2 identifies two important secular trends in this trade -- a drop of over 6 percentage points in the value of shipments originating in North America (from 20.5 to 14 percent of world trade) and a more than doubling (from 3.4 to 8.4 percent) of the share originating in South-East Asia.

In an attempt to account for size differences among exporters, the lower third of Table 6-2 shows the share of dirty goods in total exports from each region. These statistics reflect different concentrations of dirty goods in total exports. Several important points emerge from these comparisons. First, the major export value differences between the EEC(10) and North America are seen to be substantially a function of relatively larger European total trade as the overall share of dirty goods in the EC's total exports (16.1 percent) are only two points higher than that for Canada and the United States combined. Eastern Europe, followed by Latin America and the Caribbean, are currently the two regions with the highest concentration of dirty goods as these products account for over one fifth of total exports (28 percent in the case of Eastern Europe). As far as trends are concerned, there is rather clear evidence of a relative decline in the importance of these products in industrial countries' exports, while increases are observed in Eastern Europe, Latin America and West Asia. It should be borne in mind that these increases in the relative importance of dirty industry trade have taken place against a secular reduction in the share of environmentally dirty goods in total trade (from almost 19 percent in 1965 to about 15.5 percent in 1988).

From a global perspective, an interesting question is who are the major exporters of environmentally dirty products. Table 6-3 provides relevant information by showing the 25 leading exporters ranked by value.

---

*Separate tabulations for Africa indicate that only a small share of the environmentally dirty goods originate in this region. In 1988, the African countries exported about $12.8 billion of these goods which represent approximately 3 percent of world trade. Petroleum and nonferrous metals (SITC 68) accounted for about 95 percent of the total shipments.*
<table>
<thead>
<tr>
<th>Year</th>
<th>Total Trade in All Environmentally Dirty Goods</th>
<th>of which:</th>
<th>of which:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Industrial Countries</td>
<td>EEC(10)</td>
<td>North America</td>
</tr>
<tr>
<td>1965</td>
<td>32.7</td>
<td>25.4</td>
<td>12.5</td>
</tr>
<tr>
<td>1975</td>
<td>138.6</td>
<td>107.8</td>
<td>55.4</td>
</tr>
<tr>
<td>1985</td>
<td>287.7</td>
<td>201.6</td>
<td>101.9</td>
</tr>
<tr>
<td>1986</td>
<td>292.2</td>
<td>216.9</td>
<td>113.2</td>
</tr>
<tr>
<td>1987</td>
<td>337.6</td>
<td>250.1</td>
<td>129.8</td>
</tr>
<tr>
<td>1988</td>
<td>384.2</td>
<td>285.4</td>
<td>147.9</td>
</tr>
</tbody>
</table>

(value of trade expressed in US$ billion)

<table>
<thead>
<tr>
<th>Year</th>
<th>(share of all environmentally dirty goods originating in the region)</th>
<th>(share of environmentally dirty goods in all exports from the region)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1965</td>
<td>100.0</td>
<td>18.9</td>
</tr>
<tr>
<td>1975</td>
<td>100.0</td>
<td>17.3</td>
</tr>
<tr>
<td>1985</td>
<td>100.0</td>
<td>16.6</td>
</tr>
<tr>
<td>1986</td>
<td>100.0</td>
<td>15.3</td>
</tr>
<tr>
<td>1987</td>
<td>100.0</td>
<td>15.2</td>
</tr>
<tr>
<td>1988</td>
<td>100.0</td>
<td>15.7</td>
</tr>
</tbody>
</table>

For details on the countries reporting trade data see the notes to table 1.

1Bulgaria, Czechoslovakia, Hungary, German Democratic Republic, Poland, Romania and the USSR. Trade between East and West Germany is excluded from the tabulations.

2Includes Caribbean countries.
### Table 6-3: The Twenty-Five Largest Exporters of Environmentally Dirty Goods in 1988

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany, Federal Republic</td>
<td>25.8</td>
<td>13.8</td>
<td>3.1</td>
<td>20.4</td>
<td>10.2</td>
<td>15.8</td>
<td>45.6</td>
</tr>
<tr>
<td>United States</td>
<td>7.3</td>
<td>14.8</td>
<td>11.1</td>
<td>15.1</td>
<td>9.4</td>
<td>10.5</td>
<td>28.5</td>
</tr>
<tr>
<td>Canada</td>
<td>7.3</td>
<td>23.2</td>
<td>6.1</td>
<td>6.4</td>
<td>27.7</td>
<td>23.8</td>
<td>25.2</td>
</tr>
<tr>
<td>France</td>
<td>32.7</td>
<td>13.3</td>
<td>6.7</td>
<td>12.7</td>
<td>9.5</td>
<td>14.6</td>
<td>22.0</td>
</tr>
<tr>
<td>Belgium-Luxembourg</td>
<td>36.7</td>
<td>16.1</td>
<td>10.1</td>
<td>9.8</td>
<td>6.6</td>
<td>23.5</td>
<td>20.8</td>
</tr>
<tr>
<td>Netherlands</td>
<td>13.8</td>
<td>14.9</td>
<td>31.2</td>
<td>9.6</td>
<td>8.9</td>
<td>20.2</td>
<td>20.3</td>
</tr>
<tr>
<td>Japan</td>
<td>50.5</td>
<td>8.8</td>
<td>1.2</td>
<td>20.5</td>
<td>5.4</td>
<td>8.1</td>
<td>18.9</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>23.4</td>
<td>17.1</td>
<td>14.4</td>
<td>13.8</td>
<td>7.7</td>
<td>14.1</td>
<td>17.3</td>
</tr>
<tr>
<td>Italy</td>
<td>25.0</td>
<td>8.3</td>
<td>10.5</td>
<td>25.1</td>
<td>7.2</td>
<td>13.8</td>
<td>16.0</td>
</tr>
<tr>
<td>Sweden</td>
<td>20.3</td>
<td>6.1</td>
<td>5.7</td>
<td>10.4</td>
<td>34.1</td>
<td>33.0</td>
<td>15.3</td>
</tr>
<tr>
<td>Finland</td>
<td>10.5</td>
<td>6.9</td>
<td>4.2</td>
<td>2.6</td>
<td>56.1</td>
<td>52.3</td>
<td>10.0</td>
</tr>
<tr>
<td>Soviet Union</td>
<td>8.0</td>
<td>26.2</td>
<td>52.7</td>
<td>0.5</td>
<td>1.9</td>
<td>29.0</td>
<td>2.2</td>
</tr>
<tr>
<td>Brazil</td>
<td>44.7</td>
<td>16.4</td>
<td>11.4</td>
<td>3.2</td>
<td>7.5</td>
<td>24.3</td>
<td>7.9</td>
</tr>
<tr>
<td>Austria</td>
<td>27.6</td>
<td>12.5</td>
<td>0.8</td>
<td>16.8</td>
<td>22.4</td>
<td>24.6</td>
<td>6.9</td>
</tr>
<tr>
<td>Spain</td>
<td>28.7</td>
<td>9.5</td>
<td>18.5</td>
<td>14.5</td>
<td>5.6</td>
<td>18.4</td>
<td>6.8</td>
</tr>
<tr>
<td>Korea, Rep. of</td>
<td>48.0</td>
<td>5.8</td>
<td>6.5</td>
<td>24.4</td>
<td>3.9</td>
<td>11.8</td>
<td>6.6</td>
</tr>
<tr>
<td>Taiwan, China</td>
<td>12.9</td>
<td>7.4</td>
<td>2.3</td>
<td>49.3</td>
<td>2.7</td>
<td>10.0</td>
<td>6.2</td>
</tr>
<tr>
<td>Norway</td>
<td>1.7</td>
<td>42.8</td>
<td>7.8</td>
<td>4.4</td>
<td>15.2</td>
<td>27.3</td>
<td>6.0</td>
</tr>
<tr>
<td>Australia</td>
<td>7.4</td>
<td>48.3</td>
<td>5.6</td>
<td>4.4</td>
<td>1.4</td>
<td>19.8</td>
<td>5.7</td>
</tr>
<tr>
<td>Switzerland</td>
<td>12.9</td>
<td>21.0</td>
<td>1.0</td>
<td>27.7</td>
<td>8.9</td>
<td>11.2</td>
<td>5.6</td>
</tr>
<tr>
<td>China, Peoples Rep.</td>
<td>17.9</td>
<td>17.3</td>
<td>14.4</td>
<td>21.8</td>
<td>2.6</td>
<td>9.6</td>
<td>5.2</td>
</tr>
<tr>
<td>Rep. of South Africa</td>
<td>31.6</td>
<td>48.9</td>
<td>1.2</td>
<td>1.4</td>
<td>3.7</td>
<td>41.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Singapore</td>
<td>3.2</td>
<td>3.7</td>
<td>73.7</td>
<td>6.4</td>
<td>1.8</td>
<td>19.2</td>
<td>4.8</td>
</tr>
<tr>
<td>Venezuela</td>
<td>5.5</td>
<td>17.1</td>
<td>72.6</td>
<td>0.9</td>
<td>0.5</td>
<td>49.7</td>
<td>4.3</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>0.4</td>
<td>0.6</td>
<td>95.1</td>
<td>0.7</td>
<td>0.0</td>
<td>14.9</td>
<td>4.1</td>
</tr>
</tbody>
</table>
of shipments. The table also shows each country's share of world trade in these goods, as well as the share of dirty products in each nation's total exports. Finally, the table also indicates the share of five broad classes of goods in total exports of the polluting products.

Table 6-3 shows the dominant position of industrialized countries as exporters of environmentally dirty products. The 25 countries listed here account for about 85 percent of world trade in these items and only eight of the countries -- which account for 12.5 percent of global trade -- are not OECD members. The largest single exporter of the polluting goods -- the Federal Republic of Germany -- accounts for almost 12 percent of world trade alone with the United States in second place with 7 percent of the global total.

One surprising point emerging from Table 6-3 is the relatively wide national variations in the share of dirty goods in total exports. These goods account for one quarter or more of the exports of Norway, the USSR and Sweden, with the share reaching 52 percent in the case of Finland. Paper and paper manufactures account for the high pollution intensity of Nordic exports, whereas several of the developing countries' results (Singapore, Venezuela, Saudi Arabia) are due to refined petroleum.

**Shifting Patterns of National Comparative Advantage**

A key question is what national patterns become evident once the results reported in Tables 6-1 through 6-3 are further disaggregated. Here, the RCA approach can yield useful insights. Figure 6-1 illustrates the nature of the results achieved when 109 individual countries' RCA indices were computed for one of the environmentally dirty industries, namely, Iron and Steel Pipes and Tubes (SITC 678). The horizontal axis shows different RCA index values -- they increase as one moves from left to right -- with the vertical dashed line identifying the boundary for countries without a comparative advantage (to the left of the line) and those with an advantage (to the right). The left-hand vertical scale ranks countries in terms of increasing (moving upward) 1966-68 RCAs, while the right-hand scale ranks countries on the basis of the 1986-88 data. The two curves plot actual values of countries' 1966-68 RCAs (left vertical scale) and 1986-88 (right scale) revealed comparative advantage index values. Finally, the figure also provides specific information about the number of industrial and developing countries with a revealed comparative advantage in the two time periods and gives an "industry turnover" index designed to measure the extent of country changes in these groups. A value of unity for this index indicates there was no change between 1966-68 and 1986-88 in the composition of countries with a revealed comparative advantage while a value of zero indicates that all countries changed between the two periods.

---

9To simplify the exposition we plotted country and index values only where the RCA was 0.5 or more. Note that the rightward shift of the 1986-88 curve indicates the base of countries with a revealed comparative advantage in the industry was expanding. Two points on the left vertical scale are of specific interest. OR and OR' indicate the percentage of all 109 countries that had a revealed comparative advantage during the two time periods. A box in the figure provides a breakdown of the latter in terms of the actual number of developed and developing countries with RCAs exceeding unity.

10Specifically, the industry turnover ratio \( I_j \) was defined as,

\[
I_j = \frac{\sum d_i}{N_e} \quad (0 \leq I_j \leq 1)
\]

where \( N_e \) is the largest number of countries with a revealed comparative advantage in the industry in either 1966-68 or 1986-88 and \( d_i \) is a dummy variable for country \( i \) that takes a value of one if \( i \) had a RCA > 1 in both periods or zero otherwise.
Figure 6-1: The 1966-68 and 1986-88 Country Distributions for SITC Industry 678 (Iron and Steel Pipes and Tubes) (All Countries with a RCA Index of 0.5 or More)

<table>
<thead>
<tr>
<th>Countries with RCAs Over Unity</th>
<th>1966-68</th>
<th>1986-88</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial countries</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>All others</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>Least developed</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Industry Turn Over Index: .42
Two points follow from the country RCA distributions shown in Figure 6-1. First, the rightward shift of the 1986-88 curve shows that the number of countries with a revealed comparative advantage in the industry increased -- 11 percent of the 109 countries had RCAs exceeding unity in 1966-68 and the share increased to 22 percent in 1986-88, with a relatively large number of developing countries in the latter total. Specifically, the increase in developing countries achieving a revealed comparative advantage was far greater than that of the industrial countries. While the latter doubled -- from 6 to 12 countries -- the number of non-industrial countries experienced a four-fold increase (to 24).

A key question is whether the relatively greater expansion in the number of developing countries with a comparative advantage in iron and steel tubes (Figure 6-1) reflects a general pattern that is characteristic of other polluting industries. Also, it is important to determine if the rate and pattern of change in dirty industries is similar or different from that in other manufacturing industries. Table 6-4 provides relevant information by showing the number of developing and industrial countries with RCAs exceeding unity in each of the polluting industries in 1966-68 and 1986-88, as well as averages for this entire group. These latter figures are compared with those for all other industry sectors -- a total of 89 nonpolluting industry groups. Finally, industry turnover ratios are shown (to indicate the extent to which country composition changed), along with an indicator of resource or labor intensity of production in certain sectors.

Table 6-4 documents the fact that there has been a disproportionately large increase in the average number of developing countries with RCAs above unity in dirty industries, and this expansion occurred in almost all of the polluting sectors. On average, a relatively small 14 percent increase occurred in the number of industrial countries with a comparative advantage in these industries, but the increase for the developing countries was almost three times as great. The implications of this finding are that the polluting industry activities are being dispersed internationally and the dispersion is greatest in the direction of developing countries.

Table 6-4 also demonstrates that, on average, developing countries have a stronger tendency to develop a revealed comparative advantage in polluting as opposed to nonpolluting industry sectors. For the former, the average number of developing countries with a revealed comparative advantage rose from 10 to 14 (a 40 percent expansion) while the corresponding increase was only about one fifth as great (8 percent) for other manufacturing industries. The importance of the markedly stronger tendency for developing countries to gravitate toward the polluting industries is emphasized by the fact that the turnover ratios for the two groups of industries are almost identical (0.51 for the dirty industries as opposed to 0.50 for the others). The evidence suggests that some factor is exerting a locational pull for developing countries toward the polluting industries.\footnote{The data do not suggest that labor intensity is an important factor as only 15 percent of the industries listed in Table 4 are manufactured by labor intensive production processes. Of these, none is 10 percent more labor intensive than the U.S. average for all manufacturing activity. Natural resource endowments appear to have a slightly more important influence -- particularly in the nonferrous metals sector (SITC 68), as 33 percent of the dirty industries appear to have a locational pull toward natural resources.}

Table 6-5 examines the dispersion pattern of the dirty and other industries in more detail. The left side of the table groups industries by their 1966-68 country concentrations (i.e., highly concentrated industries are those in which fewer than 10 countries have a revealed comparative advantage, low concentration industries are those in which more than 30 countries have RCAs exceeding unity, etc.), while the top (horizontal) row classifies industries in terms of their 1986-88 country concentrations. Entries in the table show the percentage of the polluting and nonpolluting manufacturing industries falling in the different groups in 1966-68 and 1986-88. For example, 7.5 percent of the dirty industries had "highly concentrated" structures
<table>
<thead>
<tr>
<th>SITC</th>
<th>Description</th>
<th>Labor-Intensive Product¹</th>
<th>Resource-Based Product²</th>
<th>Industry Turnover Ratio</th>
<th>Industrial 1966-68</th>
<th>Others 1966-68</th>
<th>Industrial 1986-88</th>
<th>Others 1986-88</th>
<th>No. of countries with RCAs &gt; unity 1966-68</th>
<th>No. of countries with RCAs &gt; unity 1986-88</th>
<th>Share of industrial countries in all exporters with RCAs over unity (%) 1966-68</th>
<th>Share of industrial countries in all exporters with RCAs over unity (%) 1986-88</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>251</td>
<td>Pulp and waste paper</td>
<td>Y</td>
<td>0.50</td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>10</td>
<td>42</td>
<td>44</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>332</td>
<td>Refined petroleum products</td>
<td>Y</td>
<td>0.46</td>
<td>3</td>
<td>23</td>
<td>5</td>
<td>10</td>
<td>12</td>
<td>12</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>512</td>
<td>Organic chemicals</td>
<td></td>
<td>0.36</td>
<td>5</td>
<td>9</td>
<td>8</td>
<td>14</td>
<td>38</td>
<td>36</td>
<td>-2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>513</td>
<td>Inorganic chemicals</td>
<td></td>
<td>0.35</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>22</td>
<td>50</td>
<td>28</td>
<td>-22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>514</td>
<td>Other inorganic chemicals</td>
<td></td>
<td>0.48</td>
<td>6</td>
<td>13</td>
<td>10</td>
<td>19</td>
<td>32</td>
<td>34</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>515</td>
<td>Radioactive materials</td>
<td></td>
<td>0.33</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>67</td>
<td>56</td>
<td>-11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>521</td>
<td>Mineral tar and petroleum chemicals</td>
<td></td>
<td>0.39</td>
<td>5</td>
<td>13</td>
<td>6</td>
<td>22</td>
<td>28</td>
<td>21</td>
<td>-7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>561</td>
<td>Manufactured fertilizers</td>
<td>Y</td>
<td>0.50</td>
<td>8</td>
<td>15</td>
<td>8</td>
<td>28</td>
<td>35</td>
<td>22</td>
<td>-13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>599</td>
<td>Insecticides, fungicides, etc.</td>
<td></td>
<td>0.61</td>
<td>9</td>
<td>9</td>
<td>12</td>
<td>6</td>
<td>50</td>
<td>72</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>631</td>
<td>Plywood, veneers or improved wood</td>
<td></td>
<td>0.61</td>
<td>6</td>
<td>25</td>
<td>7</td>
<td>29</td>
<td>19</td>
<td>19</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>632</td>
<td>Wood products, nes</td>
<td></td>
<td>0.68</td>
<td>11</td>
<td>18</td>
<td>9</td>
<td>22</td>
<td>38</td>
<td>29</td>
<td>-9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>641</td>
<td>Paper and paperboard</td>
<td></td>
<td>0.55</td>
<td>6</td>
<td>0</td>
<td>7</td>
<td>4</td>
<td>100</td>
<td>64</td>
<td>-36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>642</td>
<td>Articles of paper or pulp</td>
<td></td>
<td>0.65</td>
<td>13</td>
<td>9</td>
<td>9</td>
<td>11</td>
<td>59</td>
<td>41</td>
<td>-19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>661</td>
<td>Lime and cement</td>
<td>Y</td>
<td>0.59</td>
<td>9</td>
<td>24</td>
<td>8</td>
<td>26</td>
<td>27</td>
<td>24</td>
<td>-3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>671</td>
<td>Pig iron</td>
<td></td>
<td>0.55</td>
<td>9</td>
<td>17</td>
<td>7</td>
<td>22</td>
<td>35</td>
<td>32</td>
<td>-3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>672</td>
<td>Iron ingots</td>
<td></td>
<td>0.52</td>
<td>9</td>
<td>12</td>
<td>11</td>
<td>20</td>
<td>43</td>
<td>35</td>
<td>-8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>673</td>
<td>Iron bars</td>
<td></td>
<td>0.32</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>16</td>
<td>47</td>
<td>36</td>
<td>-11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>674</td>
<td>Iron and steel plates</td>
<td></td>
<td>0.44</td>
<td>9</td>
<td>4</td>
<td>9</td>
<td>16</td>
<td>69</td>
<td>36</td>
<td>-33</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>675</td>
<td>Iron and steel hoop</td>
<td></td>
<td>0.75</td>
<td>6</td>
<td>3</td>
<td>6</td>
<td>2</td>
<td>67</td>
<td>75</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>676</td>
<td>Rails of iron</td>
<td></td>
<td>0.67</td>
<td>8</td>
<td>10</td>
<td>7</td>
<td>5</td>
<td>44</td>
<td>58</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>677</td>
<td>Iron and steel wire</td>
<td></td>
<td>0.26</td>
<td>6</td>
<td>3</td>
<td>8</td>
<td>11</td>
<td>67</td>
<td>73</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>678</td>
<td>Iron and steel tubes</td>
<td></td>
<td>0.42</td>
<td>6</td>
<td>6</td>
<td>10</td>
<td>14</td>
<td>50</td>
<td>42</td>
<td>-8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>679</td>
<td>Iron and steel castings</td>
<td></td>
<td>0.15</td>
<td>3</td>
<td>4</td>
<td>11</td>
<td>9</td>
<td>43</td>
<td>55</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>681</td>
<td>Silver and platinum</td>
<td></td>
<td>0.47</td>
<td>3</td>
<td>15</td>
<td>3</td>
<td>12</td>
<td>17</td>
<td>25</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>682</td>
<td>Copper</td>
<td>Y</td>
<td>0.57</td>
<td>4</td>
<td>11</td>
<td>7</td>
<td>14</td>
<td>36</td>
<td>33</td>
<td>-3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>683</td>
<td>Nickel</td>
<td>Y</td>
<td>0.50</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>8</td>
<td>57</td>
<td>50</td>
<td>-7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>684</td>
<td>Aluminum</td>
<td></td>
<td>0.48</td>
<td>7</td>
<td>6</td>
<td>9</td>
<td>16</td>
<td>54</td>
<td>36</td>
<td>-18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>685</td>
<td>Lead</td>
<td>Y</td>
<td>0.68</td>
<td>3</td>
<td>15</td>
<td>6</td>
<td>13</td>
<td>17</td>
<td>32</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>686</td>
<td>Zinc</td>
<td>Y</td>
<td>0.72</td>
<td>5</td>
<td>11</td>
<td>7</td>
<td>11</td>
<td>31</td>
<td>39</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>687</td>
<td>Tin</td>
<td>Y</td>
<td>0.57</td>
<td>1</td>
<td>8</td>
<td>2</td>
<td>12</td>
<td>11</td>
<td>17</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>688</td>
<td>Uranium and alloys</td>
<td></td>
<td>0.50</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>60</td>
<td>75</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry</td>
<td>Factor Intensity</td>
<td>2000</td>
<td>2001</td>
<td>2002</td>
<td>2003</td>
<td>2004</td>
<td>2005</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>------------------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other nonferrous metals</td>
<td>0.71</td>
<td>5</td>
<td>13</td>
<td>6</td>
<td>11</td>
<td>28</td>
<td>36</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal structural parts</td>
<td>0.41</td>
<td>9</td>
<td>5</td>
<td>14</td>
<td>8</td>
<td>64</td>
<td>64</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal containers</td>
<td>0.43</td>
<td>10</td>
<td>8</td>
<td>11</td>
<td>12</td>
<td>56</td>
<td>48</td>
<td>-8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wire products and grills</td>
<td>Y 0.36</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>14</td>
<td>47</td>
<td>36</td>
<td>-11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nails, screws and nuts</td>
<td>Y 0.47</td>
<td>7</td>
<td>3</td>
<td>8</td>
<td>7</td>
<td>70</td>
<td>53</td>
<td>-17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand tools</td>
<td>Y 0.65</td>
<td>9</td>
<td>6</td>
<td>8</td>
<td>9</td>
<td>60</td>
<td>47</td>
<td>-13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cutlery</td>
<td>Y 0.67</td>
<td>9</td>
<td>10</td>
<td>5</td>
<td>10</td>
<td>47</td>
<td>33</td>
<td>-14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household equipment of basematel</td>
<td>Y 0.65</td>
<td>11</td>
<td>15</td>
<td>9</td>
<td>14</td>
<td>42</td>
<td>39</td>
<td>-3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal manufactures, nes</td>
<td>Y 0.47</td>
<td>5</td>
<td>6</td>
<td>8</td>
<td>9</td>
<td>45</td>
<td>47</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average - All Above Dirty Industries 0.51 7 10 8 14 44 41 -3
Average - All Other Manufacturing Industries 0.50 7 12 7 13 44 40 -4

1 Detailed statistics on factor intensities for these and other manufacturing industries can be found in Yeats (1989). A Y in this column indicates the corresponding industry employs relatively labor intensive production processes.

2 Based on a UNIDO (1982) classification. A Y indicates the industry has a strong tendency to be drawn to the location of natural resources required as production inputs.
Table 6-5: Changes in the Concentration of Countries with a Revealed Comparative Advantage in Dirty and All Other Industries, (1966-68 to 1986-88)

<table>
<thead>
<tr>
<th>Industries grouped by the number of countries (N) with a revealed comparative advantage 1966-68</th>
<th>Highly concentrated (N &lt; 10)</th>
<th>Moderate - high (10 ≤ N ≤ 16)</th>
<th>Moderate concentration (17 ≤ N ≤ 23)</th>
<th>Moderate - low (24 ≤ N ≤ 30)</th>
<th>Low concentration (30 &lt; N)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly concentrated (N &lt; 10)</td>
<td>7.5 (7)</td>
<td>7.5 (7)</td>
<td>5 (3)</td>
<td>-</td>
<td>-</td>
<td>20 (17)</td>
</tr>
<tr>
<td>Moderate - high (10 ≤ N ≤ 16)</td>
<td>- (1)</td>
<td>5 (15)</td>
<td>17.5 (13)</td>
<td>7.5 (2)</td>
<td>-</td>
<td>30 (31)</td>
</tr>
<tr>
<td>Moderate concentration (17 ≤ N ≤ 23)</td>
<td>-</td>
<td>7.5 (3)</td>
<td>12.5 (20)</td>
<td>7.5 (6)</td>
<td>7.5</td>
<td>35 (29)</td>
</tr>
<tr>
<td>Moderate - low (24 ≤ N ≤ 30)</td>
<td>-</td>
<td>- (1)</td>
<td>2.5</td>
<td>2.5 (6)</td>
<td>5 (5)</td>
<td>10 (12)</td>
</tr>
<tr>
<td>Low concentration (30 &lt; N)</td>
<td>-</td>
<td>-</td>
<td>- (1)</td>
<td>- 3</td>
<td>5 (7)</td>
<td>5 (11)</td>
</tr>
<tr>
<td>Total</td>
<td>7.5 (8)</td>
<td>20 (26)</td>
<td>37.5</td>
<td>17.5 (17)</td>
<td>17.5 (12)</td>
<td>100 (100)</td>
</tr>
</tbody>
</table>

1 Figures in parentheses show the distribution of nonpolluting industries. Other figures show the distribution of dirty industries.

Memo Item

Sum of Elements Above Diagonal in Table - Dirty Industries = 57.7
- Other Industries = 36

Sum of Elements Below Diagonal in Table - Dirty Industries = 10
- Other Industries = 8
in both time periods while 12.5 percent were in the moderate concentration group. Entries above the diagonal in the table depict situations where industry concentrations decreased while entries below the diagonal reflect increased industry concentration. Numbers in parentheses show the 1966-68 to 1986-88 distribution pattern for the nonpolluting industries.

Overall, Table 6-5 indicates that an important net deconcentration occurred in both polluting and nonpolluting industries, but the degree of dispersion was considerably greater in the former. Overall, some 56 percent of the polluting industries moved to lower country concentration groups while only 36 percent of the nonpolluting industries experienced similar movements (see the memo item to the table). As such, comparative advantage in dirty industries was growing at a relatively faster pace than comparative advantage in other industries and it was the developing countries that were responsible (see Table 6-4) for this differential growth.

Conclusions

The evidence from trade shares and the revealed comparative advantage analysis presented in this paper suggest that dirty industries account for a growing share of exports of some developing countries. This has occurred against the background of a reduction in the share of dirty industry exports in the total exports of industrial countries, and an overall reduction of such exports in world trade. An important point to make about the approach used in this paper, however, is that trade flows are used as an indicator of locational changes in dirty industries and they may be misleading if national patterns of production and consumption are growing at different rates. Although dissaggregate data on output and consumption are not available, statistics compiled by UNCTAD (1990) strongly suggest that trade data are an accurate and reliable gauge of changes in industry location.

If there had not been a rising trend in developing country participation in dirty industry trade relative to other trade, it would have been a comparatively straightforward matter to conclude that differences in

---

12For example, the top row of the table shows that 7.5 percent of the dirty industries moved from the highly concentrated group in 1966-68 to the "moderate-high concentration" group in 1986-88, and 5 percent moved to the "moderate concentration" class. These cases reflect situations where the number of countries with a revealed comparative advantage in a specific industry was increasing. In contrast, the third row of the table shows that 7.5 percent of all industries moved from the "moderate" to the "moderate-high" concentration groups. In these cases, the number of countries with a revealed comparative advantage was decreasing.

13In contrast, only 8 to 10 percent of the other industries had fewer countries with RCAs above unity in the 1986-88 as opposed to 1966-68 period.

14If domestic production and consumption in major countries were changing at a different pace from global trade this could bias our conclusions concerning the migration of dirty industries. While global output and consumption data are not readily available at the same low level of aggregation as trade statistics, UNCTAD (1990 and other years, Table 7.1) provides aggregate information on chemicals and metals production, consumption and import penetration for the EC, United States and Japan over 1968 to 1988. These figures show no differential growth patterns in ferrous and nonferrous metals that would bias our analysis. Average import penetration ratios for metals remained virtually static (at 4.25 percent). In chemicals, trade grew at a faster pace than production and consumption (average import penetration ratios increased from about 1.6 to 3.5 percent) which indicates that the migratory pattern in this sector proceeded somewhat faster than our analysis indicates.
environmental policies among countries were not a cost factor that influenced the location of investment in dirty industries. As it is, this possibility cannot be dismissed.

On the other hand, there is no shortage of competing explanations for the phenomenon of dirty industry dispersion suggested by the trade flow data presented in this paper. Brief mention was made of the possibility that relative labor intensity could explain dirty industry location, but the evidence for this was weak, except perhaps for metals manufactures. The idea that trade flows reflected natural resource endowments appears a little more persuasive, at least as far as industries such as pulp and wafer paper, petroleum refining, cement and nonferrous metals are concerned. Apart from the usual range of cost elements that go into the determination of the competitiveness of an industry in a given location, additional considerations might be technological factors associated with many of the dirty industries, and differences in income and development levels among countries. Many of the dirty industries are basic industries, associated with the early stages of industrialization. The rapid dispersion among developing countries that a number of these industries appear to have experienced may lend some credence to this notion. The scope of this study does not permit a more thorough analysis of alternative explanations for industry location decisions.

As for the contribution of different environmental standards among countries to dirty industry location, it must be recognized that our aggregate data cannot capture particular instances of environmentally motivated investment decisions. On the other hand, data from the United States on pollution abatement and control expenditures presented in other studies tend to suggest that the evidence of dirty industry dispersion examined in this paper is unlikely to be adequately explained by environmental policy.

Finally, it is worth reiterating that even if differences in national approaches to environmental issues do account for some investment decisions, this does not provide a justification for policy actions that aim to stem the movement of dirty industries. Assuming the absence of some overriding environmental objective, of the kind that would attract widespread support beyond national frontiers, such actions would threaten the growth and development prospects of developing countries. Moreover, it does not follow that dirty industry migration engenders environmental degradation. The contrary may be true. Whether or not dirty industry migration per se is bad for the environment is a matter that can only be settled empirically. One factor that will influence the relationship between dirty industry migration and the environment is the type of technology that is used in different locations. A broad range of clean and dirty technology choices exists in many industries. On the other hand, there can be significant variations in ambient pollution absorptive capacities according to location. In addition, differences in income levels and social preferences will influence the manner in which environmental quality is perceived and defined in different locations.

\[\text{\^{15}}\text{We are grateful to Nemat Shafik for reminding us of this point.}\]
Trade Measures and Environmental Quality: The Implications for Mexico's Exports

Patrick Low

Introduction

Public attention, particularly in the United States, is focused as never before on links between trade policy and the environment. The immediate explanation for this is the deliberations in Congress in early 1991 on the extension of executive trade negotiating authority. Although the renewal of this authority had been discussed for many months almost exclusively in terms of U.S. participation in the Uruguay Round, extension of the authority was also required for the proposed negotiation of a free trade agreement (FTA) with Mexico. With surprising suddenness, the locus of the debate shifted to the Mexico FTA issue.

A major reason why the FTA proposal moved to center-stage was that environmental groups mobilized and petitioned against the FTA negotiations on the grounds that free trade between the United States and Mexico would be damaging to the environment -- an environment which was seen as already seriously compromised through accumulated neglect. The premise underlying many of the environmentalists' arguments was simply that more open trade would mean accelerated environmental degradation. The success of environmental groups in capturing public attention was abetted by the fact that an anti-FTA stance dovetailed with the concerns of labor groups, whose argument against more open trade was a more familiar one, focusing on competitiveness and wage differentials between the United States and Mexico. For at least some of the environmentalist lobbies, however, it was merely coincidental that their demands appeared indistinguishable from those of labor and industry groups opposed to freer trade.

The absence of a solid coalition between environmental groups and labor/industry interests contributed to the success of the executive branch in convincing a part of the environmental lobby that a failure to establish closer trade and economic relations between Mexico and the United States would be more threatening to environmental quality than a free trade agreement. In securing enough votes to defeat legislative proposals against extended trade negotiating authority, however, the Bush Administration is committed to ensure that environmental concerns are accorded appropriate attention. More precisely, there will be parallel negotiations on the environment and a long-term Border Environmental Plan is to be drawn up by the end of 1991.1

Even though trade liberalization in the context of the North American FTA negotiations might not be hostage to explicit environmental conditionality, the issue is unlikely to disappear. There is still a widely held view that specialization through trade and economic growth are harbingers of environmental degradation. And there are still influential interest groups that would treat disparities in environmental standards, or even differences in the costs of pollution abatement and control, as justifying the application of unfair trade remedies.

---

1Report to the Congress by the President (1991).
This paper focuses on the implications for Mexico’s exports of the imposition by the United States of a hypothetical “dirty” industry import tax that would equalize expenditures by U.S. and Mexican industries on pollution abatement and control. Although the justification for such a tax is extremely dubious on economic grounds, the idea has been promoted as a way of eradicating “unfairness” arising from differences in industry competitiveness among countries, attributable to differential environmental standards and compliance costs.

The paper contains four more sections. The next section presents data on dirty industries, based on differences in pollution abatement and control expenditures among industries in the United States. This is followed by an examination of the extent to which Mexico’s exports comprise the output of dirty industries, and looks at the growth of these industries in terms of their exports during the 1980s. The paper then analyzes the current U.S. trade policy regime facing dirty industry exports from Mexico, and presents the results of a simple simulation designed to estimate the likely trade impact of a dirty industry import tax.

The Identification of Dirty Industries

There is no standard definition of dirty industries. Like previous studies of trade and environmental policy, notably by Tobey (1990) and Kalt (1985), this paper identifies dirty industries as those incurring the highest level of pollution abatement and control expenditures. Annex Table A lists 123 industries identified at the 3-digit SIC level in descending order of pollution intensity. The data are for the year 1988, and pertain to U.S. industry. Table 7-1 in the text summarizes the above information at the 2-digit SIC level, where gross costs of pollution abatement are expressed as a percentage of industry output to yield the unit cost of abatement expenditure (column 3). This table also shows how pollution abatement operating costs are divided up between payments to government (sewage and waste disposal services) and direct operating costs to firms for air and water pollution abatement and waste disposal. These operating costs include depreciation of abatement equipment, labor, materials and supplies, and services, equipment leasing, and other costs.

Industrial activities classified as the most pollution intensive on the basis of the abatement and control costs they incur tend to be concentrated in relatively few sectors, including cement, chemicals, pulp and paper production, certain wood industries, petroleum refining, and ferrous and nonferrous metal industries. The numbers given for pollution abatement and control expenditures should be treated as indicative. Apart from limitations regarding the accuracy of the data, it should also be noted that only direct abatement costs have been included in the calculation of the degree of dirtiness.

Perhaps the most interesting fact to emerge from these data is that pollution abatement and control expenditures are small in relation to total output for the great majority of industries. The maximum “charge” resulting from pollution abatement and control activities amounted to just over 3 percent of output for the dirtiest industry (cement), and only 18 out of 123 3-digit SIC industries incurred expenditures greater than 1 percent of output. The weighted average for all industries was 0.54 percent (See Annex Table A).

---

2 See U.S. Department of Commerce (1988) which explains that the statistics were compiled from a probability sample and are subject to sampling variations. The final report on the 1986 data (not reported here) also discusses some other data limitations.

3 An attempt could have been made to measure the pollution intensity of industries in terms of inputs as well as final output. Kalt (1985) did this using the technical coefficients from the U.S. input-output table. Although the procedure did result in some reordering of industries by degree of dirtiness, it did not make much difference in terms of which broad industry groups were classified as dirty and which were not. Moreover, expressed as a share of total output, pollution abatement expenditures remained modest.
Table 7-1: Pollution Abatement Operating Costs by Type of Expenditure, 1988  
(Values in Millions of U.S. Dollars)

<table>
<thead>
<tr>
<th>SIC No.</th>
<th>Food and kindred products</th>
<th>Tobacco manufactures</th>
<th>Textile mill products</th>
<th>Lumber and wood products</th>
<th>Furniture and fixtures</th>
<th>Paper and allied products</th>
<th>Printing and publishing</th>
<th>Chemicals and allied products</th>
<th>Petroleum and coal products</th>
<th>Rubber and misc. plastics products</th>
<th>Leather and leather products</th>
<th>Stone, clay and glass products</th>
<th>Primary metal industries</th>
<th>Fabricated metal products</th>
<th>Machinery, except electrical</th>
<th>Electric and electrical equipment</th>
<th>Transportation equipment</th>
<th>Instruments and related products</th>
<th>Misc. manufacturing industries</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>1,160.1</td>
<td>351,514.9</td>
<td>0.33</td>
<td>398.6</td>
<td>347.8</td>
<td>50.8</td>
<td>761.5</td>
<td>157.8</td>
<td>325.6</td>
<td>13.2</td>
<td>264.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>37.6</td>
<td>23,831.8</td>
<td>0.16</td>
<td>6.1</td>
<td>5.3</td>
<td>0.8</td>
<td>31.5</td>
<td>12.4</td>
<td>9.5</td>
<td>0.6</td>
<td>9.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>177.0</td>
<td>64,767.9</td>
<td>0.27</td>
<td>62.4</td>
<td>50.1</td>
<td>12.4</td>
<td>114.6</td>
<td>30.5</td>
<td>48.8</td>
<td>6.5</td>
<td>28.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>236.1</td>
<td>72,065.4</td>
<td>0.33</td>
<td>20.2</td>
<td>10.1</td>
<td>10.1</td>
<td>215.9</td>
<td>84.0</td>
<td>47.5</td>
<td>16.8</td>
<td>67.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>118.4</td>
<td>39,226.1</td>
<td>0.30</td>
<td>11.1</td>
<td>5.8</td>
<td>5.3</td>
<td>107.3</td>
<td>33.8</td>
<td>6.6</td>
<td>37.4</td>
<td>29.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>1,343.3</td>
<td>122,556.2</td>
<td>1.10</td>
<td>141.6</td>
<td>107.8</td>
<td>33.8</td>
<td>1,201.7</td>
<td>372.4</td>
<td>520.0</td>
<td>32.5</td>
<td>276.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>206.4</td>
<td>143,906.8</td>
<td>0.14</td>
<td>41.8</td>
<td>24.7</td>
<td>17.1</td>
<td>164.6</td>
<td>72.0</td>
<td>9.5</td>
<td>22.4</td>
<td>60.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>3,074.9</td>
<td>259,699.1</td>
<td>1.18</td>
<td>181.8</td>
<td>154.4</td>
<td>27.4</td>
<td>2,893.1</td>
<td>706.4</td>
<td>1,274.1</td>
<td>467.1</td>
<td>445.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>2,005.5</td>
<td>131,414.8</td>
<td>1.53</td>
<td>30.5</td>
<td>14.6</td>
<td>15.9</td>
<td>1,975.0</td>
<td>1,175.8</td>
<td>547.1</td>
<td>142.8</td>
<td>109.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>278.0</td>
<td>94,200.2</td>
<td>0.30</td>
<td>50.7</td>
<td>27.0</td>
<td>23.7</td>
<td>227.2</td>
<td>62.5</td>
<td>35.2</td>
<td>35.4</td>
<td>94.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>23.1</td>
<td>9,663.7</td>
<td>0.24</td>
<td>7.8</td>
<td>5.7</td>
<td>2.0</td>
<td>15.3</td>
<td>2.5</td>
<td>5.6</td>
<td>0.9</td>
<td>6.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>438.5</td>
<td>63,059.4</td>
<td>0.70</td>
<td>27.7</td>
<td>17.1</td>
<td>10.6</td>
<td>410.7</td>
<td>247.7</td>
<td>50.6</td>
<td>25.8</td>
<td>86.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>1,809.0</td>
<td>149,079.8</td>
<td>1.21</td>
<td>63.4</td>
<td>47.5</td>
<td>15.9</td>
<td>1,745.6</td>
<td>965.8</td>
<td>468.5</td>
<td>136.2</td>
<td>175.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>761.9</td>
<td>158,833.8</td>
<td>0.48</td>
<td>73.1</td>
<td>49.0</td>
<td>24.1</td>
<td>688.9</td>
<td>135.0</td>
<td>267.8</td>
<td>169.3</td>
<td>116.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>429.7</td>
<td>243,260.8</td>
<td>0.18</td>
<td>56.6</td>
<td>38.2</td>
<td>18.4</td>
<td>373.1</td>
<td>68.4</td>
<td>101.2</td>
<td>90.7</td>
<td>112.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>659.3</td>
<td>186,950.8</td>
<td>0.35</td>
<td>86.0</td>
<td>62.6</td>
<td>23.5</td>
<td>573.2</td>
<td>92.2</td>
<td>189.9</td>
<td>163.1</td>
<td>128.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>974.5</td>
<td>354,047.8</td>
<td>0.28</td>
<td>82.6</td>
<td>60.2</td>
<td>22.3</td>
<td>891.9</td>
<td>215.7</td>
<td>239.0</td>
<td>267.8</td>
<td>169.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>197.7</td>
<td>114,528.4</td>
<td>0.17</td>
<td>23.1</td>
<td>18.2</td>
<td>4.9</td>
<td>174.6</td>
<td>21.7</td>
<td>61.7</td>
<td>49.0</td>
<td>42.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>76.7</td>
<td>34,869.4</td>
<td>0.22</td>
<td>12.7</td>
<td>6.0</td>
<td>6.7</td>
<td>64.0</td>
<td>10.1</td>
<td>14.9</td>
<td>9.5</td>
<td>29.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>14,008.6</strong></td>
<td><strong>2,617,476.9</strong></td>
<td><strong>0.54</strong></td>
<td><strong>1,378.7</strong></td>
<td><strong>1,052.9</strong></td>
<td><strong>325.8</strong></td>
<td><strong>12,629.9</strong></td>
<td><strong>4,466.5</strong></td>
<td><strong>4,223.1</strong></td>
<td><strong>1,687.0</strong></td>
<td><strong>2,253.2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mexico's Exports of Dirty Industry Products

This section briefly examines Mexico's exports in terms of the products that would be vulnerable if measures were adopted by Mexico's trading partners to reduce or eliminate trade in pollution-intensive goods. The questions of whether such action could be justified, and what the actual trade effects might be, are taken up in due course.

Annex Tables B and C list Mexico's exports of pollution-intensive goods to the United States and to the world. Notwithstanding the difficulties of establishing a concordance between a classification system based on processes (SIC) and one based on products (SITC or TSUSA), these tables have attempted to identify dirty products in terms of pollution abatement and control expenditures in excess of 0.5 percent of output.

The 48 products identified in the tables at the SITC 3-digit level accounted for 11 percent and 12 percent respectively of Mexico's exports to the United States and to the world in 1989. The tables also record growth rates of exports between 1981 and 1989 in constant (1990) dollar terms. Exports of pollution-intensive products to the United States increased at an average rate of 9 percent per year during the 1980s, compared with 3 percent for all commodities. The growth rates for individual products varied widely. Similarly, exports of pollution-intensive products to the world grew by 5 percent over the same period, while the comparable figure for total exports was 1 percent.

In summary, the trade data show that Mexico's export earnings are not overly dependent on pollution-intensive products, which account for a little over one tenth of total exports. On the other hand, pollution-intensive exports have grown considerably faster than total exports during this period. A continuation of this trend could be at risk if Mexico's trading partners were to take trade measures against dirty products.

Pollution-Intensive Goods and Trade Policy

This section examines existing import measures applied on Mexico's exports to the United States and simulates the effects on those exports of the imposition of a "pollution abatement and control expenditure (PACE) equalization tax." Taking current trade measures first, Table 7-2 shows that the average applied U.S. tariff on Mexico's exports is 2.9 percent (1990 applied rates, including preferences). The comparable figure for the products reported in Table 7-2 as being most affected by a PACE equalization tax (see below) is 2.3 percent. The final column of the table lists nontariff barriers (NTBs) on the products identified, covering a textile item (of silk or man-made fibers), certain pigments, cement and various steel products. The trade coverage ratio of these NTBs is 3.6 percent in terms of 1986 trade flows, whereas Erzan and Yeats (1991) report higher frequency counts for Mexico's total exports to the United States.\(^4\)

Since the products listed in Table 7-2 include both low volume pollution-intensive items and high volume "clean" items, the conclusion to be drawn here is that currently, U.S. trade policy is insensitive to the pollution intensity of imports, at least as far as Mexico is concerned.

Turning to the simulation exercise, whose results are reported in Table 7-2, it was assumed that following the removal of all U.S. tariffs on Mexican exports under an FTA, a PACE equalization tax was added back. The PACE equalization tax is equivalent to pollution abatement and control expenditures incurred

\(^{4}\)This study reports a trade coverage ratio for all NTBs (as defined by the UNCTAD data base) of 39 percent, and a 4 percent coverage ratio for "hard core" NTBs (quantitative restrictions -- quotas, prohibitions and VERs -- and flexible import fees).
<table>
<thead>
<tr>
<th>Commodity</th>
<th>U.S. imports from Mexico 1986 (US$'000)</th>
<th>MFN or preferential tariff</th>
<th>Cost equalization tax</th>
<th>Total trade creation and diversion effects (US$'000)</th>
<th>Current nontariff barriers (1989)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canned and cured seafoods</td>
<td>357,683</td>
<td></td>
<td>0.3</td>
<td>2,867</td>
<td>NFA restraints</td>
</tr>
<tr>
<td>Coffee, processed</td>
<td>573,051</td>
<td></td>
<td>0.3</td>
<td>4,880</td>
<td></td>
</tr>
<tr>
<td>Beverages (largely beer)</td>
<td>121,099</td>
<td>2.1</td>
<td>0.5</td>
<td>1,377</td>
<td></td>
</tr>
<tr>
<td>Paper, not impregnated or coated</td>
<td>28,344</td>
<td>-</td>
<td>2.0</td>
<td>1,370</td>
<td></td>
</tr>
<tr>
<td>Paper, paperboard, cut to size or shape</td>
<td>172,133</td>
<td>4.1</td>
<td>0.4</td>
<td>1,228</td>
<td></td>
</tr>
<tr>
<td>Other articles of silk or man-made fibers, not ornamented</td>
<td>114,292</td>
<td>9.0</td>
<td>0.4</td>
<td>1,611</td>
<td></td>
</tr>
<tr>
<td>Inorganic acids</td>
<td>58,870</td>
<td></td>
<td>2.2</td>
<td>3,396</td>
<td>Countervailing duties</td>
</tr>
<tr>
<td>Pigments</td>
<td>25,654</td>
<td>0.5</td>
<td>2.0</td>
<td>1,428</td>
<td>Countervailing duties</td>
</tr>
<tr>
<td>Petroleum, crude and refined</td>
<td>3,601,596</td>
<td>0.5</td>
<td>1.6</td>
<td>167,863</td>
<td>Countervailing duties</td>
</tr>
<tr>
<td>Cement</td>
<td>112,090</td>
<td></td>
<td>3.1</td>
<td>10,998</td>
<td></td>
</tr>
<tr>
<td>Silver</td>
<td>267,754</td>
<td></td>
<td>2.3</td>
<td>14,059</td>
<td></td>
</tr>
<tr>
<td>Iron or steel products (containing other metallic minerals)</td>
<td>45,375</td>
<td>2.5</td>
<td>1.2</td>
<td>1,765</td>
<td>VERs</td>
</tr>
<tr>
<td>Hollow drill steel</td>
<td>42,202</td>
<td>6.2</td>
<td>1.4</td>
<td>1,999</td>
<td>VERs</td>
</tr>
<tr>
<td>Ternplate and terne-coated sheets</td>
<td>51,414</td>
<td>6.4</td>
<td>1.4</td>
<td>2,457</td>
<td>VERs</td>
</tr>
<tr>
<td>Rails, joint bars and tie plates, of steel</td>
<td>49,418</td>
<td>2.5</td>
<td>1.4</td>
<td>2,283</td>
<td>VERs</td>
</tr>
<tr>
<td>Copper, copper products</td>
<td>86,469</td>
<td>0.7</td>
<td>1.8</td>
<td>2,466</td>
<td></td>
</tr>
<tr>
<td>Zinc, zinc products</td>
<td>40,934</td>
<td>1.5</td>
<td>2.3</td>
<td>2,324</td>
<td></td>
</tr>
<tr>
<td>Articles of ferrous and nonferrous metals</td>
<td>41,404</td>
<td>-</td>
<td>1.0</td>
<td>1,608</td>
<td>Antidumping duties</td>
</tr>
<tr>
<td>Engine and engine parts</td>
<td>820,155</td>
<td>2.7</td>
<td>0.3</td>
<td>9,234</td>
<td></td>
</tr>
<tr>
<td>Machinery and mechanical equipment</td>
<td>164,182</td>
<td>2.3</td>
<td>0.3</td>
<td>1,952</td>
<td></td>
</tr>
<tr>
<td>Excavators, mechanical shovels, elevators hoists, cranes, etc.</td>
<td>88,982</td>
<td>1.6</td>
<td>0.3</td>
<td>1,248</td>
<td></td>
</tr>
<tr>
<td>Office machines</td>
<td>327,962</td>
<td>1.9</td>
<td>0.4</td>
<td>6,225</td>
<td></td>
</tr>
<tr>
<td>Other machines</td>
<td>259,855</td>
<td>3.6</td>
<td>0.3</td>
<td>4,055</td>
<td></td>
</tr>
<tr>
<td>Electric motors</td>
<td>488,311</td>
<td>2.9</td>
<td>0.4</td>
<td>8,341</td>
<td></td>
</tr>
<tr>
<td>Batteries, various electric machines</td>
<td>214,236</td>
<td>2.2</td>
<td>0.3</td>
<td>2,733</td>
<td></td>
</tr>
<tr>
<td>Electrodomestic equipment, telephone apparatus, televisions</td>
<td>530,181</td>
<td>4.1</td>
<td>0.3</td>
<td>7,306</td>
<td></td>
</tr>
<tr>
<td>Sound equipment</td>
<td>1,496,456</td>
<td>4.8</td>
<td>0.4</td>
<td>25,978</td>
<td></td>
</tr>
<tr>
<td>Current regulators, circuit breakers</td>
<td>96,592</td>
<td>5.0</td>
<td>0.4</td>
<td>1,723</td>
<td></td>
</tr>
<tr>
<td>Electric lamps, tubes</td>
<td>292,085</td>
<td>0.6</td>
<td>0.4</td>
<td>5,884</td>
<td></td>
</tr>
<tr>
<td>Electrical conductors</td>
<td>917,992</td>
<td>4.8</td>
<td>0.3</td>
<td>12,107</td>
<td></td>
</tr>
<tr>
<td>Motor vehicles (except motorcycles)</td>
<td>1,637,890</td>
<td>3.3</td>
<td>0.3</td>
<td>23,131</td>
<td></td>
</tr>
<tr>
<td>Motor vehicles (except motorcycles)</td>
<td>258,812</td>
<td>2.0</td>
<td>0.2</td>
<td>1,972</td>
<td></td>
</tr>
<tr>
<td>Sub-total</td>
<td>13,343,512</td>
<td>2.3</td>
<td>N/A</td>
<td>337,868</td>
<td></td>
</tr>
<tr>
<td>Other imports</td>
<td>5,367,826</td>
<td>N/A</td>
<td>N/A</td>
<td>37,795</td>
<td></td>
</tr>
<tr>
<td>Total imports</td>
<td>18,711,338</td>
<td>2.9</td>
<td>0.6</td>
<td>375,663</td>
<td></td>
</tr>
</tbody>
</table>
by the relevant industries in the United States. This procedure involves the simplifying and unrealistic assumption that the equalization of pollution control expenditures between Mexico and the United States requires the full allocation of U.S. expenditures on Mexico's exports, or in other words that Mexican industries spend nothing at all on pollution control. This assumption, together with the assignation of the highest possible PACE equalization tax in cases where more than one SIC number concorded to a single TSUSA number, imparts an upward bias to the estimates of the trade-reducing effects of a hypothetical PACE equalization tax reported in Table 7-2.

Even if a PACE equalization tax were to be adjusted by Mexico's own expenditures on pollution abatement and control, it is far from clear what the justification would be for an attempt to offset differences in these expenditure levels. In the first place, assimilative capacities between countries are likely to be different, so that the costs of attaining the same environmental standards would not be the same. Secondly, social preferences as to the acceptable level of environmental quality may well differ between countries, which would provide a further reason for expecting abatement and control costs to differ.

Cost equalization is even more difficult to justify when local pollution questions are at issue, as opposed to those involving transfrontier spillovers. Moreover, whatever the nature of the pollution problem, it is not obvious that the threat or the imposition of trade restrictions will have a positive effect on environmental quality. In this particular instance, the trade restrictions would amount to a resource transfer from Mexico to the United States. They would not reflect the kind of cooperative behavior that could lead to agreement on environmental standards, or on how to achieve them. In short, the underlying rationale for cost equalization proposals has more to do with competitive considerations than with environmental quality. The idea of simulating the trade effects of a cost equalization tax was initially provoked by a legislative proposal to this effect made recently in the U.S. Senate. What would the effects be on Mexico's exports if a cost equalization tax were introduced following the establishment of an FTA?

The data presented in Table 7-2 suggest that the trade effects of a PACE equalization tax would be very modest, amounting at most to a 2 percent loss in export earnings for Mexico. In addition to the reasons given above as to why this estimate of a PACE equalization tax is biased upward (zero pollution abatement expenditure in Mexico and nomenclature concordance procedures), another significant source of upward bias should be noted. This arises from the assignation of the same PACE equalization tax to crude and refined petroleum (1.6 percent -- see Table 7-2), when in effect this comparatively high rate should properly be applied only to refining activities, representing just 5 percent of Mexico's fuel exports to the United States in 1989. Exports of crude petroleum to the United States far exceed those of refined products.

While these procedures will impart an upward bias to the calculation of the effects of a PACE equalization tax, it is worth noting certain factors that could make U.S. pollution abatement and control

---

5The point made earlier about the difficulty of concording production and trade data applies equally in this case.

6The proposed legislation is the International Pollution Deterrence Act of 1991 (S.984). Under the legislation, U.S. countervailing duty law would be modified so that the failure to maintain effective pollution controls and environmental safeguards would constitute a countervailable subsidy. The amount of the subsidy would be calculated as the cost that would have to be incurred by a foreign manufacturer or producer to comply with environmental standards imposed on U.S. producers of the same products. Although this proposal is not strictly designed to attain cost equalization, it would probably have a comparable effect. In any event, it is significant that the legislation is cast in terms of pollution abatement costs rather than environmental standards.
expenditures higher than the data suggest. First, it would appear that the capital expenditure information (in respect of which a depreciation figure is given in the recurrent cross data) refers only to "end-of-the-pipe" expenditures and not to overall capital costs related to environmental quality considerations. Second, particular environmental policies (such as an outright prohibition on certain technologies or production processes) may raise industry costs, but not be reflected in the PACE data. It is difficult to gauge the likely magnitude of such considerations, but overall, abatement and control of expenditures cannot be said to represent an important cost item for most industries. On the other hand, stricter environmental standards in the future would undoubtedly raise these costs.

In general, it should be emphasized that these are approximate calculations, based on a number of simplifying assumptions. As noted earlier, it was assumed that all U.S. imports from Mexico were accorded duty-free treatment and that the PACE equalization tax, at an average rate of 0.6 percent (see Table 7-2), was then added back. The total trade effects of the PACE equalization tax were calculated using reduced form equations to measure trade creation and trade diversion. Several limitations of this approach to the calculation of the trade effects of a notional PACE equalization tax should be emphasized, including its static, short-term and partial nature. It should also be noted that for computational and data availability reasons, the trade data used in the simulation are quite old, relating to 1986. The trade creation and trade diversion equations require elasticity estimates for import demand, export supply and substitution (cross price elasticities). For the calculations in Table 7-2, the price elasticities of import demand were based on estimates that have been widely used in other studies. The export supply elasticity was assumed to be infinite (with a computing value of 99), and the cross elasticity of substitution was assigned a uniform value of -1.5.

How realistic are these assumptions, or more precisely, how sensitive are the simulation results to the elasticity values? Some sensitivity analysis is reported in Annex Table D. This analysis suggests a significant degree of sensitivity to the elasticity estimates, leading to a range in the estimates of export contraction for Mexico of between 1.2 percent and 2.6 percent of total exports. However, even though the elasticity assumptions have a significant effect on the magnitude of estimated export losses, the importance of this is greatly reduced by the fact that the numbers are so small in relation to total exports.

Annex Table E summarizes some other variations made in the simulation to see whether the application of a PACE equalization tax on Mexican exports would have a significantly different impact if other countries were also subject to the tax. As expected, the export contraction experienced by Mexico as a

7The author is grateful to David Wheeler for pointing this out.
8Trade creation is the increase in imports resulting from lower trade barriers, and trade diversion is the result of substitution among preferential and nonpreferential suppliers (with no increase in total trade). The magnitude of trade creation depends on the demand and supply elasticities of imports, and the degree of trade liberalization. The size of the trade diversion effect depends largely on the elasticity of substitution between preferential and nonpreferential suppliers, in relation to the price effects of the (preferential) trade liberalization. See Laird and Yeats (1990).
9See Cline et al. (1978), Stern et al. (1975) and Laird and Yeats (1990).
10It will be recalled that the simulation results reported in Table 7-2 assumed that Mexico went to free trade with the United States and then exclusively faced a PACE equalization tax.
result of the hypothetical tax becomes less the greater the number of affected countries. Once again, however, the modest magnitude of the numbers means that the overall effect is not very dramatic.

To sum up this section, it has been argued that current U.S. trade policy does not have any systematic differential effect on Mexican exports in terms of their pollution intensity. This applies both to variations in tariff levels and to the incidence of NTBs, with prevailing measures reflecting considerations other than environmental quality. Because pollution abatement and control costs are small in relation to industrial output in the United States, the effects on Mexico's exports of a PACE equalization tax are also small.

Conclusions

This paper has looked at one way -- the imposition of a hypothetical PACE equalization tax by the United States against Mexican exports -- in which trade policy might be used, at least ostensibly, to meet environmental objectives. There are three main reasons why such a policy would be flawed.

First, and most importantly, a PACE equalization tax or some similar arrangement would have very uncertain environmental consequences. The resource transfer implied by a PACE equalization tax, even if it were significantly larger than this paper has estimated it to be, would hardly guarantee a modification in the environmental behavior of the country upon whose exports the tax was levied. In the final analysis, a policy of this kind would be driven by considerations of competitiveness, and not of environmental quality. It would be a response to the notion that differential environmental standards, or perhaps even differential compliance costs for the same standards, were a source of unfair competition. If variations in the environmental assimilative capacities of countries, differences in social preferences, and the local (as opposed to transfrontier) nature of many environmental problems were taken into account, then this "remedial" application of trade policy would be hard to justify.

Secondly, as a policy designed to secure a "level playing field," or in other words to protect domestic industry from a cost disadvantage arising from governmental regulation, a PACE equalization tax would be largely ineffectual. It would provide a minor margin of protection to domestic industry, simply because the costs of complying with environmental standards represent a relatively small element in total costs. It would have nuisance value. This nuisance value might assume greater significance over time, however, if levels of pollution abatement and control expenditure were to increase, or an exporting country developed greater reliance on pollution-intensive products.

Thirdly, the nuisance value of a PACE equalization tax would be increased by the fact that it could well fall foul of GATT obligations. A tax applied discriminatorily against one country, as simulated in this paper, would be in breach of the most-favored-nation rule of Article I of the GATT. A PACE equalization tax that raise the total level of import charges above the maximum "bound" level committed to in GATT would also constitute an infringement, unless negotiations were undertaken to make the necessary compensatory tariff reductions on other imports.

In sum, a PACE equalization tax or any similar intervention would amount to bad environmental policy and bad trade policy, and it would carry negative consequences for the GATT trading system.

11Environmental objectives may also be addressed through trade measures in order to enforce domestic product standards, to enforce international agreements and to persuade other countries, through encouragement or threat, to adopt a particular set of environmental standards.
### Annex Table A: POLLUTION ABATEMENT OPERATING COSTS BY U.S. INDUSTRY, 1988

(In Millions of U.S. Dollars)

<table>
<thead>
<tr>
<th>SIC</th>
<th>Industry</th>
<th>Pollution abatement operating cost</th>
<th>Industry output</th>
<th>Share of total industry output</th>
</tr>
</thead>
<tbody>
<tr>
<td>324</td>
<td>Cement, hydraulic</td>
<td>134.1</td>
<td>4,234.3</td>
<td>0.17</td>
</tr>
<tr>
<td>261</td>
<td>Pulp mills</td>
<td>127.5</td>
<td>5,260.1</td>
<td>0.24</td>
</tr>
<tr>
<td>245</td>
<td>Wood buildings/mobile homes</td>
<td>158.2</td>
<td>6,627.3</td>
<td>0.26</td>
</tr>
<tr>
<td>333</td>
<td>Primary nonferrous metals</td>
<td>372.3</td>
<td>15,918.4</td>
<td>0.62</td>
</tr>
<tr>
<td>281</td>
<td>Industrial inorganic chems</td>
<td>188.3</td>
<td>3,109.6</td>
<td>0.66</td>
</tr>
<tr>
<td>286</td>
<td>Industrial organic chems</td>
<td>1,275.4</td>
<td>59,971.7</td>
<td>2.34</td>
</tr>
<tr>
<td>263</td>
<td>Paperboard mills</td>
<td>334.6</td>
<td>16,094.2</td>
<td>0.63</td>
</tr>
<tr>
<td>262</td>
<td>Paper mills</td>
<td>661.2</td>
<td>33,545.8</td>
<td>1.97</td>
</tr>
<tr>
<td>287</td>
<td>Agricultural chems.</td>
<td>312.6</td>
<td>16,077.1</td>
<td>1.94</td>
</tr>
<tr>
<td>332</td>
<td>Iron and steel foundries</td>
<td>220.6</td>
<td>12,006.4</td>
<td>1.57</td>
</tr>
<tr>
<td>291</td>
<td>Petroleum refining</td>
<td>1,919.3</td>
<td>118,829.5</td>
<td>4.63</td>
</tr>
</tbody>
</table>

... (Continued with more entries...)
Annex Table A cont'd.

<table>
<thead>
<tr>
<th>SIC</th>
<th>Industry</th>
<th>Pollution abatement operating cost</th>
<th>Industry output</th>
<th>Cost/output</th>
<th>Share of total industry output</th>
</tr>
</thead>
<tbody>
<tr>
<td>369</td>
<td>Misc. elec. equip./supplies</td>
<td>66.6</td>
<td>23,013.6</td>
<td>0.29</td>
<td>0.90</td>
</tr>
<tr>
<td>363</td>
<td>Household appliances</td>
<td>49.6</td>
<td>17,332.4</td>
<td>0.29</td>
<td>0.68</td>
</tr>
<tr>
<td>351</td>
<td>Engines and turbines</td>
<td>45.7</td>
<td>16,223.1</td>
<td>0.28</td>
<td>0.63</td>
</tr>
<tr>
<td>202</td>
<td>Dairy products</td>
<td>130.1</td>
<td>46,994.3</td>
<td>0.28</td>
<td>1.83</td>
</tr>
<tr>
<td>307</td>
<td>Misc. plastics prods.</td>
<td>181.2</td>
<td>67,242.3</td>
<td>0.27</td>
<td>2.62</td>
</tr>
<tr>
<td>358</td>
<td>Refrigeration/service machinery</td>
<td>68.1</td>
<td>25,578.7</td>
<td>0.27</td>
<td>1.00</td>
</tr>
<tr>
<td>223</td>
<td>Weaving/finishing, wool</td>
<td>5.1</td>
<td>1,928.4</td>
<td>0.26</td>
<td>0.08</td>
</tr>
<tr>
<td>275</td>
<td>Commercial printing</td>
<td>123.5</td>
<td>47,459.5</td>
<td>0.26</td>
<td>1.85</td>
</tr>
<tr>
<td>284</td>
<td>Soaps, cleaners &amp; toilet goods</td>
<td>97.4</td>
<td>37,856.2</td>
<td>0.26</td>
<td>1.48</td>
</tr>
<tr>
<td>251</td>
<td>Household furniture</td>
<td>48.1</td>
<td>19,130.8</td>
<td>0.25</td>
<td>0.75</td>
</tr>
<tr>
<td>393</td>
<td>Musical instruments</td>
<td>2.2</td>
<td>875.8</td>
<td>0.25</td>
<td>0.03</td>
</tr>
<tr>
<td>325</td>
<td>Prods. of purchased glass</td>
<td>14.5</td>
<td>5,800.8</td>
<td>0.25</td>
<td>0.23</td>
</tr>
<tr>
<td>379</td>
<td>Motor vehicles/equip</td>
<td>548.1</td>
<td>221,575.4</td>
<td>0.25</td>
<td>8.64</td>
</tr>
<tr>
<td>394</td>
<td>Misc. transport equip.</td>
<td>13.8</td>
<td>5,655.3</td>
<td>0.24</td>
<td>0.22</td>
</tr>
<tr>
<td>222</td>
<td>Weaving mills, synthetic</td>
<td>20.1</td>
<td>8,462.6</td>
<td>0.24</td>
<td>0.33</td>
</tr>
<tr>
<td>354</td>
<td>Metalworking machinery</td>
<td>55.2</td>
<td>24,365.5</td>
<td>0.23</td>
<td>0.95</td>
</tr>
<tr>
<td>376</td>
<td>Guided missiles/space vehicles</td>
<td>60.7</td>
<td>28,159.7</td>
<td>0.22</td>
<td>1.10</td>
</tr>
<tr>
<td>205</td>
<td>Bakery products</td>
<td>51.8</td>
<td>24,156.8</td>
<td>0.21</td>
<td>0.94</td>
</tr>
<tr>
<td>201</td>
<td>Meat Products</td>
<td>170.8</td>
<td>81,188.7</td>
<td>0.21</td>
<td>3.16</td>
</tr>
<tr>
<td>304</td>
<td>Rubber/plastic hose/belting</td>
<td>10.7</td>
<td>5,268.1</td>
<td>0.20</td>
<td>0.21</td>
</tr>
<tr>
<td>377</td>
<td>Sawmills and planing</td>
<td>40.8</td>
<td>20,154.3</td>
<td>0.20</td>
<td>0.78</td>
</tr>
<tr>
<td>327</td>
<td>Concrete, gypsum &amp; plaster</td>
<td>49.1</td>
<td>24,365.5</td>
<td>0.20</td>
<td>0.96</td>
</tr>
<tr>
<td>316</td>
<td>Luggage</td>
<td>1.9</td>
<td>956.7</td>
<td>0.20</td>
<td>0.04</td>
</tr>
<tr>
<td>352</td>
<td>Farm/garden machinery</td>
<td>26.7</td>
<td>13,560.1</td>
<td>0.20</td>
<td>0.53</td>
</tr>
<tr>
<td>278</td>
<td>Blankbooks/bookbinding</td>
<td>8.3</td>
<td>4,267.1</td>
<td>0.19</td>
<td>0.17</td>
</tr>
<tr>
<td>255</td>
<td>Knitting mills</td>
<td>25.5</td>
<td>13,223.7</td>
<td>0.19</td>
<td>0.52</td>
</tr>
<tr>
<td>399</td>
<td>Misc. manufactures</td>
<td>23.7</td>
<td>13,223.7</td>
<td>0.18</td>
<td>0.52</td>
</tr>
<tr>
<td>349</td>
<td>Misc. fabricated metal prods.</td>
<td>47.8</td>
<td>27,261.6</td>
<td>0.18</td>
<td>1.06</td>
</tr>
<tr>
<td>353</td>
<td>Construction/related machinery</td>
<td>48.1</td>
<td>27,749.4</td>
<td>0.17</td>
<td>0.88</td>
</tr>
<tr>
<td>355</td>
<td>Misc. mach., nonelectric</td>
<td>37.9</td>
<td>21,875.7</td>
<td>0.17</td>
<td>0.85</td>
</tr>
<tr>
<td>259</td>
<td>Public building furn.</td>
<td>6.1</td>
<td>3,848.7</td>
<td>0.16</td>
<td>0.15</td>
</tr>
<tr>
<td>382</td>
<td>Measuring/controlling devices</td>
<td>41.7</td>
<td>26,813.9</td>
<td>0.16</td>
<td>1.04</td>
</tr>
<tr>
<td>276</td>
<td>Manifold business forms</td>
<td>11.6</td>
<td>7,781.4</td>
<td>0.15</td>
<td>0.30</td>
</tr>
<tr>
<td>244</td>
<td>Wood containers</td>
<td>3.4</td>
<td>2,294.4</td>
<td>0.15</td>
<td>0.09</td>
</tr>
<tr>
<td>335</td>
<td>Watches/clocks/watchcases</td>
<td>3.1</td>
<td>1,295.4</td>
<td>0.14</td>
<td>0.05</td>
</tr>
<tr>
<td>228</td>
<td>Yarn and thread mills</td>
<td>14.1</td>
<td>10,320.3</td>
<td>0.14</td>
<td>0.40</td>
</tr>
<tr>
<td>384</td>
<td>Medical instruments/supplies</td>
<td>34.3</td>
<td>25,329.9</td>
<td>0.14</td>
<td>0.99</td>
</tr>
<tr>
<td>227</td>
<td>Floor covering mills (textiles)</td>
<td>15.8</td>
<td>10,256.1</td>
<td>0.13</td>
<td>0.40</td>
</tr>
<tr>
<td>279</td>
<td>Printing trade services</td>
<td>5.3</td>
<td>4,478.5</td>
<td>0.12</td>
<td>0.17</td>
</tr>
<tr>
<td>311</td>
<td>Footwear except rubber</td>
<td>4.7</td>
<td>1,638.1</td>
<td>0.11</td>
<td>0.17</td>
</tr>
<tr>
<td>211</td>
<td>Cigarettes</td>
<td>22.1</td>
<td>20,078.3</td>
<td>0.11</td>
<td>0.78</td>
</tr>
<tr>
<td>213</td>
<td>Chewing/smoking tobacco</td>
<td>1.3</td>
<td>1,105.1</td>
<td>0.11</td>
<td>0.05</td>
</tr>
<tr>
<td>273</td>
<td>Books</td>
<td>17.8</td>
<td>17,136.6</td>
<td>0.10</td>
<td>0.67</td>
</tr>
<tr>
<td>321</td>
<td>Newspapers</td>
<td>35.7</td>
<td>32,926.8</td>
<td>0.10</td>
<td>1.28</td>
</tr>
<tr>
<td>365</td>
<td>Radio/TV receiving equip.</td>
<td>7.1</td>
<td>8,360.4</td>
<td>0.08</td>
<td>0.33</td>
</tr>
<tr>
<td>277</td>
<td>Greeting card publishing</td>
<td>3.2</td>
<td>3,081.7</td>
<td>0.07</td>
<td>0.12</td>
</tr>
<tr>
<td>241</td>
<td>Logging</td>
<td>8.1</td>
<td>11,663.8</td>
<td>0.07</td>
<td>0.45</td>
</tr>
<tr>
<td>391</td>
<td>Jewelry/silverware/plated ware</td>
<td>3.8</td>
<td>5,768.7</td>
<td>0.07</td>
<td>0.22</td>
</tr>
<tr>
<td>357</td>
<td>Office &amp; computing machines</td>
<td>27.6</td>
<td>67,643.9</td>
<td>0.06</td>
<td>2.64</td>
</tr>
<tr>
<td>381</td>
<td>Search/navigation equip.</td>
<td>7.6</td>
<td>36,509.5</td>
<td>0.02</td>
<td>1.43</td>
</tr>
<tr>
<td>272</td>
<td>Periodicals</td>
<td>3.8</td>
<td>18,611.8</td>
<td>0.02</td>
<td>0.73</td>
</tr>
<tr>
<td>274</td>
<td>Misc. publishing</td>
<td>1.1</td>
<td>8,154.4</td>
<td>0.01</td>
<td>0.32</td>
</tr>
</tbody>
</table>

All Industries 14,008.6 2,617,476.9 0.54 100.00


Notes:
1. The data cover firms of 20 employees or more with pollution abatement costs in excess of US$1 million.
2. Major SIC Group 23 (Apparel and other textile products) are excluded from the survey.
### Annex Table B: MEXICO'S EXPORTS TO THE UNITED STATES OF DIRTY INDUSTRY PRODUCTS, 1981-89  
**((In Thousands of U.S. Dollars))**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>Pulp and Waste Paper</td>
<td>81 0.0</td>
<td>222 0.0</td>
<td>137 0.0</td>
<td>540 0.0</td>
<td>739 0.0</td>
<td>8,384 0.0</td>
<td>48%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Petroleum and Products</td>
<td>329,577 2.4</td>
<td>262,797 1.7</td>
<td>894,102 4.9</td>
<td>374,827 1.6</td>
<td>218,358 0.8</td>
<td>-3%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>Organic Chemicals</td>
<td>3,370 0.1</td>
<td>12,064 0.1</td>
<td>43,889 0.2</td>
<td>22,007 0.1</td>
<td>7,058 0.0</td>
<td>-7%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>Dyes, Tanning, Colour Prod</td>
<td>167,373 1.2</td>
<td>168,631 1.1</td>
<td>153,097 0.8</td>
<td>96,831 0.6</td>
<td>154,312 0.7</td>
<td>-4%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>Medicinal, Pharm Products</td>
<td>12,015 0.1</td>
<td>10,065 0.1</td>
<td>24,677 0.1</td>
<td>27,870 0.2</td>
<td>46,491 0.2</td>
<td>17%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>Plastic Materials Etc</td>
<td>602 0.0</td>
<td>1,124 0.0</td>
<td>8,183 0.0</td>
<td>60,961 0.3</td>
<td>63,191 0.3</td>
<td>5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>Chemical Materials Etc</td>
<td>2,632 0.0</td>
<td>773 0.0</td>
<td>2,141 0.0</td>
<td>3,131 0.0</td>
<td>13,164 0.1</td>
<td>16%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>Wood, Cork Manufactures Etc</td>
<td>28,929 0.2</td>
<td>32,474 0.2</td>
<td>56,175 0.3</td>
<td>60,195 0.3</td>
<td>96,768 0.4</td>
<td>4%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>Paper, Paperboard and Mfr</td>
<td>44,370 0.3</td>
<td>39,098 0.2</td>
<td>37,905 0.2</td>
<td>37,407 0.2</td>
<td>58,042 0.2</td>
<td>4%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>Miscellaneous Etc</td>
<td>5,522 0.0</td>
<td>6,264 0.0</td>
<td>41,550 0.2</td>
<td>62,613 0.4</td>
<td>130,830 0.6</td>
<td>43%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>67</td>
<td>Lime, Cement, Building Materials</td>
<td>10,657 0.1</td>
<td>12,576 0.1</td>
<td>86,748 0.5</td>
<td>142,853 0.8</td>
<td>166,600 0.7</td>
<td>35%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>68</td>
<td>Mineral Manufactures Etc</td>
<td>12,205 0.1</td>
<td>13,300 0.1</td>
<td>13,325 0.1</td>
<td>15,723 0.1</td>
<td>24,859 0.1</td>
<td>7%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Annex Table B cont'd.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>664 GLASS</td>
<td>8,017</td>
<td>0.1</td>
<td>27,118</td>
<td>0.2</td>
<td>55,949</td>
<td>0.3</td>
<td>82,487 0.5</td>
</tr>
<tr>
<td>665 GLASSWARE</td>
<td>14,830</td>
<td>0.1</td>
<td>16,613</td>
<td>0.1</td>
<td>32,707</td>
<td>0.2</td>
<td>42,032 0.2</td>
</tr>
<tr>
<td>673 IRON AND STEEL</td>
<td>2,340</td>
<td>0.0</td>
<td>13,147</td>
<td>0.1</td>
<td>61,390</td>
<td>0.3</td>
<td>27,912 0.2</td>
</tr>
<tr>
<td>674 IRON, STEEL</td>
<td>19,518</td>
<td>0.1</td>
<td>14,014</td>
<td>0.1</td>
<td>18,295</td>
<td>0.1</td>
<td>18,024 0.1</td>
</tr>
<tr>
<td>676 RAILWAY RAILS ETC</td>
<td>0 0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>22 0.0</td>
<td>76 0.0</td>
</tr>
<tr>
<td>677 IRON, STEEL CASTINGS UNWORKD</td>
<td>752 0.0</td>
<td>112 0.0</td>
<td>1,670 0.0</td>
<td>0.0</td>
<td>1,534</td>
<td>0.0</td>
<td>320,487 1.2</td>
</tr>
<tr>
<td>681 SILVER, PLATINUM, ETC</td>
<td>207,463 1.5</td>
<td>189,969 1.2</td>
<td>310,741 1.7</td>
<td>238,173 1.4</td>
<td>244,014 1.0</td>
<td>320,487 1.2</td>
<td></td>
</tr>
<tr>
<td>682 COPPER EXC CEMENT COPPER</td>
<td>41,004 0.3</td>
<td>23,690 0.2</td>
<td>40,675 0.2</td>
<td>85,008 0.5</td>
<td>268,311 1.1</td>
<td>204,418 0.7</td>
<td></td>
</tr>
<tr>
<td>684 ALUMINIUM</td>
<td>648 0.0</td>
<td>367 0.0</td>
<td>4,807 0.0</td>
<td>4,627 0.0</td>
<td>33,155 0.1</td>
<td>16,607 0.1</td>
<td></td>
</tr>
<tr>
<td>685 LEAD</td>
<td>25,386 0.2</td>
<td>12,494 0.1</td>
<td>20,064 0.1</td>
<td>11,786 0.1</td>
<td>19,864 0.1</td>
<td>43%</td>
<td></td>
</tr>
<tr>
<td>686 ZINC</td>
<td>14,437 0.3</td>
<td>18,371 0.1</td>
<td>57,507 0.3</td>
<td>38,899 0.2</td>
<td>74,239 0.3</td>
<td>118,844 0.4</td>
<td></td>
</tr>
<tr>
<td>689 NONFER BASE METALS NES</td>
<td>5,001 0.0</td>
<td>1,579 0.0</td>
<td>2,646 0.0</td>
<td>0.0</td>
<td>4,281 0.0</td>
<td>6,033 0.0</td>
<td></td>
</tr>
<tr>
<td>691 STRUCTURES AND PARTS NES</td>
<td>3,989 0.0</td>
<td>2,221 0.0</td>
<td>4,119 0.0</td>
<td>3,871 0.0</td>
<td>6,414 0.0</td>
<td>10,394 0.0</td>
<td></td>
</tr>
<tr>
<td>692 METAL TANKS, BOXES, ETC</td>
<td>1,913 0.0</td>
<td>1,314 0.0</td>
<td>11,429 0.1</td>
<td>21,238 0.1</td>
<td>32,007 0.1</td>
<td>28,736 0.1</td>
<td></td>
</tr>
<tr>
<td>693 WIRE PRODUCTS NON ELECTR</td>
<td>4,787 0.0</td>
<td>5,358 0.0</td>
<td>8,933 0.0</td>
<td>15,407 0.1</td>
<td>21,439 0.1</td>
<td>30,615 0.1</td>
<td></td>
</tr>
<tr>
<td>694 STL, COPPR NAILS, NUTS, ETC</td>
<td>762 0.0</td>
<td>1,995 0.0</td>
<td>3,387 0.0</td>
<td>3,668 0.0</td>
<td>12,017 0.1</td>
<td>12,495 0.1</td>
<td></td>
</tr>
<tr>
<td>695 TOOLS</td>
<td>17,023 0.1</td>
<td>9,305 0.1</td>
<td>15,672 0.1</td>
<td>23,049 0.1</td>
<td>29,483 0.1</td>
<td>31,475 0.1</td>
<td></td>
</tr>
<tr>
<td>696 CUTLERY</td>
<td>175 0.0</td>
<td>207 0.0</td>
<td>627 0.0</td>
<td>454 0.0</td>
<td>4,278 0.0</td>
<td>43%</td>
<td></td>
</tr>
<tr>
<td>697 BASE METL HOUSEHOLD EQUIP</td>
<td>8,354 0.1</td>
<td>6,996 0.1</td>
<td>10,428 0.1</td>
<td>15,672 0.1</td>
<td>47,206 0.1</td>
<td>31,475 0.1</td>
<td></td>
</tr>
<tr>
<td>699 BASE METAL MFRS NES</td>
<td>55,646 0.4</td>
<td>67,539 0.4</td>
<td>98,821 0.5</td>
<td>134,628 0.8</td>
<td>232,564 1.0</td>
<td>297,958 1.1</td>
<td></td>
</tr>
</tbody>
</table>

**SUB-TOTAL**: 1,198,765 8.6 1,143,274 7.2 2,704,909 14.8 2,103,896 12.0 3,097,171 13.0 3,043,270 11.1 9%

**OTHER COMMODITIES**: 12,614,511 91.4 14,626,833 92.8 15,561,959 85.2 15,442,595 88.0 20,477,330 87.0 24,496,793 88.9 3%

**TOTAL ALL COMMODITIES**: 14,013,276 100.0 15,770,107 100.0 18,266,868 100.0 17,546,491 100.0 23,544,501 100.0 27,540,063 100.0 3%

Source: CONTRADE Data files.

**Notes**:  
1. These are import statistics because Mexico's export statistics in CONTRADE do not report "maquila" output.  
2. The compound growth rates in the final column were calculated on the basis of the average of 1981/82 and 1988/89 trade.  
3. The deflator used is the Unit Value Index in U.S. dollars terms of manufactures exported from the G-5 countries (France, Germany, Japan, United Kingdom and United States), weighted proportionately to the countries' exports to the developing countries.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>25 PULP AND WASTE PAPER</td>
<td>454</td>
<td>0.0</td>
<td>1,370</td>
<td>0.0</td>
<td>1,395</td>
<td>0.0</td>
<td>807</td>
<td>0.0</td>
<td>34,804</td>
<td>0.1</td>
<td>29,719</td>
<td>0.1</td>
<td>51%</td>
</tr>
<tr>
<td>33 PETROLEUM AND PRODUCTS</td>
<td>525,017</td>
<td>2.4</td>
<td>676,687</td>
<td>2.7</td>
<td>958,710</td>
<td>3.5</td>
<td>501,195</td>
<td>2.1</td>
<td>652,599</td>
<td>2.0</td>
<td>231,158</td>
<td>0.7</td>
<td>-7%</td>
</tr>
<tr>
<td>334 PETROLEUM PRODUCTS, REFIN</td>
<td>10,031</td>
<td>0.0</td>
<td>6,264</td>
<td>0.0</td>
<td>165,252</td>
<td>0.6</td>
<td>24,250</td>
<td>0.1</td>
<td>40,379</td>
<td>0.1</td>
<td>36,823</td>
<td>0.1</td>
<td>17%</td>
</tr>
<tr>
<td>335 RESIDUAL PETROLM PROD NES</td>
<td>293,468</td>
<td>1.3</td>
<td>225,089</td>
<td>0.9</td>
<td>191,545</td>
<td>0.7</td>
<td>127,886</td>
<td>0.5</td>
<td>204,345</td>
<td>0.6</td>
<td>194,853</td>
<td>0.6</td>
<td>-6%</td>
</tr>
<tr>
<td>336 ORGANIC CHEMICALS</td>
<td>50,126</td>
<td>0.2</td>
<td>26,634</td>
<td>0.1</td>
<td>37,103</td>
<td>0.1</td>
<td>59,678</td>
<td>0.2</td>
<td>91,028</td>
<td>0.3</td>
<td>97,608</td>
<td>0.3</td>
<td>8%</td>
</tr>
<tr>
<td>34 INORGANIC CHEMICALS</td>
<td>2,522</td>
<td>0.0</td>
<td>2,938</td>
<td>0.0</td>
<td>9,391</td>
<td>0.0</td>
<td>9,570</td>
<td>0.0</td>
<td>28,308</td>
<td>0.1</td>
<td>26,420</td>
<td>0.1</td>
<td>29%</td>
</tr>
<tr>
<td>35 MEDICINAL PHARM PRODUCTS</td>
<td>27,684</td>
<td>0.1</td>
<td>21,695</td>
<td>0.1</td>
<td>18,927</td>
<td>0.1</td>
<td>37,768</td>
<td>0.2</td>
<td>65,090</td>
<td>0.2</td>
<td>32,684</td>
<td>0.1</td>
<td>5%</td>
</tr>
<tr>
<td>351 HYDROCARBONS NES, DERIVS</td>
<td>69,722</td>
<td>0.3</td>
<td>60,468</td>
<td>0.1</td>
<td>18,927</td>
<td>0.1</td>
<td>37,768</td>
<td>0.2</td>
<td>65,090</td>
<td>0.2</td>
<td>32,684</td>
<td>0.1</td>
<td>5%</td>
</tr>
<tr>
<td>352 DYES, TANNING, COLOUR PROD</td>
<td>15,277</td>
<td>0.1</td>
<td>16,325</td>
<td>0.1</td>
<td>31,756</td>
<td>0.1</td>
<td>51,700</td>
<td>0.1</td>
<td>52,022</td>
<td>0.1</td>
<td>45,208</td>
<td>0.1</td>
<td>8%</td>
</tr>
<tr>
<td>353 PIGMENTS, PAINTS, ETC</td>
<td>3,745</td>
<td>0.0</td>
<td>5,972</td>
<td>0.0</td>
<td>4,545</td>
<td>0.0</td>
<td>12,989</td>
<td>0.1</td>
<td>24,731</td>
<td>0.1</td>
<td>3,762</td>
<td>0.0</td>
<td>11%</td>
</tr>
<tr>
<td>52 DYES, TANNING, COLOUR PROD</td>
<td>2,522</td>
<td>0.0</td>
<td>2,938</td>
<td>0.0</td>
<td>9,391</td>
<td>0.0</td>
<td>9,570</td>
<td>0.0</td>
<td>28,308</td>
<td>0.1</td>
<td>26,420</td>
<td>0.1</td>
<td>29%</td>
</tr>
<tr>
<td>522 INORG ELEMTS, OXIDES, ETC</td>
<td>27,684</td>
<td>0.1</td>
<td>21,695</td>
<td>0.1</td>
<td>18,927</td>
<td>0.1</td>
<td>37,768</td>
<td>0.2</td>
<td>65,090</td>
<td>0.2</td>
<td>32,684</td>
<td>0.1</td>
<td>5%</td>
</tr>
<tr>
<td>523 OTHER INORG CHEMICALS ETC</td>
<td>69,722</td>
<td>0.3</td>
<td>60,468</td>
<td>0.1</td>
<td>47,734</td>
<td>0.2</td>
<td>82,275</td>
<td>0.3</td>
<td>88,574</td>
<td>0.3</td>
<td>26,420</td>
<td>0.1</td>
<td>29%</td>
</tr>
<tr>
<td>53 OTHER ORGANIC CHEMICALS</td>
<td>15,277</td>
<td>0.1</td>
<td>16,325</td>
<td>0.1</td>
<td>31,756</td>
<td>0.1</td>
<td>51,700</td>
<td>0.1</td>
<td>52,022</td>
<td>0.1</td>
<td>45,208</td>
<td>0.1</td>
<td>8%</td>
</tr>
<tr>
<td>531 MEDICINAL PHARM PRODUCTS</td>
<td>3,745</td>
<td>0.0</td>
<td>5,972</td>
<td>0.0</td>
<td>4,545</td>
<td>0.0</td>
<td>12,989</td>
<td>0.1</td>
<td>24,731</td>
<td>0.1</td>
<td>3,762</td>
<td>0.0</td>
<td>11%</td>
</tr>
<tr>
<td>532 DYES, TANNING, COLOUR PROD</td>
<td>27,684</td>
<td>0.1</td>
<td>21,695</td>
<td>0.1</td>
<td>18,927</td>
<td>0.1</td>
<td>37,768</td>
<td>0.2</td>
<td>65,090</td>
<td>0.2</td>
<td>32,684</td>
<td>0.1</td>
<td>5%</td>
</tr>
<tr>
<td>55 MEDICAL, PHARM PRODUCTS</td>
<td>69,722</td>
<td>0.3</td>
<td>60,468</td>
<td>0.1</td>
<td>47,734</td>
<td>0.2</td>
<td>82,275</td>
<td>0.3</td>
<td>88,574</td>
<td>0.3</td>
<td>26,420</td>
<td>0.1</td>
<td>29%</td>
</tr>
<tr>
<td>551 MEDICAL, PHARM PRODUCTS</td>
<td>15,277</td>
<td>0.1</td>
<td>16,325</td>
<td>0.1</td>
<td>31,756</td>
<td>0.1</td>
<td>51,700</td>
<td>0.1</td>
<td>52,022</td>
<td>0.1</td>
<td>45,208</td>
<td>0.1</td>
<td>8%</td>
</tr>
<tr>
<td>552 PROD OF CONDENSATION ETC</td>
<td>3,745</td>
<td>0.0</td>
<td>5,972</td>
<td>0.0</td>
<td>4,545</td>
<td>0.0</td>
<td>12,989</td>
<td>0.1</td>
<td>24,731</td>
<td>0.1</td>
<td>3,762</td>
<td>0.0</td>
<td>11%</td>
</tr>
<tr>
<td>553 PESTICIDES, DISINFECTANTS</td>
<td>26,841</td>
<td>0.1</td>
<td>23,426</td>
<td>0.1</td>
<td>76,412</td>
<td>0.3</td>
<td>34,270</td>
<td>0.1</td>
<td>44,865</td>
<td>0.1</td>
<td>39,038</td>
<td>0.1</td>
<td>3%</td>
</tr>
<tr>
<td>559 MISCEL CHEM PRODUCTS NES</td>
<td>29,283</td>
<td>0.1</td>
<td>36,614</td>
<td>0.1</td>
<td>56,796</td>
<td>0.2</td>
<td>60,343</td>
<td>0.3</td>
<td>96,113</td>
<td>0.3</td>
<td>11,349</td>
<td>0.0</td>
<td>3%</td>
</tr>
<tr>
<td>563 VENEERS, PLYWOOD, ETC</td>
<td>46,074</td>
<td>0.2</td>
<td>51,969</td>
<td>0.2</td>
<td>39,536</td>
<td>0.1</td>
<td>38,267</td>
<td>0.2</td>
<td>59,364</td>
<td>0.2</td>
<td>95,772</td>
<td>0.3</td>
<td>2%</td>
</tr>
<tr>
<td>564 PAPER, PAPERBOARD</td>
<td>11,856</td>
<td>0.1</td>
<td>12,741</td>
<td>0.1</td>
<td>47,360</td>
<td>0.2</td>
<td>65,368</td>
<td>0.3</td>
<td>175,283</td>
<td>0.5</td>
<td>154,218</td>
<td>0.4</td>
<td>34%</td>
</tr>
<tr>
<td>565 WOOD MANUFACTURES NES</td>
<td>85,670</td>
<td>0.4</td>
<td>112,949</td>
<td>0.4</td>
<td>111,004</td>
<td>0.4</td>
<td>163,550</td>
<td>0.7</td>
<td>231,146</td>
<td>0.7</td>
<td>253,490</td>
<td>0.7</td>
<td>8%</td>
</tr>
<tr>
<td>566 CEMENT, BLDG PRODS</td>
<td>12,748</td>
<td>0.1</td>
<td>20,614</td>
<td>0.1</td>
<td>88,764</td>
<td>0.3</td>
<td>143,715</td>
<td>0.6</td>
<td>174,276</td>
<td>0.5</td>
<td>169,500</td>
<td>0.5</td>
<td>20%</td>
</tr>
<tr>
<td>567 MINERAL MANUFACTURES NES</td>
<td>15,556</td>
<td>0.1</td>
<td>18,244</td>
<td>0.1</td>
<td>13,627</td>
<td>0.0</td>
<td>18,107</td>
<td>0.1</td>
<td>29,532</td>
<td>0.1</td>
<td>35,020</td>
<td>0.1</td>
<td>5%</td>
</tr>
</tbody>
</table>
### Annex Table C cont'd.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value</td>
<td>Share</td>
<td>Value</td>
<td>Share</td>
<td>Value</td>
<td>Share</td>
</tr>
<tr>
<td>664</td>
<td>GLASS</td>
<td>11,761</td>
<td>0.1</td>
<td>37,341</td>
<td>0.1</td>
<td>73,839</td>
</tr>
<tr>
<td>665</td>
<td>GLASSWARE</td>
<td>41,299</td>
<td>0.2</td>
<td>29,537</td>
<td>0.1</td>
<td>39,915</td>
</tr>
<tr>
<td>67</td>
<td>IRON AND STEEL</td>
<td>31,122</td>
<td>0.1</td>
<td>17,809</td>
<td>0.1</td>
<td>86,105</td>
</tr>
<tr>
<td>21%</td>
<td></td>
<td>671</td>
<td>PIG IRON ETC</td>
<td>21,914</td>
<td>0.1</td>
<td>15,200</td>
</tr>
<tr>
<td>11%</td>
<td></td>
<td>672</td>
<td>IRON, STEEL PRIMARY FORMS</td>
<td>5,149</td>
<td>0.0</td>
<td>5,149</td>
</tr>
<tr>
<td>41%</td>
<td></td>
<td>673</td>
<td>IRON, STEEL SHAPES ETC</td>
<td>19,057</td>
<td>0.1</td>
<td>31,379</td>
</tr>
<tr>
<td>18%</td>
<td></td>
<td>674</td>
<td>IRON, STEEL UNIV, PLATE, SHEET</td>
<td>7,792</td>
<td>0.0</td>
<td>7,792</td>
</tr>
<tr>
<td>18%</td>
<td></td>
<td>675</td>
<td>IRON, STEEL HOOP, STRIP</td>
<td>423</td>
<td>0.0</td>
<td>423</td>
</tr>
<tr>
<td>17%</td>
<td></td>
<td>676</td>
<td>RAILWAY RAILS ETC</td>
<td>433,161</td>
<td>2.0</td>
<td>433,161</td>
</tr>
<tr>
<td>-1%</td>
<td></td>
<td>677</td>
<td>IRON, STEEL IND, EXCL</td>
<td>452</td>
<td>0.0</td>
<td>452</td>
</tr>
<tr>
<td>14%</td>
<td></td>
<td>678</td>
<td>IRON, STEEL TUBES, PIPES, ETC</td>
<td>11,714</td>
<td>0.0</td>
<td>11,714</td>
</tr>
<tr>
<td>13%</td>
<td></td>
<td>679</td>
<td>IRON, STEEL CASTINGS</td>
<td>1,869</td>
<td>0.0</td>
<td>1,869</td>
</tr>
<tr>
<td>22%</td>
<td></td>
<td>68</td>
<td>NONFERROUS METALS</td>
<td>3,240</td>
<td>0.0</td>
<td>3,240</td>
</tr>
<tr>
<td>13%</td>
<td></td>
<td>681</td>
<td>SILVER, PLATINUM, ETC</td>
<td>433,161</td>
<td>2.0</td>
<td>433,161</td>
</tr>
<tr>
<td></td>
<td></td>
<td>682</td>
<td>COPPER EXC CEMENT COPPER</td>
<td>42,672</td>
<td>0.2</td>
<td>42,672</td>
</tr>
<tr>
<td>20%</td>
<td></td>
<td>683</td>
<td>ALUMINUM</td>
<td>6,695</td>
<td>0.1</td>
<td>6,695</td>
</tr>
<tr>
<td>-5%</td>
<td></td>
<td>684</td>
<td>LEAD</td>
<td>78,904</td>
<td>0.3</td>
<td>78,904</td>
</tr>
<tr>
<td>33%</td>
<td></td>
<td>685</td>
<td>ZINC</td>
<td>317</td>
<td>0.0</td>
<td>317</td>
</tr>
<tr>
<td>18%</td>
<td></td>
<td>686</td>
<td>STRUCTURES AND PARTS NES</td>
<td>78,116</td>
<td>0.3</td>
<td>78,116</td>
</tr>
<tr>
<td>13%</td>
<td></td>
<td>687</td>
<td>TOOLS</td>
<td>317</td>
<td>0.0</td>
<td>317</td>
</tr>
<tr>
<td>11%</td>
<td></td>
<td>688</td>
<td>CUTLERY</td>
<td>6,615</td>
<td>0.0</td>
<td>6,615</td>
</tr>
<tr>
<td>10%</td>
<td></td>
<td>689</td>
<td>BASE METAL MANUFACTURES NES</td>
<td>1,869</td>
<td>0.0</td>
<td>1,869</td>
</tr>
<tr>
<td>13%</td>
<td></td>
<td>69</td>
<td>METAL MANUFACTURES NES</td>
<td>79,142</td>
<td>0.3</td>
<td>79,142</td>
</tr>
<tr>
<td></td>
<td></td>
<td>691</td>
<td>STRUCTURES AND PARTS NES</td>
<td>21,905</td>
<td>0.1</td>
<td>21,905</td>
</tr>
<tr>
<td>-5%</td>
<td></td>
<td>692</td>
<td>METAL TANKS, BOXES, ETC</td>
<td>11,985</td>
<td>0.1</td>
<td>11,985</td>
</tr>
<tr>
<td>18%</td>
<td></td>
<td>693</td>
<td>WIRE PRODUCTS</td>
<td>9,959</td>
<td>0.0</td>
<td>9,959</td>
</tr>
<tr>
<td>16%</td>
<td></td>
<td>694</td>
<td>STEEL NAILS, NUTS, ETC</td>
<td>2,227</td>
<td>0.0</td>
<td>2,227</td>
</tr>
<tr>
<td>1%</td>
<td></td>
<td>695</td>
<td>TOOLS</td>
<td>2,227</td>
<td>0.0</td>
<td>2,227</td>
</tr>
<tr>
<td>10%</td>
<td></td>
<td>696</td>
<td>CUTOVER</td>
<td>2,227</td>
<td>0.0</td>
<td>2,227</td>
</tr>
<tr>
<td>10%</td>
<td></td>
<td>697</td>
<td>BASE METAL MANUFACTURES</td>
<td>11,714</td>
<td>0.0</td>
<td>11,714</td>
</tr>
<tr>
<td>10%</td>
<td></td>
<td>699</td>
<td>BASE METAL MANUFACTURES</td>
<td>79,142</td>
<td>0.3</td>
<td>79,142</td>
</tr>
<tr>
<td>15%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SUB-TOTAL</td>
<td>2,262,039</td>
<td>10.3</td>
<td>2,308,495</td>
<td>9.1</td>
</tr>
<tr>
<td>5%</td>
<td></td>
<td>OTHER Commodities</td>
<td>19,667,049</td>
<td>89.7</td>
<td>22,977,955</td>
<td>90.9</td>
</tr>
<tr>
<td>1%</td>
<td></td>
<td>TOTAL ALL Commodities</td>
<td>21,929,088</td>
<td>100.0</td>
<td>25,286,450</td>
<td>100.0</td>
</tr>
</tbody>
</table>

**Source:** COMTRADE Data files

**Notes:**
1. These are import statistics (expressed in current U.S. dollars) because Mexico's export statistics in COMTRADE do not report "maquila" output.
2. The compound growth rates in the final column were calculated on the basis of the average of 1981/82 and 1988/89 trade.
3. The deflator used is the Unit Value index in U.S. dollars terms of manufactures exported from the G-5 countries (France, Germany, Japan, United Kingdom and United States), weighted proportionately to the countries' exports to the developing countries.
### Annex Table D: SENSITIVITY ANALYSIS ON ELASTICITY ESTIMATES
(In Thousands of U.S. Dollars)

<table>
<thead>
<tr>
<th>Elasticity Assumptions</th>
<th>Trade Creation</th>
<th>Trade Diversion</th>
<th>Total Effect</th>
<th>Share of 1986 Exports (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Best&quot; estimates</td>
<td>-235,605</td>
<td>-140,059</td>
<td>-375,663</td>
<td>2.0</td>
</tr>
<tr>
<td>em = &quot;best available&quot; (BA)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ex = 99</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>es = -1.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changes in em</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 1 (em = 0.5 BA)</td>
<td>-115,204</td>
<td>-138,426</td>
<td>-253,630</td>
<td>1.4</td>
</tr>
<tr>
<td>Alternative 2 (em = 1.5 BA)</td>
<td>-361,201</td>
<td>-141,664</td>
<td>-502,866</td>
<td>2.6</td>
</tr>
<tr>
<td>Changes in ex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 1 (ex = 1)</td>
<td>-74,235</td>
<td>-137,692</td>
<td>-211,927</td>
<td>1.2</td>
</tr>
<tr>
<td>Alternative 2 (ex = 3)</td>
<td>-134,198</td>
<td>-130,519</td>
<td>-272,717</td>
<td>1.5</td>
</tr>
<tr>
<td>Changes in es</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 1 (es = 0.75)</td>
<td>-233,531</td>
<td>-69,573</td>
<td>-303,103</td>
<td>1.6</td>
</tr>
<tr>
<td>Alternative 2 (es = -2.25)</td>
<td>-237,666</td>
<td>-211,444</td>
<td>-449,110</td>
<td>2.6</td>
</tr>
</tbody>
</table>

**Key**
- em = price elasticity of import demand
- ex = elasticity of supply
- es = cross price elasticity of substitution
### Annex Table E: ALTERNATIVE ASSUMPTIONS ABOUT THE GEOGRAPHICAL INCIDENCE OF THE PAC EQUALIZATION TAX (in Thousands of U.S. Dollars)

<table>
<thead>
<tr>
<th>Alternative Scenarios</th>
<th>Trade Creation</th>
<th>Trade Diversion</th>
<th>Total Effect</th>
<th>Share of 1986 exports (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic Scenario</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexico to free trade</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>with PAC equalization</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tax added back; regime unchanged for all other. U.S. imports</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>-235,605</td>
<td>-140,059</td>
<td>-375,663</td>
<td>2.0</td>
</tr>
<tr>
<td>Alternative 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAC equalization tax</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>applied to all developing countries; regime unchanged for U.S. imports from industrial countries</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>-217,349</td>
<td>-64,549</td>
<td>-281,898</td>
<td>1.7</td>
</tr>
<tr>
<td>All developing countries</td>
<td>-1,389,662</td>
<td>-418,316</td>
<td>-1,807,978</td>
<td>1.5</td>
</tr>
<tr>
<td>Alternative 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAC equalization tax</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>applied to all U.S. imports</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>-217,349</td>
<td></td>
<td>-217,349</td>
<td>1.3</td>
</tr>
<tr>
<td>All countries</td>
<td>-4,259,633</td>
<td></td>
<td>-4,259,633</td>
<td>1.2</td>
</tr>
</tbody>
</table>
Economic Growth and Environment

Marian Radetzki

Introduction

It is commonly believed that economic growth constitutes a threat to the environment. The starting point for this view is that there is a limit to the carrying capacity of the environment. As the economy expands, this limit will eventually be reached. All further growth will then necessarily involve a depletion of the resource base that yields environmental services, and a subsequent deterioration in the quality of the environment. It follows that the environment constitutes a constraint to growth. The rate of economic expansion must be reduced, and eventually arrested, to prevent an increasingly severe environmental degradation.

The writings of Thomas Malthus 200 years ago (Malthus, 1798) provide the base inspiration to this plausible belief. Malthus worried about the miseries that would arise when the number of humans exceeds the ability of the land to produce food. The Club of Rome (Meadows, 1972) expressed similar concerns. The scarcity of minerals and energy were the focus of its worries. During the latter half of the 1980s, the limitations of our environment have been brought up as the main argument against unlimited economic expansion (Ehrlich and Ehrlich, 1990).

The purpose of this paper is to take a closer look at the relationships between economic growth and environmental quality. The purported environmental threat posed by economic growth cannot be waved away by pointing to the failures of earlier doomsday prophets. After all, the current world economy is far larger than 20 or 200 years ago, so the probability of hitting against one or other resource constraint could be greater than in earlier periods.

A clarification of the relationship between economic growth and environmental quality has an important bearing on the subjects treated in this volume. International trade has long been acknowledged as a strong stimulant to growth. The positive impact of exports and imports on economic expansion has been ascribed, inter alia, to the gains in productivity attained by specialization, to the scale economies from an extended market, to fiercer competition through encounters with foreign suppliers, and to the speed-up of technical progress that follows from international contacts (Mill, 1848; Krueger, 1980). The world economic stagnation of the 1930s has been importantly attributed to the restrictive trade policies, with tariff wars and quantitative restrictions introduced by major countries in the wake of the Great Depression (World Bank, 1987). Obversely, the liberalization of trade policy and the ensuing trade expansion after the Second World War, are seen as a major factor behind the historically exceptional world economic growth between 1950 and the early 1970s (Bhagwati, 1988). At a disaggregated level, statistical analyses reveal a clear positive relationship between the degree of outward orientation of trade policy and growth rates among countries (World Bank, 1987, p 93), as well as between shifts in trade policy and changes in economic growth in individual countries (Krueger, 1989, ch 3).

*Financial support from the Swedish Employers’ Federation is gratefully acknowledged.
If it is true that economic growth harms the environment, then those concerned with environmental preservation would have a case for trade restrictions, for this would retard the growth process, and so save on the environment. But this case for protectionism breaks down if economic growth has no clear impact on environmental quality, or if a plausible argument can be made that environmental conditions tend to improve with economic expansion. Herein lies the importance of disentangling the relationship between growth and environmental quality in the context of the present monograph.

My basic tenet is that the environmental resource base does not constitute a binding constraint on economic expansion. History shows that human behavior has been repeatedly adapted in response to tendencies towards environmental degradation. Such adaptations will occur in future too, and so assure the compatibility of continued economic growth with the maintenance of satisfactory environmental standards.

In the next section, I define a few key concepts and provide the points of departure for the ensuing analysis. Based on a scrutiny of historical and contemporary data, this paper refutes the purported negative relationship between economic growth and environmental quality. It points to the human efforts to improve the environment by adjusting the natural conditions to human needs and explains why an increasing level of economic activity commonly reduces environmental damage caused by external effects. Later in the paper I discuss the changing composition of GDP during the economic development process, and the implications for environmental wear. Then I explore the changing consumer attitudes towards the environment, as economies grow richer. Finally, the main results are summarized.

Definitions and Points of Departure

For the purpose of the present study, economic growth is conventionally defined as expansion of GDP. Usually, such expansion is caused by a combination of growth in population and of an increasing output per person. Hence, a rise in GDP is typically accompanied by economic development, defined as a process of rising GDP per capita. A related, unconventional concept employed in the following analysis is economic density, obtained by dividing total GDP by the surface of the countries studied.

Despite its well-known shortcomings, GDP does ordinarily provide a fair representation of the level, and hence, the density, of economic activity in a given area. Similarly, GDP per capita constitutes a reasonable measuring rod for inter-country comparisons of development and welfare standards (McGranahan, 1970; World Bank, 1989a).

Environmental quality is a more ambiguous concept. I look at "environment" as a physical and natural, not a social, cultural or spiritual concept. Also, the discussion concerns the environmental conditions for humans. Within this limitation, however, environment is broadly defined to comprise all the physical aspects that shape the human habitat. The complex composition of environment creates difficulties in measuring the change in its quality. Increased economic activity will usually impact on many facets of the environment, in both positive and negative ways. There is no unobjectionable way to aggregate such impacts into a single measure of change.

Two central characteristics of a good environment are that it should provide for human survival and well-being. While the rates of survival can at least be objectively measured, the degree of well-being is subjectively determined. For example, some may find quietness highly desirable; others will feel uncomfortable without background noise. Furthermore, environmental tastes are unstable and may change. Most city dwellers find city life more attractive than rural life, precisely because they were brought up in urban environments. Their preferences would probably be different if they had always resided in rural areas.
When analyzing the impact of economic growth, one must keep in mind that environmental change is often unrelated to human activities. The climate improvement at the end of the "Little Ice Age" in the 18th century (Economist, 1990a), had nothing to do with human endeavors. Similarly, the southward spread of the Sahara desert over the past decades has been mainly caused by falling levels of precipitation, a change over which humans have exerted little influence.

All these ambiguities warrant great caution when discussing environmental quality change. Assuming rational economic behavior, i.e. that human actions aim at satisfying some desired end, why do people behave in ways that unambiguously compromise the environment? I see three possible explanations. The first has to do with external effects. So long as the consequence of environmental damage is borne by others, the ensuing cost will be disregarded. The second has to do with the trade-offs between the desired benefits of the action, and the resulting environmental damage. The latter will be accepted so long as the benefits are valued more. The third is incomplete knowledge of the causality, so that the environmental change will emerge as an unintentional consequence.

**Level of Economic Activity and Environmental Wear**

The view that the environment constitutes a constraint to economic growth has its parentage in economic analyses of both exhaustible and renewable but overexploited natural resources. All economic activities require some environmental inputs. The resource base from which environmental services are derived is renewable in some measure. Quietness is restored as soon as the noise-producing activity is discontinued. Air and water have an ability of self-cleaning. Sores in the landscape will tend to heal through revegetation. Nevertheless, as the density of economic activity rises, there will come a point where the need for environmental services will exceed the rate of environmental renewal. Irreversibilities will further aggravate the problem. The ensuing depletion or other damage to the resource base will impair the carrying capacity of the environmental system, and lead to a gradual degradation of the environmental conditions.

The above view is hard to vindicate empirically. Available data are not unequivocal, but, if anything, they seem to indicate the obverse relationship: that the environment has a tendency to improve with rising levels of economic activity.

Economic density is far higher in today's industrialized countries than it was in the same countries during earlier periods, or than in today's developing countries. Table 8-1 presents some data to demonstrate this point. In all the industrialized countries shown, the density of economic activity has increased more than tenfold over the past 120 years. And the developing country figures (South Korea excepted) are on a par with those that prevailed in the industrialized countries in 1865.

If economic growth causes environmental depletion, the rich countries should have exhibited a gradually deteriorating environmental trend over time; and the state of their environment today should be inferior to that of low-income countries.

Support for a negative relationship between economic density and environmental quality can certainly be found. The environmental problems of chemical fertilizer and pesticide use do not become serious until the agricultural activities have intensified with increasing population and rising income levels. Forest-killing acid rain, a consequence of untreated emissions from coal and oil burning, has emerged only late in the industrialization and economic growth process. Industrial techniques used on a massive scale are responsible for introducing asbestos and lead into the human body, both resulting in serious health hazards.

Such examples notwithstanding, the wealth of empirical data point to improvement, not deterioration, if human survival and well-being are used as the measuring rod.
Table 8-1: Density of economic activity
(GDP, thousand 1987 dollars per km²)

<table>
<thead>
<tr>
<th></th>
<th>1865</th>
<th>1987</th>
<th>Developing</th>
<th>1987</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>25(^1)</td>
<td>6287</td>
<td>South Korea</td>
<td>1238</td>
</tr>
<tr>
<td>Netherlands</td>
<td>158</td>
<td>5795</td>
<td>Bangladesh</td>
<td>122</td>
</tr>
<tr>
<td>France</td>
<td>124</td>
<td>1597</td>
<td>India</td>
<td>67</td>
</tr>
<tr>
<td>United States</td>
<td>9</td>
<td>480</td>
<td>Indonesia</td>
<td>37</td>
</tr>
<tr>
<td>Sweden</td>
<td>7</td>
<td>306</td>
<td>Brazil</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nigeria</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Philippines</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Kenya</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Madagascar</td>
<td>4</td>
</tr>
</tbody>
</table>

\(^1\) 1875

Sources: Kuznets (1971); World Bank (1989b).

During the 18th century, a foul smell was the first indication to travellers in Europe that they were approaching cities. In the absence of sewage systems and waste collection, excrements and garbage were thrown onto the street. Diseases thrived. Pest was spread by rats, while cholera frequently infected the drinking water supply. The urban mortality rates regularly exceeded the birth rates, so the long-run survival of the cities required continuous immigration.

Conditions started to improve only after industrialization had taken a firm hold, and the level and density of economic activity increased. The environmental conditions needed to assure human survival improved both in urban areas and in the countryside. Life expectancies rose briskly, importantly because of improved environmental and hygienic standards. A dramatic instance is provided in Figure 8-1 which depicts the declining mortality rates from typhoid fever in the city of Chicago.

In more recent times, the increasing environmental problems caused by maturing industrialization have incited widespread actions to reverse negative trends. Illustrative examples are easy to quote: (a) Figure 8-2 shows the decline since the early 1970s in the Swedish forest industry's use of environmentally damaging chlorine, despite continuous increases in pulp output. (b) The water quality of the Rhine in Germany as measured by Biological Oxygen Demand (high BOD indicates low water quality) deteriorated over many decades, to reach 8 mg/liter in 1975. In the following 10 years, a sharp improvement occurred, with BOD falling to 4 mg/liter. The change was even more dramatic in the Seine in France, where the BOD declined from 10 mg/liter in 1975 to only 3.3 mg in 1985 (OECD, 1989b). (c) Total SO2-emissions in North-Western Europe declined from 14.6 to 9.5 million tons, or by 35 percent in the course of the 1980s (Schotte, 1990), despite a simultaneous increase in GDP of more than 25 percent.

Similar findings emerge also in a comparison between contemporary developed and underdeveloped societies. The worst environmental degradation is probably found in the poor, not in the rich countries. The
Figure 8-1: Death rates from typhoid fever per 100,000 people, City of Chicago, 1860-1942

Source: Dublin et al. (1949).
Figure 8-2: Swedish Forest Industry: Production of bleached chemical pulp and consumption of chlorine

air is harder to breathe, the water is dirtier, and the sanitation and health conditions are poorer in Calcutta, Lagos or Mexico City, than in New York, Tokyo and London. The metropolises of the poor countries have little to show that compares with the cleaning up efforts of New York, Paris and London in the past decades. Figure 8-3 provides a conspicuous example of the improvements that have occurred. A recent study of air quality in some 50 cities in many countries (Grossman and Krueger, 1991), generalizes these tendencies. On the basis of econometric analysis of cross-section data, the authors conclude that urban air pollution is at its worst in cities with per capita GDP of around US 1985 $5000. As incomes rise above this level, the air persistently tends to improve. The industrial labor safety standards, another important aspect of human environment, are far superior in the economically mature nations. The differences are striking in the rural areas too. Forested lands in industrial nations have remained more or less stable over the last 50 years. In contrast, exploitative deforestation occurs in tropical countries with pointedly low densities of economic activity. Soil erosion, malaria and poisoning from pesticides and insecticides constitute a far more serious rural environmental hazard in the developing countries than in industrialized ones.

The above list of examples points in the same direction as the results of a thorough study by Baumol and Oates. There simply is no evidence of general environmental deterioration in consequence of continued economic growth (Baumol and Oates, 1979). Empirical observation suggests, if anything, the obverse relationship to be closer to the truth: that the quality of the environment improves as the density of the economy increases.

The following sections provide some explanations to this counter-intuitive finding.

Adjustment of the Environment to Specific Human Needs

There is a tendency in current debates to regard all human intervention with the environment as damaging. In my opinion, this is a fallacious view. Human actions often have the precise purpose to adjust the state of the environment in conformance with human needs. This should be viewed as an improvement, not a deterioration in environmental quality.

However the original state of the environment is defined, it is a truism to say that the activities of any living species will result in changes of that state. In the early phases of earth’s history, the establishment of life led to fundamental alterations in the atmospheric balance. The proliferation of forests is known to affect local climate. Termites fashion the terrain to suit their convenience, while beavers affect the landscape by building dams. As a species increases in number, its overall level of activity and impact on the environment will rise. This, in turn, reduces the living space available to competing species.

The explosive increase of the human population, and of the aggregate activities undertaken by our species over the past millenium has profoundly changed the state of the environment. This change has mainly involved adjustments in natural conditions to suit the expanding human needs. The most critical human interference is probably the removal of original vegetation to provide space for agriculture. Other important changes include the domestication of animals, control of floods and provision of irrigation, construction of transport systems, establishment of cities, and the virtual elimination of numerous pestilences causing hazards to human health. The text in Figure 8-1 above details some of the actions to rid the human environment of one deadly epidemic disease.

Only part of the human interference with environment has had the form of undesired spillovers, or was unintentionally negative. A larger part has had the express aim of reshaping the original environmental conditions to suit the needs of our species. This is one important reason why environmental quality appears to have improved -- not deteriorated -- with increasing economic activity.
Figure 8-3: Settleable particulate matter in New York City air
(Micrograms per m$^3$)

Economic Density, External Effects and Environmental Damage

Resources will appear limitless when economic activity is small. Production methods which use the abundant resources indiscriminately will be favored if they are attractive in other respects. Slash-burning agriculture is extremely wasteful on land and environment. Yet, this agricultural technique is widely practiced when the man/land ratio is low, because it yields high outputs per unit of labor. Resource constraints emerge as population increases, and this encourages the development of stationary agriculture which initially lowers labor productivity, but permits large land and environmental resource savings for a given output (Boserup, 1965).

Behavioral changes of this kind arise quite generally in response to increasing economic pressures on a limited resource base. Two institutional adaptations frequently occur. One is the proliferation of property rights. The other is public regulation of the use of commons. Both play important resource-saving roles, primarily by curtailing the occurrence of negative external effects.

The extent of property rights over some set of resources is related both to their scarcity and to the ease with which they can be appropriated (Pejovich, 1972). When the density of economic activity is limited, the value of many resources will be so low as to make their appropriation not worthwhile. As exploitation of these resources is intensified, and a limit on their availability is perceived, the establishment of property rights will become increasingly economical.

Forest resources in Europe before the 12th century, or in the U.S. Great Lakes states until the mid-19th century, were so large in relation to ongoing exploitation, that ownership made little sense. The establishment of property rights occurred only when the value of these resources had risen sufficiently in consequence of increasing levels of economic activity and of the ensuing rise of exploitation that threatened the forest stocks (North, 1972; Nelson, 1985).

A similar, more recent example of appropriation is that of the rights to ocean fishing. No one was concerned about owning this resource so long as there were more fish in the ocean than man could ever hope to catch. Only after the 1960s, when widespread overfishing had occurred, and the rights to ownership of fishing grounds acquired an increasing value, were property rights established through national appropriation, subsequently sanctioned by the Law of the Sea.

The importance of property rights for environmental preservation emerges starkly in the case of natural rubber (Maurice and Smithson, 1984). At the turn of the century, world production was concentrated in the Amazon Basin. The virgin forest was a typical common without owners, and the rubber trees seemed doomed to extinction, as exploitation expanded. The most productive short-run mode of extraction was to cut the whole tree. No one was interested in caring for the trees, since the benefit of such efforts could not be appropriated. These methods of exploitation contrast with the practices in South-East Asia, where production was established early in the present century. Plantations with clear property rights guaranteed not only the survival of the rubber trees, but also provided inducements for long-run work on genetic improvement.

The establishment of property rights is not always easy. In many cases it is considered unfair on equity grounds. If someone becomes the exclusive owner of a resource, no one else will be able to benefit from its use. One social cost of the privatisation of commons in 18th century England was that many small landowners were turned into landless laborers in the process. Property rights may also be hard to impose on ubiquitous resources. The Law of the Sea, granting individual nations exclusive rights to large tracts of the ocean, is difficult to control.
Where the establishment of property rights encounters difficulties, the effort to protect endangered commons from depletion often takes the form of public regulation, restricting economic agents' freedom of access. Such regulation typically consists of quotas or fees and taxes imposed on the use of a particular resource.

Protection of endangered resources will be quite intricate when several nations with opposing interests make claims on them. Nevertheless, a number of cross-border agreements exist to regulate the employment of river water, to control emissions into the atmosphere, or to allocate radio frequencies and stationary satellite orbit space among claimants. The most severe complications arise when the external effects are hard to identify, or when they occur with an extended time lag. The possible climate change caused by greenhouse gas is a case in point, even though I would surmise that the absence of policy action so far is mainly due to the recency of the awareness that a limit is being hit, and to the uncertainty whether environmental damage will really ensue.

The above analysis has demonstrated that economic growth and the ensuing increase in economic density tend to proliferate property rights and regulations which reduce the prevalence of negative external effects. The damage to environmental and other resources will be reduced as economic agents' freedom to overexploit and spoil is circumscribed. This provides another explanation to the absence of a negative relationship between economic growth and environmental quality.

The Content of Economic Activity and the Intensity of Environmental Wear

The preceding section dealt with an adaptation in human behavior caused by economic growth, irrespective of whether such growth resulted from increased population or rising income levels. In this and the following section, the focus is on adaptations triggered by economic development.

In the present discussion, I want again to draw on resource economics, and introduce the concept of intensity of use, defined as the consumed quantity of a base material like steel or copper, per million (constant) dollars of GDP. I also want to introduce the "intensity of use hypothesis", according to which the intensity of use data take the shape of an inverted u-shaped curve, when plotted against per capita GDP. The relevance of these constructs for the subject under study will shortly become clear.

Empirical studies provide reasonable support for the intensity of use hypothesis insofar as base materials go (International Iron and Steel Institute, 1972; Malenbaum, 1978; Radetzki, 1987). The inverted U-shape, obtained in a cross-section plot, is due to variations in the economic structure of countries at different levels of economic development. The intensity reaches a peak in middle-income countries where the effort to industrialize and to establish a physical infrastructure is at its maximum. The intensity subsides in richer countries, as services and high-tech industry with limited materials needs expand their share of GDP. Examination of time-series data for individual countries suggests an additional tendency now for the intensity of use to decline over time at each per capita GDP level, because of the materials saving bias of technological progress (Tilton, 1990).

The intensity of environmental wear, a concept analogous to the intensity of materials use, is much harder to quantify. Basically, it is meant to measure the amount of environmental services used up in the generation of a unit of GDP. Though environmental services come in many shapes, and their aggregation raises intricate problems, I nevertheless assert that so long as a reasonable aggregation method is employed, the intensity of use hypothesis will apply to the environmental inputs in the same way as it does to base materials. Figure 8-4 provides a graphical representation of the relationship.
Figure 8-4: The Intensity of Environmental Wear Hypothesis

Environmental wear per constant dollar GDP

- **A** = Cross-country data for 1960
- **B** = Cross-country data for 1990
- **C** = Time-series for a single country 1960-1990
My assertion rests on the premise that there will be a strong correlation between the relative base materials needs of different sectors in the economy, and the relative environmental input needs of the same sectors. After all, base material intensive activities like the production of metals, heavy chemicals and cement, or the construction of railways and harbors, typically tend to be large absorbers of space and heavy polluters of water, air and quietness. In contrast, banking and insurance, or manufacture of high-tech products use only limited amounts of both base materials and environmental resources per unit of value added.

Just as with base materials, technological progress will have a tendency to reduce the wear on the environment per unit of finished output over time. The resource saving bias might be even stronger in the case of environmental inputs, given their augmenting values and increasing appropriation in a growing economy. This bias will tend to be further amplified by the environment-rescuing and environment-saving policies introduced in response to changing consumer spending patterns, as countries get richer (see next section).

The declining intensity of environmental use, resulting from structural shifts and technological progress in mature economies, provides a further reason why environmental strains don't necessarily increase with growth. Many developing countries are of course located on the upper slope of the intensity curve. In their case, the consumption of environmental resources will increase faster than GDP growth, even though part of that tendency will be countered by the adoption of novel, resource-saving technologies.

Since the rich countries dominate the world economy, growth will normally result in declining intensities worldwide. A falling intensity does not imply that the absolute quantity of environmental inputs must fall as GDP expands. But the rate of expansion of environmental use will necessarily be slower than the rate of GDP growth in such circumstances, thereby relaxing the environmental resource constraint to growth in some measure.

Changing Consumer Values and Spending Patterns in the Economic Development Process

I now turn to the demand for the services that the environment itself provides. My thesis is that high quality environmental services have a very high income elasticity of demand. As consumers get richer, the share of income expended on such services will rise. This will be expressed through a willingness to abstain from consumption known to harm the environment, to spend increasing sums on the repair of environmental damage, and to implement measures that will prevent such damage from occurring in the first place.

The trade-offs between material output and environmental conditions will vary at different levels of income. Poor individuals must satisfy their base needs even if the quality of their environment suffers in consequence. The rich find it easier to forego more dispensable consumption for the benefit of high environmental standards.

Public policy vis-a-vis the environment shifts in parallel with individual trade-offs, as nations grow richer. Economic density by itself explains in some degree the emergence of environmental action in poor nations too, but income levels play an important role for the proliferation of public environmental concerns. Public bodies in rich countries, but not in poor ones, spend large amounts to heal environmental damage. The prevalence of legislation to restrict environmentally harmful activities, or to force the polluter to pay, is strongly related to the per capita income level. By increasing the production costs for polluting industries, such policies have encouraged the development of equipment for effluent control. But they have also led to a substantial relocation of environmentally harmful activities from rich countries to poor ones, where the cost of polluting is less.
Here, then, is a further reason why environmental wear does not necessarily increase as economic activity expands. Environment is predominantly a rich man's concern. As people grow richer, they make greater efforts to preserve its quality.

Two further issues warrant discussion in this section. One is the tendency to widen the concept of "environment," as higher income levels are reached. The other is to clarify the reasons for the severe environmental degradation in Eastern Europe.

**A Widening "Environment" Concept**

At very high levels of prosperity, consumer satisfaction appears to be derived from environmental conditions without a direct bearing on survival and well-being. For instance, there is an increasing urge in the developed countries to preserve or even restore natural environmental states, usually in far-away places. A related interest concerns the assurance of other species' survival. The rich countries exhort the poor to protect the elephants or the rain forests or the fish in tropical rivers. The diversity of life is emerging as a consumer value in its own right. These exhortations do not yet include the tsetse fly or the malaria mosquito.

The difference in demand patterns is interestingly illuminated by the attitudes of the rich and poor in this regard. The governments of many low-income nations are unwilling to accede to the environmental pushes from the rich, simply because they assess the cost, in terms of foregone income, to be greater than the benefit that such environmental preservation would yield. They argue, with considerable justification, that the rich have altered their own environment profoundly, and have little moral ground for their prodding. So, to satisfy their own wishes, the rich increasingly employ financial transfers to make it worthwhile for the poor to cooperate in such schemes.

**The Eastern European Environmental Disaster**

The past decade has revealed the extravagant carelessness with which the environment has been treated in Eastern Europe. For example, in 1986, no more that 4.6 percent of all river water in Poland was potable on the basis of chemical analysis; 39.4 percent of the water was so polluted that it could not even be employed for industrial uses (Yearbook of Statistics, 1988). Sweden and Finland which possess some three quarters of the Baltic coastline, together accounted for 11 and 17 percent of total phosphorus and nitrogen discharges, respectively, into the Baltic Sea in 1988. The share of Poland and the USSR was 72 percent for each of the two materials (Hansson, 1990). In 1988, Czechoslovakia, East Germany and Poland each recorded NOx-emissions per dollar of GDP that were double or more the levels in France, Italy or West Germany; their SO2-emissions, measured in the same way, were more than 10 times higher than in the three Western European nations (Economist, 1990b; Hansson, 1990).

The environmental unconcern of these societies is surprising. One would expect the Socialist ideology to be particularly concerned with public goods, including the environment. Furthermore, the avoidance of environmentally damaging external effects should be particularly easy in a centrally planned economy.

In my view, the environmental degradation of Eastern Europe is primarily explained by the political suppression of consumer choice. The political elite focused one-sidedly on physical output growth, without much regard either for the quality of that output, or for the ensuing environmental impact. Voters and consumers were given no opportunity to react to the deteriorating environmental conditions. Symptomatically, the environmental debate in Eastern Europe did not arise in earnest until after the communist political monopoly had crumbled.
A Summary of Findings

The plausible belief that environmental conditions tend to deteriorate as economic activity intensifies, finds very limited support in empirical facts. More often, increasing levels and densities of economic activity are accompanied by improved environmental conditions. Four factors explain this counter-intuitive observation.

(a) All human activities by necessity alter the virgin natural environment. But a majority of these alterations involve conscious efforts to improve by making the environmental conditions better suited to human needs.

(b) Negative external effects, a common cause of environmental damage, become increasingly circumscribed through widening property rights and regulation of the use of commons, as the density of economic activity increases.

(c) The economic structure tends to change in ways that reduce environmental resource inputs per unit of output, as national economies mature. There is a shift from heavy industry and investments in physical infrastructure, to high-tech industries and services, and the latter activities cause little wear on the environment.

(d) The income elasticity of demand for environmental services is high. Rich consumers are more willing than poor ones to spend substantial parts of their income for safeguarding high environmental standards.

The four factors in combination explain why environmental conditions do not deteriorate, and often improve as economic activity intensifies. They also suggest that high environmental standards are compatible with continued economic growth. Like in the past, humans are likely to adjust their behavior vis-a-vis the environment, whenever their activities hit against constraints that threaten survival and well-being. Such adjustments have not been and will not be the result of environmental laissez-faire. Many of the behavioral adaptations, sometimes quite painful, have been prompted by social mandates overriding the freedom of unregulated markets.

The findings and conclusions of the above analysis refute the case for protection on environmental grounds. They suggest the contrary: that growth promoting liberalization of trade will often lead to improved environmental standards.
Discussant's Comments

Charles Blitzer

Marian Radetzki has written a very readable, interesting and thought-provoking paper. It should be read by all who are concerned about the relationships between economic growth and the environment. As we just heard in the presentation, it is a controversial paper. It attempts to contradict what might be called the "politically correct" view that economic growth in general is harmful to the environment and that limited environmental resources will impose limits to growth in the foreseeable future.

This view, which seems to attract wide support these days, is based on the fact that modern economic activity requires some environmental inputs and results in environmental changes. Since the rate of renewal for environmental resources is limited, increasing levels of economic activity eventually would lead to net depletion and a gradual deterioration of environmental conditions. This degradation in turn would limit economic activity.

Professor Radetzki challenges this "neo-Malthusian" scenario on both empirical and conceptual grounds. His conclusion is that there is no evidence that economic growth leads to a general deterioration in environmental conditions and that, to the contrary, the evidence might support the reverse hypothesis that economic growth is environmentally beneficial.

Since I basically agree with this conclusion as well as with the analysis of the various factors which Radetzki uses to explain the historical evidence, I have few specific criticisms to offer. Instead, I would like to use my time to comment on a few points which need emphasis or clarification.

First, it is important to understand clearly what Radetzki means by "environmental quality." The paper does not claim that economic activity does not lead to substantial environmental changes. Indeed, the development of agriculture, urbanization and industrialization have had a profound impact on the environment. But in Radetzki's view, environmental change -- per se -- does not mean deterioration and does not imply negative effects. Rather, the changes must be related to "environmental quality" which is measured in terms of its contribution to human survival and well-being. Hence, the heavy emphasis which is placed on improved water and air in terms of their affect on health. Radetzki believes that most environmental changes through history have been beneficial for human welfare. This is a strong and important conclusion on which much more empirical work is needed.

Second, in the analysis the environment enters overall welfare directly as a variable additional to income and indirectly as an input into the production of income. Radetzki argues that increased income, both in terms of density and per capita income, will tend to work in favor of the environment through both the direct and indirect channels. Specifically, the willingness to trade-off income for environmental amenities will rise with per capita income, which is what the paper means when it says that the environment is a rich man's concern. Radetzki recognizes that increasing density and levels of economic activity often lead to unsustainable declines in some environmental resources. As these problems are recognized, property rights develop, regulations are imposed, and technological change occurs which, in practice, work to sustain the environmental resources. The paper provides examples from agriculture and fishing practices, but I believe that examples from industry can also be documented.

These are very important insights into the mechanisms through which economic development can lead to beneficial environmental outcomes. However, while the conceptual analysis is appealing, further empirical research will be required for its verification.
Third, it should be pointed out that these types of changes -- regulation, property rights, increased protection for environmental amenities -- cannot occur in an entirely laissez-faire context. Externalities are involved which require collective decision making and governmental intervention. These are particularly difficult to bring about when the environmental issues are international and the countries involved differ in their income and density levels or in their perception of the problems.

Fourth, although in the past action has usually been taken in time to address environmental sustainability problems -- recent examples include acid rain and fisheries -- it may be more problematic in the future. This is because some potential severe problems are very long run in nature and global in scope, include irreversibilities which are hard to detect, and hence are more difficult to evaluate in terms of impact and costs. In this regard, the issues of global warming and loss of species stand out.

Finally, I want to say a few words about the implications for international trade policy. In his paper, Radetzki concludes that it would be wrong to introduce trade restriction since that would lead to reduced global growth which in practice would work against, not for, the environment. While I, too, am against trade restrictions whether introduced for environmental or other reasons, I would state the case differently.

Environmental concerns already do and will continue to impose some constraints on economic activity or income generation. Some of these constraints appear through the need to preserve environmental inputs into income production and human well-being. More directly, and especially in richer countries, the environment is increasingly valued for its own sake, which poses a further trade-off with growth. Clearly, collective action -- national, regional and international -- is required to ensure that the trade-offs are made properly. But both theory and history teach us that international trade restrictions are an inefficient and ineffective way to bring about the proper balance between economic growth and other objectives, in this case the environment.
The Environment as a Factor of Production: The Economic Growth and Trade Policy Linkages

Ramon Lopez

A large number of developing countries have recently embarked on profound economic reforms with the aim of increasing economic efficiency and stability. Among these reforms, trade liberalization has been emphasized. Trade reform in most developing countries has involved a rather drastic realignment of relative prices. One consequence of the reforms that is present in a large number of cases is a significant improvement of the domestic relative prices of agriculture vis-a-vis the manufacturing sector. In many cases the decrease of the anti-export biases induced by trade liberalization has entailed a reduced protection of the manufacturing sector (typically the major import substitution sector) and a concomitant reduction in the effective taxation of agriculture, in most cases the key export sector.

The increased economic efficiency associated with trade liberalization leads to once-and-for-all income gains. Empirical measurement of these static gains have been in most cases shown to be rather small. However, several empirical studies have concluded that increasing the degree of openness of the economy induces dynamic income gains that are much larger than the static gains (Balassa, 1982; Kavoussi, 1984; Ram, 1985). These growth effects apparently arise from an acceleration of investment and an increase in the rate of adoption of new technologies that an export-oriented trade strategy seems to bring about.

Several authors have addressed different aspects of the relationships between environmental degradation and economic growth (Anderson, 1990; Uimonen and Whalley, 1991). The connection between trade policies and the environment has also been the object of recent analysis (Sutton, 1988; Schuh, 1990; Lutz, 1991; Uimonen and Whalley, 1991). In general there is very little agreement on the nature of the linkages among trade reform, growth and environmental degradation. This is not surprising in view of the complexity of the issues and given the large number of environmental factors that one can consider and the variety of mechanisms by which growth, relative prices and environmental change can interact.

The objective of this paper is to reconsider the growth/trade policy/environment analysis but within a substantially more modest and limited framework: (i) Instead of focusing on the interactions between economic growth and environmental developments we consider only a one-way connection from growth to environmental degradation. To do this we define growth as increases in the conventional factors of production.

---

1See Dean (1991) for an excellent survey of this literature.

2Some authors have even questioned the relevance of the analysis because whatever the environmental effects are, the analysis needs to focus on the externality/public goods aspects of the environment. Since these issues have been thoroughly explored in the theoretical literature, it is argued that there is little new in the debate on growth/trade/environment relationships. See Uimonen and Whalley (1991) for an analysis of these issues and for a discussion of why this simple Pigouvian view of the world needs to be qualified in important ways.
and technological change rather than as output growth. Instead of focusing on liberalization of trade at a world scale we consider only unilateral trade liberalization in a small open developing country, where liberalization is defined as a reduction in tariffs that protect the manufacturing sector. (iii) We try to provide a systematic analysis of polar cases using highly simplified models. The fact that we concentrate on polar cases and the simplistic nature of the models used obviously subtract "realism" from the exercise but at the same time it may be useful to introduce a degree of systematicity to the analysis and serve as a departing point to consider more "realistic" aspects.

The idea is to reconsider the growth/trade policy/environment relationships using a neoclassical model that incorporates the more or less standard assumptions that have been most widely used in conventional general equilibrium and growth analyses. These assumptions include: (i) the existence of an aggregator function of capital (K), labor (L) and technology (t), f(K, L, t), that in the conventional models is called "output"; (ii) the production technology exhibits constant returns to scale in the factors of production; (iii) preferences are homothetic. The basic question is what such a standard and well-accepted neoclassical model would have to say when the environmental factor is inserted in this framework.

We suggest that in the analysis of the impact of growth and trade policy on the environment there are two important distinctions to be made that may significantly alter the effects. On the one hand it is necessary to distinguish whether the natural resource has or has not stock feedback productive effects. That is, whether the changes in the stock of the environmental factor play a role on output. Examples of environmental factors that have productive stock feedback effects are the forest resource, the fish stock and agricultural soil depth. In these cases production can expand in the short run by more intense exploitation of the resource but at the cost of a gradual reduction in the stock which eventually may decrease productivity in the respective industries. An important example where the productive stock feedback effects are negligible is air quality. Expansion of industrial production may increase air pollution but greater air pollution is unlikely to significantly affect industrial production. Moreover, at least on a local basis the stock effect of air pollution is very short lived. A reduction in emissions is likely to cause a fast recovery of air quality in the local (city) framework and thus the stock effect is quite negligible.

A second essential distinction is whether producers and consumers internalize temporal and intertemporal externalities whether through private ownership, contractual community arrangements à la Coase or government policies. It turns out that the impact of economic growth and trade policy are crucially dependent on the internalization of the environmental effects by individual producers in the case where productive stock feedback effects are present. However, internalization is of no consequence for the qualitative effects of growth/trade policy on the environment in the absence of productive feedback effects.

---

3Output growth is necessarily affected by environmental change while capital expansion or technical change may allow us to at least conceptually consider them as independent of environmental changes.

4Practically all neoclassical growth models use the first two assumptions. The exception is the more recent "endogenous" growth literature (see Lucas (1988) and Romer (1985) among others). General equilibrium trade models traditionally use the three assumptions. Examples are Van Wijnbergen (1987), Johnson (1958), Dornbusch (1980), Razin and Svensson (1983) and many others.

5Air pollution, however, does have a negative direct effect on welfare, but not through income.

6This is ignoring global stock effects related to climatic warming and ozone depletion.
The remainder of the paper is organized as follows: The first section considers the case of resources that exhibit little stock productive effects, while the next section discusses the opposite case. Then we devote a section to the relative price effects of trade liberalization, consider available empirical evidence, and finally draw conclusions and discuss the policy implications of the analysis.

Resources that do not have Stock Feedback Effects in Production

Here we consider environmental resources that affect output and/or utility essentially through a flow effect. That is, the environmental factor can recover quite rapidly as soon as its exploitation rate is reduced. There are no important stock accumulation effects. An example of this is air pollution. Air quality tends to improve very fast when the rate of air emissions is reduced. Moreover, air pollution does not have directly negative effects on production although it does have a negative utility effect.

We assume that the economy is comprised of two sectors. Consistent with the conventional neoclassical assumption we assume that we can define an aggregator function of capital, labor and technology for each industry of the form

$$f_i(K_i, L_i; t), \quad i = 1, 2,$$

where $K_i$ and $L_i$ are capital and labor in industry $i$, respectively and $t$ is an index of technology. The functions $f_i(\cdot)$ are assumed increasing and linearly homogenous in $K_i$ and $L_i$. The functions $f(\cdot)$ are of course, the production functions, typically specified as independent of the environmental factors.

To consider the environment as a factor of production we simply extend (1) to specify that total industry output is also a function of the environmental factor of production,

$$y_i = G[f_i(K_i, L_i; t), x_i; \tau], \quad i = 1, 2,$$

where $y_i$ is output of industry $i$, $x_i$ is the environmental factor used by industry $i$ and $\tau$ is an index of technology. $G(\cdot)$ is increasing and concave in $f_i$ and $x_i$. Technical change may generate changes in $\tau$ that could affect the marginal rate of substitution between the conventional factors $f_i$ and the environmental factor $x_i$. Consistent with the conventional neoclassical specification of technology we assume that $G(\cdot)$ is also linearly homogenous in $f_i$ and the level of air pollution, $x_i$. This implies that the macro production function $G(\cdot)$ is characterized by constant returns to scale in $K_i$, $L_i$ and $x_i$.

The specification (2) assumes weak separability between the conventional factors of production and the environmental factor. This is quite consistent with the neoclassical specification. Weak separability as in (2) is a condition for the production function defined only in terms of conventional factors of production to make sense when factors other than the conventional ones change. Moreover, this assumption simplifies the algebra substantially by allowing us to consider the interactions between one aggregate conventional factor and the environmental resource. The robustness of the results to relaxing this assumption will be discussed.

Assuming that the total capital and labor endowments are fixed and mobile across sectors we can define a revenue function as follows,

---

7For the case of air as an environmental factor, $x_i$ are air emissions produced by industry $i$. 

(3) \[ R[p; f(K, L, t), x, \tau] = \max_{x_i, \Sigma x_i, \Sigma L_i} \left\{ \sum_{i} p_i G_i[f(K_i, L_i; t), x_i; \tau] : \Sigma K_i = K, \Sigma L_i = L, \Sigma x_i = x \right\}, \]

where \( p \) is a vector of output prices, \( K \) and \( L \) are total capital and labor endowments, \( x = \Sigma x_i \) is the total utilization of the environmental factor (i.e., the total level of air emissions) and \( f(\cdot) \) is an aggregator of the total conventional factors of production. The revenue function is homogeneous of degree one in \( p \). Moreover, because of the constant returns to scale assumption \( R(\cdot) \) is also linearly homogeneous in \( K, L \) and \( x \). We note that in contrast with \( K \) and \( L \), the total use of the environmental factor, \( x \), is not fixed. In the absence of any internalization of the environmental externality, presumably firms would use \( x_i \) until its marginal product is zero. If the air quality effects are internalized (through policy), firms would be forced to pay a price for their emissions. In either case as long as the price paid by firms is identical, we can use well-known aggregation theorems to define \( R(\cdot) \) in terms of \( x \) rather than of the individual \( x_i \).

Apart from being a factor of production, \( x \) has a direct effect on the societal welfare function, \( \mu(\cdot) \). We assume that \( \mu(\cdot) \) is a function of total consumption and \( x \). Total consumption, in turn, is assumed equal to the revenue. The welfare function is then increasing and concave in \( R \) and decreasing and concave in \( x \). Moreover, for simplicity we assume that preferences are homothetic. Thus, the welfare function is,

(4) \[ \mu = \mu[R[p; f(K, L; t), x; \tau], x]. \]

Maximization of \( \mu(\cdot) \) with respect to \( x \) yields the optimal level of air emissions under the assumption that the air quality externality is completely internalized. The first order condition of such maximizations is,

(5) \[ \mu_1(\cdot) R_3(\cdot) = -\mu_2(\cdot) \]

where \( \mu_1(\cdot) \) and \( \mu_2(\cdot) \) stand for the marginal utility of the consumer good and emissions, respectively and

\[ R_3 = \frac{\partial R}{\partial x}. \]

First we consider the growth effect, i.e., an increase in \( f(\cdot) \) caused, for example, by capital accumulation (of course \( df/dK > 0 \)) or by a combined increase in capital and employment and the technical change \( t \), that is, of an increase in output as defined in conventional models. We examine here two polar cases, namely, a case where no policies are in effect to affect the externality arising from the fact that firms' emissions have a detrimental effect for consumers, and the other extreme case that occurs when there is full internalization of the externality as in (5). The first case may occur either because of lack of policies to internalize the externality or simply because \( \mu_2(\cdot) \) is about negligible. In this case we have,

(6) \[ R_3(\cdot) = 0 \]

and, hence, that

\[ \frac{dx}{df} = -\frac{R_{32}}{R_{33}}, \]

which is necessarily positive by concavity of \( R \) (\( R_{33} < 0 \)) and by the fact that \( R_{32} \) is positive under the constant returns to scale assumption. In general, without constant returns to scale, \( R_{32} \) is positive under the plausible assumption of cooperating factors of production, i.e., that the marginal product of one factor increases when the level of the other factor rises. Thus, the level of pollution emissions necessarily rises with growth in conventional factors of production. This result is not dependent on the constant returns to scale assumption. Furthermore, it can be easily seen that an increase of any conventional factor of production (say \( K \)) or
technology t, will have an unambiguously positive effect on air pollution even if the separability assumption is not imposed. All that matters is that the marginal revenue product of x be increasing in the conventional factor that expands. Under constant returns to scale and separability (6) can be written as,

\[ (6') \quad \frac{x}{f} = g(p, \tau) > 0, \]

where \( g(\cdot) \) is a positive function. From (6') it is clear that the factor ratio \( x/f \) is fixed for given \( p \) and \( \tau \). Hence, any increase in \( f(\cdot) \), whether originated in increasing levels of factor endowments or technical change \( t \), will be followed by a proportional increase in air pollution.

In the second polar case we use (5) which given constant returns to scale in production and homothetic preferences can be written as follows,

\[ (7) \quad R_3 \left[ \frac{x}{f(\cdot)} \right] = - \frac{\mu_2[1, x/R[p, f(\cdot), p; \tau]]}{\mu_1[1, x/R[p, f(\cdot), p; \tau]]} \]

\[ = \psi \left( \frac{x}{f(\cdot) \left[ \frac{p, 1, x}{f(\cdot) p, 1, \frac{x}{f}; \tau} \right]} \right), \]

where \( \psi(\cdot) \) is a well defined function. Note that the constant returns to scale assumption implies that \( R_3(\cdot) \) is homogenous of degree zero in \( x \) and \( f(\cdot) \). Hence, \( R_3(\cdot) \) is a function of the \( x/f \) ratio. Similarly, the assumption of homothetic preferences also implies, without loss of generality, that \( \mu(\cdot) \) is linearly homogenous and, hence, that the right hand of (7) can also be written as a function of the ratio \( x/f \).

Thus, from (7) we can solve for the \( x/f \) ratio as,

\[ (8) \quad \frac{x}{f(\cdot)} = \phi(p; \tau) > 0, \]

where \( \phi(p) \) is some function of the vector of output prices. To see the effect of \( f \) on \( x \) we, therefore, do not require any specific knowledge of the function \( \phi(p) \) except that it is positive. This is enough to allow us to know that an increase in \( f(\cdot) \) will necessarily cause the level of emissions \( x \) to proportionally increase.

Differentiating (8) with respect to time and assuming that factors are paid their marginal value products, we obtain

\[ (9) \quad \dot{x} = s_K \dot{K} + s_L \dot{L} + A + \eta, \]

where \( \dot{\cdot} \) indicates rate of growth, \( s_k \) is the share of capital and \( s_l \) the share of labor in total revenue, \( A = \dot{f}/f \) is the rate of (conventional) factor enhancing technical change and \( \eta = \dot{\phi}/\phi \) is the rate of technical innovation that changes the pollution intensity. A negative value for \( \eta \) reflects technical change that is environmental saving and \( \eta > 0 \) implies conventional factor saving technical change. Coefficient \( A \) is of course non-negative under normal conditions. That is, technical change if anything increases the efficiency of the conventional factors of production, \( A \geq 0 \).

From (9) it is clear that growth based on capital accumulation or increased employment necessarily causes increases in pollution. If growth is based purely on technological change the effect on pollution would
be ambiguous. To the extent that technical change is environmentally saving, i.e., \( \eta < 0 \), the net effect will depend on the strength of this effect relative to \( A > 0 \).

The positive relationship between factor endowments and pollution is robust to the separability assumption to the extent that the capital/labor ratio is constant as in the long-run neoclassical growth model. Without imposing separability it can be shown that (7) implies,

\[
\frac{x}{L} = \psi(p, K/L, \tau, t) > 0,
\]

where \( \psi(\cdot) \) is some positive function. In this case a simultaneous increase in \( K \) and \( L \) that preserves the capital labor ratio will unambiguously increase pollution \( x \). That is, as in the neoclassical growth model, steady state factor ratios do not change (unless non-neutral technical change occurs); this is true for the pollution/labor and pollution/capital ratios. Therefore, any increase in factor endowments will necessarily imply a corresponding increase in the third factor of production, \( x \).

Another important implication of the above analysis is that the degree of pollution intensity \((x/f)\) can be affected by the price level \( p \) and will depend on whether the externality is internalized or not. It can be shown that \( g(\tau) > \phi(\tau) \) in (6') and (8); that is, the pollution intensity is less when the negative consumption effects of the externality are taken into consideration in the production decisions than when they are not. The growth effects, however, are identical in both cases! That is, the elasticity of pollution with respect to \( f \) is equal to one whether the externality is internalized or not.

The cost of pollution controls for firms in industrialized economies have been shown to be very small, less than 1 percent of total costs (Low, 1991). Hence, one would expect that the research and development efforts of the private sector in developed countries (the originator of most new technologies) to generate environment-saving innovations are not likely to be large. Given the small private cost share of pollution controls, environment saving technical change is not likely to generate very significant increases in profits for firms while the large costs of conventional factors, particularly labor, imply that the bulk of the research effort in the private sector is likely to continue to be oriented to conventional factor saving technical change. All this implies that the factor \( A \) in (9) is still very large while \( \eta \) may not yet be sufficiently negative to induce a negative \( g \) even if growth were entirely based on technological change.

If growth is originated in both conventional factor accumulation and productivity growth, the possibility of a net negative value for \( g \) is even more remote. In summary, growth based on factor expansion necessarily increases pollution. Growth based on factor accumulation and technological change is likely to also increase pollution. It is important to emphasize that this happens in the best possible situation, when firms are forced to fully pay for the pollution externalities.

Resources that have Stock Feedback Productive Effects

In this section we consider resources that have both flow and stock effects on production. We will consider here only the effects of changes in the conventional factors of production (and of \( t \)). We ignore here \( \tau \), but all the caveats about \( \tau \) discussed in the previous section apply. An example of the stock feedback effects in production of environmental resources can be found in agriculture. Agriculture production under shifting cultivation in tropical areas is dependent not only on the cultivated land area (i.e., the amount of deforestation) but also on the stock of forest (biomass) itself because soil quality and fertility are dependent
on an adequate stock of forest or biomass. This permits us to write the production function in agriculture as

\[ y^A = F^A(K^A, L^A, z, s), \]

where \( y^A \) is agricultural output, \( z \) is cultivated land and \( s \) is the stock of forest or biomass. \( F^A(\cdot) \) is thus increasing and concave in the four factors of production. Moreover, we also assume that \( F^A(\cdot) \) exhibits constant returns to scale in the four factors of production. The assumption of constant returns to scale in all factors including the stock of the resource was tested by Lopez (1991) for agriculture in Côte d'Ivoire. He could not reject this hypothesis, finding that the estimated returns to scale fluctuated between 0.92 and 1.01.

For a given total availability of land the stock of biomass depletion is proportional to the level of cultivated area. Hence, assuming that the natural rate of biomass growth is \( \alpha > 0 \) and that biomass extraction is \( \beta z \), where \( \beta \) is a positive constant, the time evolution of the stock of biomass is,

\[ s' = \alpha s - \beta z. \]

The revenue function for an economy comprised of two sectors, agriculture and the rest of the economy, under the assumption of weak separability between the conventional and the environmental factor can be written as,

\[ R = R(P_A, P_N; f(K, L), z, s), \]

where \( P_A \) is the price of the agricultural good, \( P_N \) is the price of the nonagricultural output, and \( K, L \) are the total resource endowments of capital and labor in the economy.

We assume that the nonagricultural sector is also characterized by constant returns to scale and, hence, \( R(\cdot) \) is linearly homogenous in \( f, z, \) and \( s \). Also \( f(\cdot) \) itself is homogenous of degree one in \( K \) and \( L \). Given that only agriculture uses the environmental factor we have that \( R_{z4} = \frac{\partial^2 R}{\partial P_A \partial z} > 0 \), \( R_{z4} < 0 \), \( R_{z5} > 0 \), \( R_{25} < 0 \).

The socially optimal level of \( z \) would then be determined by,

\[ \max_z \int_0^\infty R(P_A, P_N; f(K, L), z, s) e^{-\alpha t} dt \]

---

*The level of forest itself plays an important role in preventing flooding and soil erosion. Also in the context of shifting cultivation the fertility of the land periodically cleared for cultivation depends on the forest density. For details on the stock/flow effects see Lopez and Niklitschek (1991). Another example is in the context of soil conservation. Agricultural output depends on both the extent of soil loss (the flow) and on soil depth (the stock of the resource) (McConnell, 1983).*

*The larger the cultivated area the shorter the fallow periods and, hence, the shorter the period allowed for regeneration of the forest.*

*Here for notational simplicity we are ignoring the factor \( x \) used in the nonmanufacturing sector. This does not, however, affect any of the results below.*
\[ s(t) = \alpha s - \beta z \]

where \( r \) is the discount rate and \( s(0) \) is the initial level of biomass stock. The first order necessary conditions are

\[
\begin{align*}
(i) & \quad R_s(\cdot) = \lambda, \\
(ii) & \quad \dot{\lambda} = (r-\alpha)\lambda - R_x(\cdot), \\
(iii) & \quad \dot{s} = \alpha s - \beta z, \\
(iv) & \quad s(0) = \bar{s}_0; \lim_{t \to \infty} e^{\pi \lambda(t)} s(t) = 0,
\end{align*}
\]

where \( \lambda \) is the current value co-state variable measuring the shadow value of \( s \).  

First we consider the case when individual producers do not internalize the stock effect of the resource on society's wealth. This may happen when the stock of biomass is public or common property and the community for whatever reason has not developed the necessary contractual arrangements that would have led to a solution like (14). We first analyze a polar case where producers totally ignore the shadow value of biomass in their decisions. That is, they behave as if \( \lambda = 0 \), and hence equation 14(ii) would not form part of the solution and equation 14(iii) will simply take the role of an accounting identity. Thus, the effect of economic growth is in this case entirely ruled by the condition \( R_s(\cdot) = 0 \).

Figure 9-1 considers the effect of an increase in \( f \) for the case when the initial equilibrium is stable. Before \( f \) increases, the stock of biomass is \( s_0 \) and the cultivated area is \( z_0 \). A rise in \( h \) will increase the marginal revenue product of cultivated land for any given level of the stock. Hence, the \( R_s = 0 \) schedule will shift upwards. This will cause an instantaneous increase in the area cultivated to \( z' \) which, in turn, will cause the stock \( s \) to decline. As \( s \) is reduced the marginal revenue product of cultivated land is gradually reduced, thus causing \( z \) to decline. This process is shown by the arrow lines. The new steady state will occur at a lower stock and service flow of the resource. That is, under stability, capital expansion or more generally, an increase in the conventional factors of production will necessarily cause a higher rate of deforestation.  

Next we examine the other polar case, individual producer decisions take full account of the social value of the stock of biomass. In this case the behavior of the system is ruled by the complete system of equations (14). First we consider the steady state, i.e., we assume \( \dot{\lambda} = \dot{s} = 0 \). In this case we have

\[
R_x(p_A, p_H; f(K, L), \frac{\alpha}{\beta} s^*, s^*) = \frac{1}{r-\alpha} R_s(\cdot),
\]

\[ ^{11} \text{An additional assumption is that } r > \alpha. \]

\[ ^{12} \text{The unstable case occurs when the slope of the } R_s = 0 \text{ schedule is flatter than the } \dot{s} = 0 \text{ schedule. In this case an increase in } h \text{ will lead to complete extinction of the resource.} \]
Figure 9-1
where $s^*$ is the steady state level of biomass stock. Individual producers fully consider the social shadow price of the stock of biomass (the right-hand side of (15)) and also they are fully aware that in the long run the flow of resource extraction is proportional to the long run level of the stock, in the long run $z = \frac{\alpha}{\beta} s^*$.

Under constant returns to scale both $R_4(\cdot)$ and $R_5(\cdot)$ are homogeneous of degree 0 in $h, z,$ and $s$ and, hence, (15) can be expressed as,

$$ R_4[p_A, p_N; \frac{f(K, L)}{s^*}, \alpha, 1] = 1 - R_5[p_A, p_N; \frac{f(K, L)}{s}, \alpha, 1]. $$

Thus, (16) can be solved for $\frac{f}{s^*}$,

$$ \frac{f(K, L)}{s^*} = \varepsilon \left[ p_A, p_N, \frac{\alpha}{\beta}, \frac{1}{1-\alpha} \right] > 0, $$

where $\varepsilon(\cdot)$ is some unspecified function of the exogenous variables. Since $\varepsilon(\cdot) > 0$ we have that the optimal long-run level of the stock of biomass, $s^*$, is necessarily increasing in $f(\cdot)$ and, therefore, in $K$ and $L$. That is, in contrast with the case when producers do not internalize the biomass externality, now deforestation will decrease as economic growth takes place.

An expansion in the level of conventional factors of production increases the value of biomass as a factor of production. The marginal productivity of the resource extracted from the forest also increases, and hence producers would like to extract more biomass from the forest. However, producers are aware that in order to extract a greater flow of resources from the forest stock on a sustainable basis they need to allow the stock of biomass to expand. In contrast with the previous case, now individual producers have incentives to increase the stock because they will directly benefit from their investment in the resource stock. In the previous polar case, because of lack of private property or lack of adequate contractual arrangements, an individual producer may not necessarily benefit in the long run by investing in the resource stock, and hence has no incentives in allowing the stock of biomass to expand. This is the crucial difference between the two polar cases.

The dynamic of the system can be represented by the following two differential equations derived from (14),

$$ \dot{z} = \frac{1}{R_4} [(r-\alpha) R_4(\cdot) - R_5(\cdot) - R_{45} (\alpha s - \beta z)] $$

$$ \dot{s} = \alpha s - \beta z. $$

From (18) we obtain the slopes of the $\dot{z} = 0$ and $\dot{s} = 0$ schedules. The slope of the $\dot{z} = 0$ schedule is positive with slope $\alpha/\beta$ (Figure 9-2). The slope of the $\dot{s} = 0$ may be positive or negative but stability requires

...
that its slope be less than the slope of the \( x = 0 \). Figure 9-2a shows the case when the slope of the \( x = 0 \) schedule is positive and Figure 9-2b shows it when is negative. Also Figures 9-2a and 9-2b show with the arrows the motion of the system in the neighborhood of the steady state shown by the points A in the figures. Stability thus requires that the adjustment shown as line 00 in Figure 9-2 to be steeper than the \( x = 0 \) schedule.

Figure 9-3 shows the adjustment toward equilibrium when \( f(\lambda) \) increases. A rise in \( h \) will not affect the \( x = 0 \) schedule. Since we know from (17) that the new steady state occurs at a higher \( s \), it is clear that the schedule \( x = 0 \) must shift to the right (from \( x = 0 \) to \( x' = 0 \) in Figure 9-3). The adjustment path from the old steady state A to the new one at C is depicted by the arrow line BC. That is, first the rate of extraction is reduced from \( x^* \) to \( x \), and then gradually increases to the new steady state level \( x'' \) which is above the original extraction level \( x^* \).

We have so far considered two polar cases of resource control, namely, where the stock effect is not considered at all in producers' decisions and alternatively when the complete shadow value of the resource stock is considered in the allocation decisions. In cases where the resource is privately owned the second polar case would be valid. There are, however, important examples, particularly in LDCs, where natural resources are owned in communal form rather than individually. In this case it is most likely that neither of the two polar cases analyzed would be entirely appropriate.

A recent study by Lopez (1991) using data from Côte d'Ivoire has empirically tested the hypothesis that social controls in the context of communal ownership are sufficient to induce individual producers to fully internalize the value of the resource stock in their decisions. Lopez found that, in fact, although the communities do exert some control on individual producers these controls are far from being sufficient to cause socially optimal allocation. The biomass stock is overexploited although some internalization of the stock value does occur. Lopez found that on average producers consider about 30 percent of the social value of the resource stock in their decisions, i.e., the value of \( \lambda \) actually considered is about one third of the true \( \lambda \) in (14).

Thus if \( \lambda' \) is the actual value of the resource stock considered by producers, then \( \lambda' = \Omega \lambda \), where \( \Omega \) in the case of Côte d'Ivoire is about 0.3. If the \( \Omega \) coefficient does not change with \( f \), i.e., if the actual distortion does not change with economic growth, one would expect the analysis of the second polar case to be valid for this intermediate situation. If, however, \( \Omega \) does change with growth, the analysis would become more complicated. Presumably, if \( \Omega'(f) > 0 \), that is, if growth induces a greater resource control, the result of increased resource conservation as growth occurs would be reinforced. If \( \Omega'(f) < 0 \), on the other hand, the net effect of growth on the resource stock would be ambiguous. In general, unless economic growth causes an increase in the rate of distortion affecting resource valuation, resource degradation will decrease with growth.

The Relative Price Effects of Trade Liberalization

In this section we consider the effects of trade liberalization in a typical developing country on the environment. We focus here on the effects that take place through the changes in relative prices as well as through the static income effect induced by trade liberalization.
Figure 9-2b
Figure 9-3
We assume that the economy is small and open. It produces two tradable outputs, an agricultural good which is exportable and a manufactured good which is a substitute for imports. Both production and consumption of the manufactured good generates air pollution. Neither production nor consumption of the agricultural good, on the other hand, causes air pollution. The pollution effect at the consumer level has not received nearly as much attention in the literature as the production generated pollution. However, consumption pollution appears to be quite important particularly in the consumption of durable (manufactured) goods. Pollution from the operation of cars, refrigerators, air conditioners, etc., appear to be a major source of air contamination in many middle and high income countries. On the other hand, consumption of food and other agricultural products does not appear to be nearly as polluting as the manufactured good.

We assume that initially the manufacturing import substitution sector is protected to the detriment of the agricultural export-oriented sector. We assume that neither the production nor the consumption air pollution externalities are internalized. Revenue function for this economy is thus,

\[ R = R(p_A, 1 + m, f(K, L), x_1), \]

where we normalize the world price of the manufactured good to 1, m is the ad valorem tariff rate, \( p_A \) is the price of the agricultural good (1 + m is therefore its domestic price) and \( x_1 \) is now industrial production pollution. As before, constant returns to scale implies that \( R(\cdot) \) is linearly homogenous in \( f(\cdot) \) and \( x_1 \), and \( R_i > 0 \) for \( i = 1, 2, 3, 4 \).

Moreover, due to the fact that only the manufacturing sector emits production pollution, \( R_{14} < 0 \) and \( R_{24} > 0 \). In the absence of pollution controls firms will drive the marginal revenue product of \( x_1 \) to zero,

\[ R_4(\cdot) = 0, \]

which implies that

\[ \frac{\partial x_1}{\partial m} = - \frac{R_{24}}{R_{22}} > 0 \]

That is, trade liberalization, i.e., a reduction in \( \tau \), necessarily decreases production pollution.

To consider consumption pollution we need to incorporate the consumption sector in a general equilibrium framework. We define \( x_2 = x_2(c_2) \), with \( x'_2(c_2) > 0 \) as consumption pollution. The level of \( x_2 \) is an increasing function of the consumption of the manufactured good \( c_2 \). The (dual) expenditure function is,

\[ E = E(p_A, 1 + m; \mu, x_1 + x_2(c_2)), \]

which is increasing and concave in \( p_A \) and \( 1 + m \) and increasing in \( \mu \). \( E(\cdot) \) is of course also increasing in \( x_1 + x_2 \). The economy wide budget constraint implies that,

\[ E(p_A, 1 + m; \mu, x_1 + x_2(c_2)) = R(p_A, 1 + m; f, x_1) \]

\[ - m[E_2(\cdot) - R_2(\cdot)]. \]

Next to specify the consumption of the manufactured good, \( c_2 \), we can use Shephard's lemma,

\[ c_2 = E_2(p_A, 1 + m; \mu, x_1 + x_2(c_2)). \]
By differentiating (23) and (24) using (21) it can be shown that the effect of a decrease in m is to increase the consumption of the manufactured good. This, in turn, would cause an increase in consumer originated air pollution.

Thus, the net effect of trade liberalization on air pollution is ambiguous. Lowering protection reduces production generated pollution but at the same time increases consumer generated pollution. The strength of the production effect will depend on the supply elasticity of the manufactured good and on the pollution intensiveness of manufacturing production. Empirical studies suggest (Michaely et al., 1991) that the manufacturing sector has a large degree of flexibility to respond to decreased protection. Thus, the level of economic activity in manufacturing tends to be only slightly affected by trade liberalization in most cases. Moreover, given that developing countries tend to have relatively more lenient environmental regulations than developed countries, it is likely that trade liberalization would bring about changes in the composition of industrial output toward more pollution-intensive activities. Thus, one would expect that the effect of decreased industrial protection will cause a relatively minor reduction in production generated pollution.

The consumption effect is likely to be greater. The consumption effect depends on the demand elasticity for the manufacturing goods and on the degree to which pollution increases with an expansion in the consumption of industrial goods. Demand for manufactured goods in developing countries appears to be very elastic with respect to both price and income. Hence, the decrease in price of import substitutes and increase in income associated with trade liberalization is likely to cause a large expansion in demand for manufactured goods, particularly automobiles and other durables. The experience of certain Latin American countries is illustrative. After a period of adjustment, trade liberalization has been followed by a strong expansion in the demand for durables. In Chile, for example, after the trade reform of 1975, the automotive park increased almost three times in six years in part because of the drastic reduction in the domestic price of motor vehicles. Thus, it appears that the consumption effects of trade reform are likely to dominate the production effects causing a net increase in air pollution.

Finally, we consider the effect of trade liberalization on deforestation. If there is no internalization of the stock effect of biomass and assuming that agriculture is a more intensive user of biomass than manufacturing, the effect of trade liberalization on the stock of forest biomass is unambiguously negative. A decrease in protection of manufacturing in this case causes a flow of capital and labor toward agriculture which now is relatively more competitive. This, in turn, increases the marginal value product of the biomass extracted from the forest (i.e., increases the marginal value product of cultivated land) inducing greater deforestation.13

If farm producers do internalize the stock value of the forest, trade liberalization induces an increase in the forest stock. The effect of a reduction in m on agriculture is entirely captured by an increase in f. As m is reduced factor returns in the manufacturing sector temporarily fall thus inducing capital and labor to flow from industry to agriculture, thus increasing f in agriculture. From this point the analysis is, therefore, identical to the growth effect in the first section of this paper. The net effect is to increase the long-run forest stock. The key thing to understand is that the complete effect of a reduction in m is through an expansion in the f(Ki, L) for agriculture.

13See Lopez and Niklitschek (1991) for details about the adjustment dynamics in this case.
Empirical Evidence

Empirical evidence on the effect of growth and the trade regime on environmental degradation is quite scarce. Two recent empirical studies have focused on air pollution generated in the manufacturing sector using developing and developed country data for 1960-88 (Lucas, Wheeler and Hettige, 1991; Birdsall and Wheeler, 1991). Both studies conclude that toxic intensity of GDP (i.e., air pollution emissions/GDP) does not decline with income.

Lucas et al. find that pollution intensity remained constant throughout the 1960s being independent of income. During the 1970s and 1980s the pollution-intensity effect of income is on average also zero or rather negligible. However, the effect of income on pollution intensity tends to be negative in more open countries while it is positive in closed economies. Even in the most open countries, however, the absolute level of pollution increases with income despite the fact that pollution intensity declines. These effects are quantitatively more important during the 1980s than in the 1970s. In fact, the strength of the openness effect in the 1980s is more than twice that effect in the 1970s.

These findings are highly consistent with the results that emerged from the theoretical model in the first section of this paper. The absolute constancy of the pollution-intensity indexes during the 1960s and their constancy when evaluated at average values of the explanatory variables in the last two decades suggest that the elasticity of total pollution with respect to income is equal to one. A major result in the first section is that this elasticity is indeed about 1 (equation (8)).

Another theoretical result is that increasing economic openness should cause a once-and-for-all decrease in production pollution intensity. The empirical results by Lucas et al. indicate that air pollution intensity during the 1970s and 1980s decreased with openness. The openness effect, however, appears to be dynamic rather than once-and-for-all as our model suggests. It is possible, however, that Lucas et al. are effectively capturing a purely static effect of openness on pollution intensity in their data for the 1970s and 1980s. Several developing countries experienced significant increases in their degree of openness during the 1970s and, particularly, the 1980s. So countries that show a greater degree of openness during each decade are also the countries that have liberalized their economy more in the same decade. Hence, it is possible that Lucas et al. are capturing the one-and-for-all effects of liberalizing trade on pollution intensity that spread over a few years. This is consistent with the fact that the effect of openness is much greater during the 1980s than in the 1970s. In fact, trade liberalization episodes were more intensive and were implemented by more countries in the 1980s than in the 1970s.

Conclusions

The major implication of the previous analysis is that the effects of economic growth and relative price changes on the environment critically depend on the nature of the resource stock effects on production and/or whether individual producers internalize such stock effects. It is shown that for resources that have a productive stock feedback effect, economic growth and trade liberalization in a typical developing country decrease degradation both in the short run and long run if individual producers internalize the stock effect. This is valid whether the internalization is induced by government policy, contractual arrangements among producers or because individual private property on the resource prevails. Also, the effect of trade liberalization is dependent on two assumptions, namely, that initially the manufacturing sector is protected vis-a-vis the primary sectors and that the productive stock effects of the resource occur entirely in the primary sectors. On the other hand, the effects of economic growth and trade liberalization on the resource stock are unambiguously negative if individual producers do not internalize the productive stock effects of the resource.
For environmental factors that do not have stock effects on production (i.e., air quality), economic growth originated by the accumulation of conventional factors is necessarily detrimental whether individual producers (are forced to) consider the environmental externality or not. Moreover, policies (i.e., trade policy, price policy, taxation of pollution, etc.) can affect pollution intensity (pollution per capita or per unit of capital) in a once-and-for-all form but will not affect the relationship between pollution change and (conventional) factor accumulation. The elasticity of environmental degradation with respect to factor accumulation is identical in the long run whatever the policy mix. In the absence of environmentally biased technical change the elasticity is equal to one.

The effect on air pollution of growth based on technical change is in principle ambiguous. Technical change has two effects: (i) it increases the efficiency of conventional factors of production, and (ii) it may generate biases toward more or toward less environment-intensive technologies. Insofar as (i) is effectively equivalent to conventional factor accumulation, its effect on the environment is negative. The effect of (ii) is to decrease environmental degradation if technical change is environment saving. Given that environmental control costs are a very small fraction of the total cost in developed countries, it is likely that the bulk of the R & D efforts by the private sector are still oriented more toward the development of conventional factors saving techniques rather than to environmental saving techniques. Hence, it is likely that the effect (i) of technical change dominates the effect (ii), implying that growth, even if generated by technological change only, will lead to increased pollution. Finally, the effect of trade liberalization in a typical developing country for the latter type of resources is ambiguous: production pollution tends to decrease but consumption pollution is likely to increase in response to trade liberalization.

The policy implications of the analysis are quite clear. Policies that provide internalization of the full social value of the resources that have stock productive effects can be very effective in inducing resource conservation. These policies not only cause a once-and-for-all decrease in the rate of extraction of the resource but also lead to a positive dynamic relationship between resource conservation and economic growth.

Thus, to a large extent the fate of resources such as biomass, fishing, forestry, soil quality, etc., so vital for many developing countries, will depend crucially on the ability of the developing countries to implement and enforce an adequate regulatory framework. This implies provision of the legal and institutional infrastructure to support socially efficient commercial exploitation of resources in some cases, provision of individual private property rights for resources in others, and implementation of adequate taxation systems (i.e., stumpage fees, etc.) to internalize the true social costs of the resources in still others. An important issue here is that many developing countries, particularly the poorest, do not seem to have sufficient institutional capability to implement these first-best type policies. In these cases an important question is the extent to which governments should use second- or even third-best policies, such as trade policy, which are usually easier to use than the first-best policy. Although these policies can be enforced more easily, they require a lot of fine-tuning and flexibility to assure that their benefits are greater than the efficiency losses that they cause in the allocation of other resources. It is unlikely that the poorest developing countries will have sufficient expertise to achieve this.

For environmental factors that do not have productive stock effects things are quite different. Efforts by developing countries to introduce policies to force individuals to fully pay the social cost of the environmental factors can cause static once-and-for-all reductions in environmental degradation, but the dynamic effects of growth are still likely to be negative. The negative relation between environmental conservation and economic growth can only be broken if the biases of technological change become more environmentally saving and less labor (and other conventional factors) saving. Since most new technologies are developed in the industrialized world, what developing countries do in terms of policy will matter very little in this respect. If the induced innovation hypothesis is a reasonable theory of endogenous technical
change, one can conclude that such technological change will take place only if developed countries force firms to fully pay for any environmental losses that they cause.\textsuperscript{14} To the extent that this will cause environmental costs to become a sizable component in the total cost, firms will orient a greater proportion of their R&D resources to generate these new technologies. Thus, by implementing policies to fully internalize the social cost of environmental resources, developed countries can achieve not only static gains but also dynamic gains by altering the relationship between economic growth and environmental degradation. Given the technological dependence of the developing countries, these dynamic gains may have strong spillover effects in the less developed countries as well.

\textsuperscript{14}For an early account of endogenous technical change, see Hayami and Ruttan (1971). The authors not only present an insightful analysis of endogenous technical change in the context of the induced innovation hypothesis but also provide convincing empirical evidence of it for the United States and Japan. It is unfortunate that the recent literature on endogenous growth has not paid any attention to this important pioneering work.
Discussant's Comments

Sweder van Wijnbergen

Lopez presents a model, claimed to have the relevant real world features, in which both opening up to international trade and economic growth are inimical to the environment. The only addition required for a grand slam is that poverty alleviation harms the environment. But do the model predictions actually fit the facts?

Lopez is silent on this rather crucial question; some evidence suggests that it does not. On the trade link, Birdsall and Wheeler note in this volume that the more open economies in Latin America tend to score better on a variety of environmental score cards. On growth, Grossman and Krueger (1991) in a careful and exhaustive analysis demonstrate that for certain important pollutants the link between growth and pollution is an inverted U-shape, rising initially but falling from a threshold level of around $5000 per capita onwards. These results, tentative as they may be, suggest at the least that reality is more complicated than Lopez’ analysis would have us believe.

If model results are unconvincing, either the assumptions made to get definite results are off, or the model is structurally ill-suited to analyze the questions at hand because it leaves out important factors. I certainly think that several of the assumptions made are unconvincing: agriculture does contribute to pollution, and many LDCs are net importers of agricultural products and net exporters of manufactures, for example. But the real problems with his analysis are deeper than that and trace back to the fact that his model leaves out many factors that are crucial to the questions analyzed. I will discuss in turn trade and growth, and in each case will ask whether including features that I consider essential might reverse his results. The answer is in each case, yes.

Trade and the Environment

On trade I highlight four points. First, an important contribution of more open trade to higher welfare is the fact that more open trade means more product and technology varieties to choose from for consumers and producers alike. In most LDCs those varieties will come from developed countries, and thus by and large from countries with more stringent environmental regulation than the LDC that is opening up. It is therefore a priori plausible to assume that the product mix and technology choice will be expanded in environmentally favorable ways. An example would be the lifting of trade barriers to automotive products in Mexico: the fastest way to overhaul the existing vehicle fleet towards catalytic converters would be simply to allow imports of secondhand cars from the United States, almost all of which are equipped with those converters.

The second point derives from the fact that LDC-DC trade tends to be more Heckscher-Ohlin than intra-industry. With lower capital/labor ratios in LDCs, opening up to trade will cause production to shift towards labor-intensive and thus more environmentally benign goods. The third point is related; in a global analysis one should expect the mirror image of such developments in the rest of the world: expansion of labor-intensive products and contraction of capital-intensive products in say Mexico will be matched by the opposite shifts in the country’s trading partners, in Mexico’s case mostly the United States. Since DCs have more stringent environmental regulation than LDCs, this means that the most polluting production processes (since the most capital intensive ones) will shift to the country with the more stringent environmental regulation. Overall, trade expansion should thus lead to lower pollution on a global scale, something that Lopez’ partial equilibrium, one country analysis necessarily misses.

The fourth point is more political economy in nature, and probably much less general than the other three. It is once again best demonstrated using the current Mexico-Canada-US negotiations about a Free
Trade Agreement. Opening up of trade between LDCs with lax regulation and DCs with more stringent regulation is likely to lead to pressure for much more stringent environmental regulation in the LDC: fixed factors in the DC are going to complain about "unfair competition" because of more relaxed environmental standards in the LDC.

An argument that goes the other way has often been derived from the empirically supported claim that more open trade leads to higher growth, and higher growth surely harms the environment. While the first step in the argument is probably true, the second is not necessarily; I turn to that issue now.

Growth and the Environment

Notwithstanding his claims to the contrary, Lopez actually does not analyze growth at all. He simply associates an increase in the level of income with a higher growth rate. So what would a more serious analysis of the link between growth and the environment focus on? The issue is important, because economic growth is generally accepted as an objective of economic policy. Of course we are really interested in welfare, not growth per se, and if, once properly measured, the two clash, growth might have to be slowed down.

An obvious starting point is the observation that more abatement expenses divert capital from production purposes and thus presumably negatively affect growth. In a similar vein, more capital means, at least for given technology, more pollution, once again suggesting a negative link between higher growth and environmental quality. But modern growth theory has made clear that this may be too shallow a view. Capital accumulation explains only a very small fraction of economic growth. Most growth stems from technological innovation which is kept exogenous in the "old" growth theory. What happens if we incorporate technological innovation in the analysis?

I would like to raise two issues, one related to innovation activity and one related to human capital. Environmental regulation has two effects on innovation: (1) it diverts R&D resources from improvements in productive capacity towards R&D on environmental issues; (2) it is likely to increase overall R&D activity. Because of (2), the overall effect on technological innovation, and, importantly, on the speed with which such innovation is incorporated in the capital stock, could very well be positive.

But the costs of environmental compliance are so low (see Low in this volume) that all these arguments, whichever way they go, would seem quantitatively unimportant. Harder to measure but possibly quite important is a much more subtle channel, best illustrated using Lucas' well-known growth through human capital investment analysis. In Lucas' framework, arbitrage equates the rate of return on physical and human capital; but the marginal productivity of investing in human capital is set and thus anchors down the growth rate. Increases in the cost of capital because of environmental compliance would in this setup change only the composition of the aggregate capital stock, away from physical towards more human capital, and would leave the long-run growth rate unaffected.

In fact recent research on the effect of environmental pollution suggests an even stronger result. Margulis (1991) provides convincing evidence that several airborne pollutants significantly lower IQ in children of school age, harm concentration ability and so on. This strongly suggests that environmental policy, if effective in cleaning up the environment, might in fact raise the productivity of investing in human capital and might thus raise rather than lower long-term rates!

Of course this suggestion, if it holds up, needs to be interpreted with care: it does not mean that unfettered growth promotion will benefit the environment. Instead, it argues that well-designed environmental policies might in fact increase long-term growth, although this growth will rely more on human rather than on physical capital investment than it would have without such policies.
Trade Policy and Industrial Pollution in Latin America: Where are the Pollution Havens?

Nancy Birdsall and David Wheeler

Introduction

The prevailing assumption is that free trade will increase environmental degradation in developing countries. Among environmentalists, one common concern is that liberalized trade regimes and market-driven exchange rates, by increasing the incentive to export, will lead to greater exploitation of such natural resources as native forests. A second concern, and the one we explore in this paper, is that free trade will increase industrial pollution in developing countries, through displacement of dirty industries from developed countries with stricter environmental regulation, and through competitive pressure on developing countries to reduce further their environmental standards.

The question we address is simply: Among countries of Latin America, has greater "openness," defined in terms of trade regimes and foreign investment, been associated with pollution-intensive industrial development? More generally, are open economies more likely to be so-called pollution havens?

There are at least three reasons to expect higher pollution intensity (i.e. more pollution per unit of output) in developing countries, given the existence of trade. First, environmental amenities are normal goods; higher income in the developed countries produces greater demand for clean air and water. Similarly, at lower levels of income and higher discount rates, income gains and jobs are more valued relative to health and other costs of pollution. Second, the relative costs of monitoring and enforcing pollution standards are higher in developing countries, given scarcity of trained personnel, difficulty of acquiring sophisticated equipment, and the high marginal costs of undertaking any new governmental activity when the policy focus is on reducing fiscal burdens. Third, growth in developing countries is associated with a shift out of agriculture into industry and with rapid urban growth and heavy investment in urban infrastructure; this is more likely to imply increasing levels of pollution for each unit of output. In developed countries, in contrast, growth is associated with a shift out of industry into services, and thus with decreasing levels of pollution for each unit of output. These structural differences are consistent with differences in comparative advantage and would be reinforced by free trade.

For these reasons, rising pollution intensity in developing countries could simply reflect differences across countries in the social cost comparative advantage of different mixes of polluting activities (Dean, 1991). Many economists subscribe to this view, arguing that free trade and increased openness should not be resisted even if they increase environmental problems in developing countries.

*Respectively, Director, Country Economics Department, and Environmental Economist, Environment Department, World Bank. We gratefully acknowledge the collaboration of the Center for Economic Studies, U.S. Bureau of the Census.
There are two problems with this common wisdom, however (if not with the general conclusion about support for openness). First, if the social costs of pollution are not appropriately reflected in current environmental standards in developing countries, then freer trade could increase those social costs, possibly even eclipsing the conventional economic gains of openness. Though secondary instruments to address the pollution problem could be designed (rather than using trade policy, which would increase economy-wide distortions), the failure to use such secondary instruments in the first place implies they are not easy to design or implement. Furthermore, if free trade increases pollution in developing countries, total world pollution may rise. This could impose additional costs on developed countries if some polluting activities have negative transnational externalities.

Second, the premise -- that freer trade and more open economies will lead to more environmental degradation -- may be wrong in itself. From a policy point of view, this would mean that an important argument in favor of more openness is being overlooked, and that the potential for a happy marriage of economists and environmentalists is being lost.¹

The question of what effect openness has on the extent of industrial pollution in developing countries is, of course, an empirical one. In the rest of this paper, we suggest why the effect may be positive rather than negative, and present some qualitative evidence for one country (Chile) that tends to support the likelihood of a positive relationship. Finally, we use new estimates of emissions intensity for Latin American industry during the period 1960 - 1988 to investigate three related questions: (1) Does pollution intensity generally increase during industrial development? (2) Did Latin American industry follow a more pollution-intensive path after OECD environmental regulation became stricter? (3) Has industrial development in open economies been more or less pollution intensive than development in more protectionist regimes?

How Free Trade Could Reduce Industrial Pollution

Industrial pollution at the country level can be decomposed as follows:

\[
\text{Industrial Pollution/GDP} = \left[ \frac{\text{Value added (VA) of industry}}{\text{GDP}} \right] \times \\
\left[ \frac{\text{VA (dirty industries)}}{\text{VA (all industries)}} \right] \times \\
\left[ \frac{\text{Pollution from dirty industries}}{\text{VA (dirty industries)}} \right]
\]

The first term (or "development effect") measures the tendency for the industrial and urban share to be increasing in the product of developing countries. The second term (or "composition effect") measures the effect of distribution among industries whose pollution intensity differs greatly (e.g. petrochemicals and cement vs. beer). The third term (or "process effect") measures the extent to which polluting industries reduce or fail to reduce emissions. The degree of openness could affect the size of any of these terms. We concentrate on possible pollution reduction from composition and process effects.

First, labor is relatively more plentiful in developing countries; there is some evidence that more capital-intensive sectors are also more pollution intensive. As Kosmo (1989) demonstrates for Turkey,

¹This is more than a philosophical issue. Some groups of environmentalists may continue to resist through political channels a free trade agreement between the United States and Mexico, for fear of the environmental effects. Similarly, the agreement is resisted by groups that fear a loss of jobs in the United States if firms move south to avoid environmental standards in the United States. Some of the resistance to this and future free trade agreements could arise because of incorrect predictions about the actual links between free trade and environmental standards.
protection therefore tends to bias industrial composition toward pollution intensity. Second, exports must often meet product standards higher than those of the producing country. To the extent that clean products require clean processes, an export-oriented economy will have cleaner processes for some industries. Katz (1991) refers to two examples for Chile: the fishmeal industry is treating its effluents to eliminate bacterial contamination of its product; and the pulp and paper industry has had to treat its effluents and change some of its processes to eliminate trace amounts of dioxin.

Third, foreign investors may simply impose a common international emission standard wherever they invest. Multinational corporations may face high costs in implementing different business practices (different pollution standards) in different settings. High costs could come in the form of stockholder pressure not to "exploit" populations of poor countries by using dirty processes; or in the form of costs associated with retraining managers and changing familiar production processes. Low (1991) suggests that the costs to industrial firms of clean technology and processes are now small in the United States (less than 1 percent of total costs); for new investments, the business and information costs of differentiating in different settings could easily exceed any direct cost advantage of dirtier production.

Fourth, openness and resulting competitive pressure will increase investment in the latest technology, all other things being equal. To the extent that the newest and most efficient technology embodies cleaner processes, this will reduce overall emissions. Fifth, if the costs of being clean are low for new investment but high for retrofitting, then a higher overall growth rate is likely to induce cleaner processes. This is independent of but complementary to the possibility that the more efficient technology embodies cleaner processes.

The first point above suggests a benign compositional impact for openness: the comparative advantage of developing countries is actually with labor-intensive industries that are intrinsically less polluting. The second and third points rely on a process effect, i.e., the possibility that irrespective of local demand for pollution control and short-run local comparative advantage, openness would induce industries in developing countries to adopt cleaner processes. The fourth and fifth points also rely on process effects, though in both cases effects that are fully consistent with long-run comparative advantage. Openness, by increasing competitive pressures, would accelerate investment in new technologies which tend to be cleaner because they are imported from countries with higher pollution standards. Such new technologies are also generally more efficient in terms of overall factor productivity, even if not perfectly suited to the factor proportions of a particular developing country. In addition openness, through its effect on growth, would increase the rate of retirement of older dirtier equipment and processes.

Note that of the five potentially beneficial effects of openness (beneficial in the simple sense of reducing pollution intensity), only one works through a shift in the composition of industry (the composition effect); the others affect the cleanliness of the process in given industries (the process effect). This distinction is important for assessing the relevance of the empirical work reported later in this paper.

The Chile Case2

Chile provides a useful example of a country with limited or no controls on industrial emissions, and openness to trade and foreign investment. Is Chile a "pollution haven"?

---

2This section relies heavily on Scarsborough (1991, mimeo) and on discussions between one of the authors and Scarsborough while working jointly on a study of the effects of macroeconomic and sectoral policies on environmental problems in Chile.
The former military government that assumed power in 1973 established an economic system based on limited intervention by government in markets and on export-led growth under a liberalized trade regime. Barriers to foreign investment were eliminated; import restrictions were eliminated and tariffs reduced to their current low of about 15 percent. Restrictions on industry for environmental reasons were presumably not considered; they would have been seen as discouraging growth and as an example of a potentially welfare-reducing intervention by government in the affairs of the market.

The democratic government that assumed power in 1990 has announced its intention to address the country's environmental problems, and is exploring alternative instruments for control of industrial air and water pollution. However responsibilities are widely diffused among various agencies, and the legislative and regulatory arrangements and capacity for enforcement of any policies or programs that might be desirable will take time to be put in place.

The most visible immediate environmental problem is air pollution in Santiago; after Mexico City, Santiago has the most polluted air in the world, due in part to a recurring thermal inversion layer that traps pollutants. This problem has demanded the attention of the new government, which has so far responded with short-term emergency measures, including restrictions on vehicle use during periods of high pollution. The visibility of the air pollution problem and the need for recurrent imposition of emergency measures have put environmental problems, especially air and water pollution, higher on the public agenda. For this reason if no other, industry executives anticipate that the government will eventually impose emissions and ambient standards; their chief concern is not whether such standards will be imposed, but how and at what level.

Thus Chile represents a case study of an open economy with nonexistent pollution standards, but in which there is a credible threat of future imposition of standards.

We have only anecdotal evidence on the behavior of industrial firms in Chile with respect to pollution. That evidence suggests, however, that the situation is not consistent with the notion that Chile has become a pollution haven -- either by attracting multinational companies seeking a cost advantage because standards are low, or by leading to even laxer enforcement by government of any existing standards in order to attract more foreign investment through regulatory competition.

For example, several representatives of the largest and apparently most profitable pulp and paper and petrochemical firms report they do not know the extra costs they incur in the form of "cleaner" equipment; they invest in modern, efficient, clean equipment -- as a package. In some cases they accept higher costs to reduce emissions to ensure that the exported product meets foreign standards; for example, paper produced with chlorine will have traces of dioxin and cannot be exported to Germany. But even where product standards can be met with dirty processes, the fact that the newest technology is clean dominates any search for lower costs. Representatives of large multinational firms with operations in Chile report that in any event, they face pressure from shareholders in Europe to avoid polluting the environment in developing countries. In contrast, state-owned enterprises that enjoy relative monopoly positions within Chile and access to government subsidies to shield them from international competition are the dirtiest; the state-owned copper company is an example.

3The manager of a large pulp and paper plant in Chile was quoted recently in the New York Times (November 10, 1991, p. E6) as conceding that the investment in pollution control by his company was not to abide by Chilean law, but rather to be able to sell his pulp in Europe, where green movements have persuaded many governments to impose high import tariffs on pulp made with a process that creates chlorine gas as a byproduct.
Government and industry representatives report that industry itself is prodding the government to establish pollution standards, and that through the industry association, firms are sponsoring development of self-regulating standards. Scarsborough (1991) points out that, in the face of the threat of future regulation, the least-cost way for the industrial sector to respond is to urge the government to adopt a mutually negotiated set of standards; this is particularly attractive to the larger cleaner firms as it would permit them to eliminate local cost competition from dirtier firms. For multinational firms the least-cost way to meet the threat is to adopt the standards prevailing in their home countries.

A stylized summary of the effect of openness on the intensity of industrial pollution in Chile, abstracting from the effects of economic growth per se on pollution, would thus be as follows. Openness to foreign investment and the absence of barriers to technology imports encourage multinational companies to invest in Chile, and ensure that domestic producers will have to compete with them. The fact that cleanliness is embodied in newer equipment and processes, and/or the shareholder effect, push industry toward in effect exceeding local standards. The larger, often multinational, firms then attempt to reduce local competition by encouraging the government to introduce or raise standards. The threat of future regulation may reinforce the process, but may not actually be necessary to it.

The overall effect is that openness in Chile is associated with, if not contributing to, the opposite of a pollution haven effect -- perhaps even implying higher standards than are actually efficient given social preferences in Chile.

Cross-Country Evidence

The Chile evidence refers entirely to the "process" effect in the three-part decomposition set out above. We now turn to evidence regarding the "composition effect" in Latin America, i.e. the trend in the mix of "dirty" vs. "clean" industries. Our database is a pooled cross section of time series for 25 Latin American countries during the period 1960-1988. We estimate an equation that describes the relationship between changes in pollution intensity and three variables: per capita income, growth of per capita income, and the degree of openness. We use the results to test three hypothesized effects: The positive income elasticity of environmental protection, which should reduce pollution intensity at higher incomes (ceteris paribus); the displacement effect of stricter OECD regulation, which should raise pollution intensity for Latin America after the early 1970s; and the compositional impact of openness, which should affect the pollution intensity of more open economies (again, ceteris paribus).

Data

Wheeler and colleagues in the World Bank have constructed indices of the toxic intensity of industries per dollar of output in the United States for all four digit industries on the International Standard Industrial Classification. Their estimates are based on a sample of 15,000 industrial plants in 1987, formed by merging output data from the U.S. Census of Manufactures with pollution data from the Toxic Release Inventory (TRI) of the U.S. Environmental Protection Agency. TRI reports releases of 320 toxic substances into the air, water, and as underground and solid waste. Three indices are constructed which incorporate different assumptions about the health and other risks of various toxic emissions; the results reported below use one index but are not sensitive to the index used.

---


5 Lucas, et al. (1991) show that all simple correlations between indices are above .94.
The measures of toxic intensity are applied to the mix of industrial outputs for the 25 Latin American countries, using data reported in the United Nations *Industrial Statistics Yearbook*. This yields an annual index of pollution intensity for each country. The index is of course related solely to the mix of industries, and not to unobserved and unmeasured differences in technologies and enforcement standards.\(^{6}\)

Table 10-1 reports the results from a pooled regression of pollution intensity change on the log of per capita income; growth of per capita income; and the interaction of per capita income growth with an openness index developed by David Dollar (1990) for the World Bank’s 1991 World Development Report.\(^{7}\)

The results for per capita income are consistent with a positive income elasticity of environmental protection. They show that pollution intensity growth is lower (although still positive) at higher levels of per capita income in all three decades. There is also evidence for displacement in the significant, positive dummy variable interactions for the 1970s and 1980s. Latin American growth rates of toxic intensity were generally higher (at each income level) after OECD environmental regulation became stricter. However, the positive interaction of Dollar’s index with income growth for the 1980s suggests that openness to trade generated a significant countervailing force. The implied toxic elasticity of income growth was much higher in relatively closed economies (i.e., those with high numerical rankings on the index).

Table 10-2 has been designed to aid interpretation of the regression results. It shows how predicted toxic intensity changes as income, growth, and the Dollar index vary independently across their full range of values in the data set.\(^{8}\) The ameliorating effect of openness is clearly strong during the 1980s, particularly for fast-growing economies where sectoral shares in total output can change rapidly. For low income, fast-growing economies, switching from closed to open status is predicted to decelerate pollution intensity growth from 35.1 percent annually to 4.7 percent. In middle income, fast-growing economies, the predicted change is from 28.9 percent to -1.5 percent. The effects are also present for the 1970s, but considerably weaker.

The effect of rising income on pollution intensity can be evaluated in Table 10-2 by looking at equivalent cells in the low, middle and high income matrices. For example, the predicted transition for slow-growing closed economies in the 1970s is 11.5 percent (low); 5.1 percent (middle); 1.1 percent (high). In the 1980s, it is 16.8 percent (low); 10.6 percent (middle); 6.7 percent (high). In every case, the predicted transition is toward lower intensity growth rates at higher incomes. Indeed, the prediction for fast-growing economies is negative intensity growth rates at high incomes.

By looking at equivalent cells for the 1970s and 1980s, we can gauge the apparent size of the displacement effect. Most paired cells do suggest progressive displacement from OECD environmental

---

\(^{6}\)In addition, as Lucas, et al. (1991) note, to apply the U.S. intensities to other countries requires the assumption that the pollution intensity of different products within an industry group is similar or that the mix of products within each industry group is similar across countries; and the assumption that emissions are related to output, not to value added, as in fact seems reasonable.

\(^{7}\)The openness index ranks countries from one to seven with respect to openness. Economies with rank one are the most open.

\(^{8}\)The ranges are as follows:

Income: High (US 1987 $3000)), Middle ($1500), Low ($500)
Income growth: Fast (6%), Slow (1%)
Dollar index value: Open (1), Closed (5)
Table 10-1

Dependent Variable: TXGR

Analysis of Variance

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Prob &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>9</td>
<td>0.02696</td>
<td>0.00300</td>
<td>4.092</td>
<td>0.0027</td>
</tr>
<tr>
<td>Error</td>
<td>24</td>
<td>0.01757</td>
<td>0.00073</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C Total</td>
<td>33</td>
<td>0.04452</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Root MSE 0.02705
Dep mean 0.01205
C.V. 224.46988

R-square 0.6055
Adj R-sq 0.4575

Parameter Estimates

| Variable   | DF | Parameter Estimate | Standard Error | T for HO: Parameter=0 | Prob > |T| |
|------------|----|--------------------|---------------|-----------------------|---------|
| INTERCEP   | 1  | 0.437405           | 0.14085690    | 3.105                 | 0.0048  |
| NAS        | 1  | 0.043748           | 0.01690451    | 2.588                 | 0.0161  |
| PCGR       | 1  | 3.331180           | 1.11456940    | 2.989                 | 0.0064  |
| LINC       | 1  | -0.081427          | 0.02407656    | -3.382                | 0.0025  |
| PCGRD70    | 1  | -4.454373          | 1.35963457    | -3.276                | 0.0032  |
| PCGRD80    | 1  | -6.009647          | 2.38588004    | -2.519                | 0.0188  |
| LINC70     | 1  | 0.023213           | 0.00614154    | 3.780                 | 0.0009  |
| LINC80     | 1  | 0.025131           | 0.00569804    | 4.411                 | 0.0002  |
| PGRD70     | 1  | 0.144721           | 0.32904150    | 0.440                 | 0.6640  |
| PGRD80     | 1  | 1.268344           | 0.67901370    | 1.868                 | 0.0740  |

TXGR = Toxic intensity growth rate for the decade (from log regression)
NAS = Dummy variable for non-Andean South American countries
LINC = Log of per capita income in the decade's initial year (thus represents 1960s in the results)
PCGR = Per capita income growth rate for the decade (from log regression) (thus represents 1960s in the results)
PCGRD70 = PCGR X Dummy variable for the 1970s
PCGRD80 = PCGR X Dummy variable for the 1980s
LINC70 = LINC X Dummy variable for the 1970s
LINC80 = LINC X Dummy variable for the 1980s
PCRD80 = PCGR X Dummy variable for the 1980s X Dollar openness index
PGRD70 = PCGR X Dummy variable for the 1970s X Dollar openness index
Table 10-2: Comparative Effects on Toxic Intensity Growth Income, Income Growth and Openness

<table>
<thead>
<tr>
<th></th>
<th>Open</th>
<th>Closed</th>
<th>Open</th>
<th>Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1970s</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Income</td>
<td>SLOW</td>
<td>0.109</td>
<td>0.115</td>
<td>0.117</td>
</tr>
<tr>
<td></td>
<td>FAST</td>
<td>0.061</td>
<td>0.095</td>
<td>0.047</td>
</tr>
<tr>
<td>Middle Income</td>
<td>SLOW</td>
<td>0.046</td>
<td>0.051</td>
<td>0.055</td>
</tr>
<tr>
<td></td>
<td>FAST</td>
<td>-0.003</td>
<td>0.031</td>
<td>-0.015</td>
</tr>
<tr>
<td>High Income</td>
<td>SLOW</td>
<td>0.005</td>
<td>0.011</td>
<td>0.016</td>
</tr>
<tr>
<td></td>
<td>FAST</td>
<td>-0.044</td>
<td>-0.009</td>
<td>-0.054</td>
</tr>
</tbody>
</table>
regulation -- typical Latin American pollution intensity growth was higher in the 1980s. This was not true, however, for fast-growing open economies. Low, middle and high income economies in this category all show lower rates of pollution intensity growth.

Conclusions

This paper began by asking: Among countries of Latin America, has greater "openness", defined in terms of trade regimes and foreign investment, been associated with pollution-intensive industrial development? Our evidence suggests the opposite conclusion — openness is cleaner for industry. Anecdotal evidence from Chile suggests several reasons why the elimination of barriers to importation of new technology and to foreign capital may lead to importation of industrial country pollution standards. Once these higher standards are introduced (and despite the fact that they may be too high from the point of view of local demand for environmental quality), the larger multinational firms are likely to push for enforcement so as to reduce the cost advantage of smaller local firms.

The econometric evidence, though at best exploratory, suggests that over the last two decades the more open economies have ended up with a cleaner set of industries. This is consistent with a growing literature suggesting that it is capital- and materials-intensive industries that have both enjoyed protection and been heavy polluters.

We should introduce two caveats, however. First, we are far from a comprehensive picture at this point -- empirical research on the relationship between economic policy and environmental outcomes has only begun. Secondly, our evidence is strongly consistent with the displacement hypothesis: Pollution intensity grew more rapidly in Latin America as a whole after OECD environmental regulation became stricter. An obvious inference is that the fully-accounted costs of pollution reduction may be considerably higher than previous work has suggested. However, our own results suggest that natural comparative advantage still dominated under relatively free trading conditions: Fast-growing open economies experienced faster growth in clean industries, even in the environmental era. We conclude that "pollution havens" can be found, but not where they have generally been sought. They are in protectionist economies.
Discussant's Comments

Gunnar Eskeland

Birdsall and Wheeler ask a sensible question: Is open trade policy good or bad for the environment. It is sensible because protection of the environment is a policy objective, and choices among feasible trade policies might affect environmental outcomes positively or negatively.

From a hasty, theoretical perspective, the question might be discarded as practically uninteresting. Trade policy instruments are likely to be imperfectly correlated with environmental objectives such as clean air, water and healthy biotypes, and thus will always be dominated by first-best instruments such as charging for damage caused, permit markets and liability. But the authors are well aware that first-best instruments may not be available, or applied, and changes in the use of less perfect instruments may then be attractive. Indeed, we are likely to have fewer instruments than objectives, and we will thus want to pursue several tasks with each. Further motivation, of course, lies in the fact that trade links the wealth of nations, so any international talk comprising trade policy will be benefited by substantive interest from the parties involved.

The authors address the question of the link between an open trade policy and the environment by, productively and innovatively, studying the correlation between data series representing toxicity and openness. First, they provide a framework consisting of the equation:

\[
\text{Ind. Poll.} = \frac{\text{V.A. in Ind.}}{\text{GDP}} \cdot \frac{\text{V.A. in Dirty Ind.}}{\text{V.A. Ind.}} \cdot \frac{\text{Poll. in Dirty Ind.}}{\text{V.A. Dirty Ind.}}
\]

My comment to this equation, which I find very useful, is that we really care about the amount of pollution, not the pollution intensity of GNP, and I would therefore like to contrast it with following:

\[
\text{Ind. Poll.} = \frac{\text{GDP}}{\text{V.A. in Ind.}} \cdot \frac{\text{V.A. in Dirty Ind.}}{\text{V.A. Ind.}} \cdot \frac{\text{Poll. in Dirty Ind.}}{\text{V.A. Dirty Ind.}}
\]

The level of pollution, rather than pollution divided by GDP, would be relevant for the analysis, for two reasons: First, for most environmental problems, a limited sink capacity makes the marginal costs of pollution increase with the level of pollution. Thus, a nation that expands industrial activity without taking countermeasures will experience a declining supply of environmental services. Thus, while it is true that a nation would want, everything else equal, to have more environmental services when it becomes wealthier, the services are likely to become increasingly expensive, in relative terms. The second, more important reason, is that an assumed strong positive relationship between openness and growth is the driving force behind trade reform, and we would therefore expect openness to contribute to pollution through its presumably positive impact on growth. Having said that, anyone interested in the relationships among openness, growth and the environment would want to know whether the effect on the composition of industries would be contributing to pollution or not. This is what the study aims to analyze, and it does it well.

The authors start with stylized facts (or conjectures) about the relationships between development and pollution, and between openness and pollution. The following table summarizes these, in terms of the above equation:
First, we can note that the last column, how clean or dirty each industrial activity is, is dealt with only qualitatively, with evidence from Chile. The quantitative analysis deals with whether the composition of industrial GDP is driven towards the cleaner or dirtier segments of industries (as defined by the toxicity index) by growth and openness. In their quantitative analysis, the authors make interesting findings, among which I would like to highlight a few.

The first is a result they do not make much out of, but which I find very interesting. Birdsall and Wheeler find that the toxicity index (a measure of toxic releases per unit of value-added in industry) is generally growing with income. This should not be confused with an observation that growing economic activity threatens the environment. Rather, their finding is that the sectoral composition of industrial GNP gets ever dirtier with economic growth. I might mention that we have made a similar finding studying data from Mexico; the toxicity index points upwards all through the post-war period, seemingly independently of changes in economic regime.

To arrive at what happens to the level of industrial pollution, one would multiply by the level of industrial activity (the two first columns in the table). Consequently, the task of protecting the environment by making each individual activity cleaner, as has been the direction of effort in industrialized countries, has to compensate not only for growth in industrial activity, but also for an increasing concentration in the most polluting industrial subsectors.

Secondly, they find that the greater the openness of the trade regime, the lower the growth in the toxicity index. In interpreting the result, they allude to the comparative advantage these countries have in labor-intensive industries. Noting that labor is a clean input, and that also for more subtle reasons there could be a positive correlation between capital and material intensity on the one hand and the pollution intensity on the other, this observation certainly is a relevant input in the debate on trade policy and the environment.

<table>
<thead>
<tr>
<th>POLLUTION</th>
<th>= GDP</th>
<th>V.A. IND. GDP</th>
<th>V.A. DIRTY V.A. IND.</th>
<th>POLL. FROM DIRTY IND. V.A. DIRTY IND.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stylized Facts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development</td>
<td>+</td>
<td>+ Early</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Later</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Openness</td>
<td>+</td>
<td></td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>

| **Birdsall/Wheeler Findings** |       |               |                     |                                       |
| Development | n.a.  | n.a.          | +, but less if fast | n.a                                   |
| Openness    | n.a.  | n.a.          | -                   | - Chile (evidence)                   |

n.a.: not analyzed
An interesting extension would be to use the same data and the same approach to test for the intensity of industrial pollution in GDP, rather than only in industrial GDP, bringing in the shares of agriculture and services in GDP in addition to the composition of industrial GNP. This could test an intuitive line of reasoning about comparative advantage similar to the one about labor, utilized above. Assuming that agricultural activities are important in LDCs, and that these will get a boost from increased openness, this could give an additional effect of reducing the intensity of industrial pollution in the economy as a whole (column 2 in the table). Together with the effort to make each industrial activity cleaner, these reductions in pollution intensity will need to compensate for the pollution effects of GDP growth (both the direct ones and those through composition), if we are to keep polluted environments from becoming more polluted.

In conclusion, the principal finding of the study, that openness has contributed to reducing the emission intensity of Latin American economies, is interesting, and the authors provide a good discussion. If we believe comparative advantage will drive the effects of opening an economy, then we should look for price differences for the major cost components of firms. In fact, most U.S. industries spend less than 3 percent of their costs on pollution control while the cost shares for components such as labor will usually be much higher. Consequently, LDCs that sell their environment cheaply have little to offer investors, compared to those offering a cheap efficient labor force, to take one example.

Finally, we should remind ourselves that the framework applied, useful as it is, deals with shifting weights between sectors, but not with cleaning each sector, which is what environmental protection in industrialized countries have concentrated on (and enormous progress has been made). Indeed, if we try to build an argument mostly around changing weights between sectoral shares based on comparative advantage, then we are talking about migration of pollution, even if the direction, this time, was from the South to the North.
Introduction

Economics and ecology share a few other things besides their common Greek root. The task of identifying areas of convergence, however, is not a simple one and the size of the convergence set depends on the core paradigm chosen to represent each science. Mainstream economic analysis tend to dismiss most of the worries of ecologists with respect to natural resource depletion or generalized environmental degradation -- see, for instance, the collection of papers in Simon and Kahn (1984). But professionals working in the field of resource economics have gone a long way in promoting a "marriage" between economics and ecology over the last few years (Dasgupta, 1990).

It is true that the "economization" of ecology is considered by some at best a "marriage of convenience," and at worst a misreading of the environmental question. Still, it has strengthened the view that there is no free lunch in the use of nature's resources by mankind. The protection of the environment is now considered an essential component of development policies geared to fight poverty and to promote sustainable growth (Development Committee, 1990). In short, the dialogue between economics and ecology has contributed also to the "greening" of economics.

The impact of international trade on the environment, however, remains as one of the most divisive issues in this evolving dialogue. One can rationalize the antitrade bias of environmentalists as another facet of their belief that economic growth sooner or later will bring environmental degradation (see, for instance, the paper by Radetzki). In other words, international trade -- as the "handmaiden of growth" (Lal and Rajapatirana, 1987, p. 190) -- is an inevitable "suspect" from an environmental perspective. I will argue, however, that the attitude of environmentalists toward international trade is not framed simply by "growth-anxiety" considerations. "Energy ecologists" in the mid-nineteenth century, for instance, favored autarky while striving to maximize agricultural production (Bramwell, 1989). It is also true that one can find modern...
day environmentalists who believe that international trade could help extractivism become a sound alternative for the exploitation of tropical forests, both on economic and ecological grounds.3

Still the attitudes of most ecologists toward international trade is dominated by the perception of its role as a major carrier of the seeds of systemic disturbance to frontier ecosystems. Excessive logging of tropical timber, trade in ivory and endangered species, fishing of whales and tuna are some of the familiar issues in the environmental agenda which typically have a distinctive antitrade bias. And the support for trade regulation either as a device to halt environmental degradation or as an instrument to enforce higher environmental standards runs strong even among those environmentalists who are not followers of "deep ecology." It seems that most ecologists accept the use of trade restrictions in the pursuit of these objectives as a matter of fact. By the same token, they tend to distrust the soundness of the neoliberal trade system built around the General Agreement on Tariffs and Trade (GATT), which emphasizes trade liberalization and market-oriented disciplines for trade policies.

The potential for conflict between GATT disciplines and ecological concerns is well exemplified by those economic activities which have an impact on tropical moist forests.5 Calls for a ban on tropical timber imports have multiplied in OECD countries lately (Vincent, 1990). The proposition that "rainforests are worth more standing than converted into timber or hamburgers" (Anderson, 1989, p. 168) is not only increasingly popular in industrialized countries, but it is also often interpreted as a clear indictment of international trade.

This paper focuses on the role played by international trade in the process of depletion of tropical moist forests.6 Most of it is devoted to the analysis of the economic and environmental implications of international trade in tropical hardwood. The recent experiences of Brazil and Indonesia are analyzed here in an attempt to illustrate the complexities of the problem. The paper first reviews the dimensions of the tropical deforestation process and some of the questions raised by this process. Then we briefly review the macroeconomic environment that prevailed in Brazil and Indonesia over the 1980s and the role of forestry in

3Brazilian nuts as inputs for American ice-cream and tropical forest essences and oils for British health and beauty products are the prime examples in this context (Margolis, 1990). Lately, several studies have argued that extractivism of nonwood products in the Amazon region (edible fruits, essences and oils, latex, fibre and medicinal herbs) would be over the long run more profitable (from an economic standpoint) than logging or clearing the forest for cattle ranching (Peters, Gentry and Mendelsohn, 1989; Fearnside, 1990a). The economic feasibility of extractivism on a large scale is disputable, however, given the limited size of the markets for tropical nonwood products. And as the history of the Brazilian rubber sector illustrates, forest extractivism (even when highly protected) has not been able so far to compete effectively with alternative economic activities in the tropical forests.

4Followers of "deep ecology" are defined here as those who believe that the preservation of global ecological integrity should be mankind's main objective.

5Tropical moist forests are defined as forests "situated in areas receiving not less than 100 millimeters of rain in any month for two out of three years, with a mean annual temperature of 24 C or higher; mostly lowlying, generally closed. Subdivided into tropical rain forest and tropical moist deciduous forest" (World Bank, 1991a, p. 95). For a detailed discussion of alternative definitions of tropical forest ecosystems see German Bundestag (1990, pp. 143-63).

6Depletion encompasses both significant qualitative disruption of the ecosystem and outright deforestation—i.e., the clearing of forests and the conversion of lands to nonforest uses. See Myers (1986) for further details on these concepts.
these economies. Next is an analysis of how trade policies (applied to tropical hardwood) may affect economic welfare and the environment. The paper ends with a brief evaluation of the role that the GATT can play in the debate concerning trade in tropical hardwood.

The Dimensions of the Problem

Tropical moist forests cover an area of 1.5 billion hectares, corresponding to approximately 42 percent of the world's forest area (World Bank, 1991a). Fifteen developing countries hold around 1.0 billion hectares of closed tropical forests. Among them, Brazil and Indonesia contain the largest existing holds of tropical forests. Both countries have also experienced significant deforestation over the 1980s -- see Table 11-1.

International concern over the rapid pace of deforestation in the developing world has increased significantly over the last decade. Current figures for worldwide deforestation are hotly debated, but rates of destruction in the range of 14 to 20 million hectares of tropical forests (moist and dry) per year are often found in the literature (World Resources Institute, 1990; Postel and Ryan, 1991). Environmentalists are prompt to assert that if this rate is maintained "most accessible tropical forests and up to one-quarter of the earth's species could vanish within the lifetime of today's children" (Miller and Tanglely, 1991, p. 2). And the sense of crisis is magnified by the belief that the rate of deforestation has increased over the last decade: in the early 1980s, the deforestation rate in the tropics was estimated at 11.4 million hectares per year (FAO, 1988).

There are, however, reasons to believe that the above mentioned range for global deforestation rates is biased by the overestimation of the Brazilian deforestation rate for 1987. The often mentioned Brazilian figure of 8,000,000 ha/year relied on information provided by the thermal band of a high resolution radiometer in a meteorological satellite, which captured fire activity in the Amazon region. This technique has been criticized not only because of the imprecise correlation between fire and new tropical deforestation (a significant proportion of the fires occur in regions where the forest had already been cleared or in secondary forests), but also because the sensibility of the sensor tends to magnify the area identified as under fire (Fearnside, 1989a). Furthermore, 1987 was an unusual year with a longer than usual dry season and with political developments (the Constitutional debate on land reform in Brazil) that fostered the use of fire in the context of attempts to consolidate property rights in the Amazon region. More recent official estimates suggest a deforestation rate of 2.3 to 2.6 million ha for 1989 and of 1.4 million ha for 1990 (Garschagen, 1991). Even with these revisions, however, it remains true that the Amazon region faced a significant acceleration of its deforestation rate over the 1980s.7

The terms of the debate on global deforestation are not framed by the so-called "timber-famine" proposition. The Malthusian specter is, of course, present in the discussion. After all, forest depletion has already significantly affected the economy of some developing countries, constraining their capacity to generate foreign exchange via exports of forest products -- e.g., Philippines, Nigeria and Cote d'Ivoire. And there are estimates that, if the pace of deforestation of the mid-1980s is maintained in the 1990s, the number of net exporters of forest products among developing countries will fall from 33 to less than 10 by the end of the century (World Resources Institute, 1985).

7According to German Bundestag (1990, p.193), the deforestation rate calculated as a percentage of remaining forest cover in Brazil's Amazon region increased from around 0.4 percent by 1980 to approximately 2.3 percent by 1989. In the case of Indonesia, according to the same source, the rates were 0.5 and 1.4 percent for 1980 and 1989, respectively.
### Table 11-1: Tropical Forests and Deforestation Rates in the 1980s
(Countries with the 15 largest remaining tropical closed forests)

<table>
<thead>
<tr>
<th>Country</th>
<th>Closed Forest Area (1,000 Ha.)</th>
<th>Average Annual Deforestation (1,000 Ha.)</th>
<th>Extent</th>
<th>Percent (^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>375,480</td>
<td>High estimate</td>
<td>8,000 (^2)</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low estimate</td>
<td>2,100 (^3)</td>
<td>0.6</td>
</tr>
<tr>
<td>Indonesia</td>
<td>113,895</td>
<td>High estimate</td>
<td>1,300 (^4)</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low estimate</td>
<td>900</td>
<td>0.8</td>
</tr>
<tr>
<td>Zaire</td>
<td>105,750</td>
<td></td>
<td>182</td>
<td>0.2</td>
</tr>
<tr>
<td>Peru</td>
<td>69,680</td>
<td></td>
<td>270</td>
<td>0.4</td>
</tr>
<tr>
<td>Colombia</td>
<td>46,400</td>
<td></td>
<td>820</td>
<td>1.8</td>
</tr>
<tr>
<td>Mexico</td>
<td>46,250</td>
<td></td>
<td>595</td>
<td>1.3</td>
</tr>
<tr>
<td>Bolivia</td>
<td>44,010</td>
<td></td>
<td>87</td>
<td>0.2</td>
</tr>
<tr>
<td>India</td>
<td>36,540</td>
<td></td>
<td>1,500</td>
<td>4.1</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>34,230</td>
<td></td>
<td>22</td>
<td>0.1</td>
</tr>
<tr>
<td>Myanmar</td>
<td>31,941</td>
<td></td>
<td>677</td>
<td>2.1</td>
</tr>
<tr>
<td>Venezuela</td>
<td>31,870</td>
<td></td>
<td>125</td>
<td>0.4</td>
</tr>
<tr>
<td>Congo</td>
<td>21,340</td>
<td></td>
<td>22</td>
<td>0.1</td>
</tr>
<tr>
<td>Malaysia</td>
<td>20,996</td>
<td></td>
<td>255</td>
<td>1.2</td>
</tr>
<tr>
<td>Gabon</td>
<td>20,500</td>
<td></td>
<td>15</td>
<td>0.1</td>
</tr>
<tr>
<td>Cameroon</td>
<td>16,500</td>
<td></td>
<td>100</td>
<td>0.6</td>
</tr>
</tbody>
</table>


Notes:
\(^1\) Rates of deforestation as percentages of the remaining forest cover by the late 1980s.
\(^2\) This figure for deforestation is the one reported in WRI (1990). It is based on a 1987 study and is considered an over-estimation (see text for additional information).
\(^3\) According to Fearnside (1989b), quoted in German Bundestag (1990, p. 194), the rate of deforestation in the so-called "Amazonia Legal," was around 3,500,000 ha/year when both open and closed forest were considered.
\(^4\) Based on data for the 1982-90 period.
Still, most economists tend to reject projections of timber scarcity on a global basis (Hyde et al., 1991). Relative price changes and technical progress are expected to play their usual role in avoiding dramatic forest-related shortages over the long run. Actually, recent efforts to model the world timber market suggest that the expected impact of technological progress – wood-saving technology on the demand side combined with yield-enhancing and "wood-extending" effects on the supply side – will be sufficient to avoid any "serious upward movement in real prices in the foreseeable future" (Sedjo and Lyon, 1990, p. 180). Global modelling also suggests that the impact of tropical deforestation on the world's timber supply will not be critical, given the simple fact that tropical forests account for less than 10 percent of the global supply of industrial wood. Such a perspective, of course, does not mean that the social costs of tropical forest depletion should be considered irrelevant. It is well known, for instance, that deforestation may have a devastating impact on indigenous populations. But generic timber-famine statements are perceived as a subset of the Malthusian predictions with respect to natural resources scarcity. And the poor track record of such "doomsday" predictions does not help environmentalists to convince economists of the relevance of their concerns.

Ecologists, in turn, criticize standard forest economics for its narrow approach in estimating the value of tropical forests. From their perspective, a proper evaluation should consider not only the price of timber and other marketable forest products, but also nonmarket forest values -- such as the importance of tropical forests in terms of climate regulation and biodiversity. Evaluation of logging in tropical forests, in turn, should take into account not only direct private costs associated with these activities, but also their potential externalities at local (e.g., soil erosion, environmental impact of high-grading, negative impact on indigenous cultures) and global (e.g., effects on climate and the erosion of genetic assets) levels.

The incorporation of environmental losses in economic analyses does not pose a major challenge from a theoretical point of view. As Dasgupta (1990, p. 53) points out, the gist of the problem was addressed by Pigou "in his classic development of the concept of externalities, and his exposure of the difference between private and social costs (and benefits) in the phenomenon of externalities" more than 70 years ago. In practice, however, the adoption of the Pigouvian methodology is open to criticisms given the inevitable uncertainty concerning the estimation of damage functions associated with externalities. In the case of deforestation in the tropics, this uncertainty is magnified both by doubts about the accuracy of deforestation figures and by reservations concerning the scientific evidence related to some of these externalities (e.g., the debate surrounding the greenhouse effect; Schneider S., 1989).

The main direct causes of depletion of tropical forests are well known. Conversion of forests to alternative uses such as agricultural production and cattle ranching, commercial logging, and demand for fuelwood are the leading factors behind this process. Estimates of the contribution of each one of these activities to forest depletion, however, are even more precarious than the available estimates for deforestation rates. Johnson (1991) suggests that 64 percent of tropical forest depletion can be attributed to agricultural conversion, 18 percent to commercial logging, 10 percent to the action of fuelwood gatherers, and 8 percent to cattle ranching. The World Bank (1991a, p.31), in turn, points out that tropical moist forests "are being lost primarily to agricultural settlement (about 60 percent of the area cleared each year), with the balance split roughly between logging and other uses (roads, urbanization, fuelwood, and so on)."

It is recognized that the dynamics of the forest depletion process are not well captured by these shares. Forest depletion usually involves the interaction of different economic activities. The environmental impact of commercial logging, for instance, is open to debate. Clear felling is not a common practice in tropical moist forests. Still, the building of logging roads, the movement of heavy equipment, and careless operations may have a significant impact on nontargeted trees. Available estimates suggest that under conditions of selective felling, direct damage affects as much as 10 percent of the forest area and indirect damage usually
modifies 20 to 30 percent of the forest. Overall damage estimates as high as 70 percent of the total targeted forest area, however, have been mentioned in the literature (German Bundestag, 1990).

The indirect contribution of logging to deforestation is also often emphasized. Logging operations tend to facilitate access to forest areas and in this context they may foster agricultural conversion. In some African countries, for instance, it is alleged that "over 75 per cent of the forest land cleared annually by peasant farmers ... had previously been logged over" (World Rainforest Movement, 1990, p. 51). Furthermore, by affecting the delicate balance of these ecosystems, commercial logging is accused of nurturing conditions that may contribute to ecological disaster. It has been argued, for instance, that the Kalimantan fire that ravaged 3.6 to 3.7 million hectares of Indonesian forests in 1982-83 was "helped" by overlogging in that region (Johnson, 1984). Hence, even though the exact contribution of commercial logging to tropical forest depletion is hard to estimate, there is no doubt that its environmental impact may be significant.

**Sources of Deforestation in Brazil and Indonesia**

The process of tropical deforestation in Indonesia and in Brazil has already motivated a large array of contributions to the literature on environmental economics -- e.g., Repetto, 1988; Gillis, 1988; Mahar, 1989; World Bank, 1990; Reis and Margulis, 1991; and Binswanger, 1991. Table 11-2 summarizes the main sources of deforestation identified in this literature. Despite some important differences in terms of the main economic activities being carried on in the tropical areas of Brazil and Indonesia, one can find a common pattern of exploitation of natural resources. In both countries, poverty (as reflected by the role of small farmers in the deforestation process), official development projects, rapid migration and private activities backed by governmental subsidies (e.g., logging and cattle ranching) are the main sources of deforestation in these regions.

External demand (international trade) does play a role in explaining some of the economic activities identified in Table 11-2. The most obvious cases are provided by logging in Indonesia and the outward-oriented "Grande Carajas Program" in Brazil. Activities geared to the domestic market -- such as subsistence agriculture and cattle ranching -- however, are the main players in the deforestation process. Any attempt to estimate the contribution of international trade to tropical deforestation is, however, a hopeless quest unless one can build complete general equilibrium models for these economies with well specified environmental damage functions per economic activity. And I would argue that to pursue this route would not be intellectually rewarding. After all, the question of the source of demand is not the relevant one (unless one can make a strong case that the production process depends upon the market orientation of the industry in a perverse way). The following questions seem to be more relevant for the ongoing debate on international trade between environmentalists and economists: Does freer trade necessarily diminishes welfare by fostering environmental degradation? Are trade restrictions the best approach to deal with environmental externalities? The analysis of tropical wood industries in Brazil and Indonesia, despite their many operational differences (see below), is illustrative in this context. The relevance of this analysis has been enhanced by the growing pressure in favor of trade restrictions against tropical woods in the industrialized world.

The already mentioned uncertainty concerning externalities associated with tropical forest depletion and the low quality of the existing statistics (both for deforestation rates in general and in terms of...
Table 11-2: Major Economic Activities Linked to Tropical Deforestation in Brazil and Indonesia

<table>
<thead>
<tr>
<th>Activity</th>
<th>Development Projects</th>
<th>Commercial Logging</th>
<th>Smallholder Conversion</th>
<th>Ranching &amp; Livestock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BRAZIL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Large-scale Mining</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Grande Carajas&quot; Program</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Concentrated in the states of</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Para and Rondonia</td>
<td>Approximate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4,000 sawmills</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Concentrated in the states of</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Para and Rondonia</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,000,000 farms in properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>with less than 100 Ha</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1,000 Ha/ year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Large-scale Mining</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Hydroelectric Projects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>483</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Roads</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INDONESIA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Government Sponsored Tree-Crop</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&amp; Transmigration Program</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200-300</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Approximate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2,500</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sawmills</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Concentrated in the islands</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>of Sumatra and Kalimantan</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80-150</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Concentrated in the islands</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>of Sumatra and Kalimantan</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,060,000 farms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>families</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Large-scale Mining</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Hydroelectric Projects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Roads</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Valverde (1989); World Bank (1990); Reis and Margulis (1991); Anderson A. (1990).

Notes:
1. The mining concession of the Carajas project covers 411,000 Ha.
2. Estimates reflecting the impact of the operations of the 13 projected pig-iron mills in the Greater Carajas area. Currently only 4 mills are in operational conditions.
3. The flooded area by the existing hydroelectric dams is mainly accounted for Balbina (239,000 Ha), and Tucuruí (192,600 Ha).
4. Reis and Margulis (1991) found that road density per area of tropical forest explained 8 percent of the deforestation occurred during the 1980-85 period.
5. Reis and Margulis (1991) did not find a statistically significant coefficient for logging in their analysis of deforestation in Brazil's North Region. Still, based on some "heroic" assumptions they estimated logging to be responsible for 13% of the deforestation occurred during the 1980-85 period.
6. Fires, often "helped" by logging, are estimated to add 70,000 to 100,000 Ha per year to the deforestation rate.
7. Reis and Margulis (1991) found population density and crop production to explain 49 and 20 percent, respectively, of the deforestation occurred during the 1980-85 period.
8. Reis and Margulis (1991) found cattle ranching to explain 10 percent of the deforestation occurred during the 1980-85 period.
contribution of specific economic activities) limits the power of this type of analysis. Still, relevant qualitative recommendations can be derived from economic theory. Environmental problems can usually be understood in the context of market failure. Inadequate property rights, for instance, can play an important role in explaining overlogging by timber companies in tropical forests (Hyde, Newman and Sedjo, 1991). In a similar fashion, inadequate tenure security for farmers has also been shown to be associated with tropical deforestation (Southgate, Sierra and Brown, 1991). Mistaken government policies, in turn, distort (sometimes inadvertantly) economic incentives in a way that stimulates environmental degradation, leading to suboptimal solutions from a social point of view. In short, market and government failures frame the process of tropical deforestation in Brazil and Indonesia.

The Forest Sector in Brazil and in Indonesia

Tropical rain forests cover almost 40 percent of the Indonesian territory, being concentrated in Kalimantan, Sumatra and West Irian. The Brazilian rain forest, in turn, is found mainly in the Northern region of the country, covering approximately 39 percent of Brazil's territory. In both countries, the areas covered by tropical forests have much lower population densities than the rest of the country. The outer islands of Indonesia, with 92 percent of the country's territory, are home for only 28 percent of its population (Ahmed, 1991). The North Region of Brazil, in turn, encompasses 41 percent of its territory, but in 1985 accounted for only 5.7 percent of Brazil's population (Reis and Margulis, 1991). It is worth mentioning, however, that migration flows into the tropical forest areas have increased significantly in both countries over the 1980s.

Brazil and Indonesia have often relied on interventionist trade policies in an attempt to foster economic development. In both cases, the evolving trade regime has frequently been characterized by a significant antitrade bias (Martone and Primo Braga, 1988; Fane and Phillips, 1991). More recently, however, both economies began to pursue trade liberalization reforms. In the case of Indonesia, a trade liberalization program was initiated in 1984. This liberalization effort lowered average MFN tariffs from 37 percent to 22 percent between 1984 and 1990 and it also significantly diminished the restrictiveness of Indonesia's nontariff barriers (GATT, 1991b). In the case of Brazil, major liberalization efforts started in 1990. Most nontariff barriers were eliminated in 1990 and a gradual program of tariff reduction began in 1991. By 1994, the average tariff is expected to be around 14 percent (versus 32 percent in 1990) and the maximum tariff will be 40 percent -- a significant diminution vis-a-vis the maximum tariff of 105 percent in 1990 (World Bank 1991c).

So much for the similarities at an aggregated level. Brazil and Indonesia are countries at different levels of economic development as Table 11-3 illustrates. While Brazil can be classified as an upper middle-income country (with an income per capita of US$ 2500 in 1989), Indonesia remains a low-income country (with an income per capita of US$ 500 in 1989). Not surprisingly, the contribution of the primary sector to each economy is much higher in Indonesia than in Brazil.

The relative economic weight of commercial logging in these countries follows the same pattern. Forest-related activities -- mainly commercial logging -- accounted for as much as 3 percent of the Indonesian GDP in the late 1970s. And even though their direct contribution to GDP had shrunk to approximately 1 percent by 1988, exports of hardwood products continued to account for a significant share of Indonesian exports: 13.8 percent in 1988. The economic importance of manufactured wood products, in turn, has been

---

9Brazil's Legal Amazonia encompasses the states of Acre, Amapa, Amazonas, Para, Rondonia and Roraima (the so-called North Region), Mato Grosso, Tocantins, and Maranhao west of the 44th meridian.
Table 11-3: Brazil and Indonesia, Selected Indicators

<table>
<thead>
<tr>
<th></th>
<th>Brazil</th>
<th>Indonesia</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Population</td>
<td>147.3</td>
<td>178.2</td>
</tr>
<tr>
<td>Mid-1989 (Mil.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. GNP per capita</td>
<td>2,500</td>
<td>500</td>
</tr>
<tr>
<td>(1989 US$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Average Annual Labor Force Growth Rate, 1980-85</td>
<td>2.3</td>
<td>2.4</td>
</tr>
<tr>
<td>4. Growth Rate of GDP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1965-73</td>
<td>9.8</td>
<td>6.6</td>
</tr>
<tr>
<td>1973-80</td>
<td>6.4</td>
<td>7.2</td>
</tr>
<tr>
<td>1980-90</td>
<td>2.8</td>
<td>5.3</td>
</tr>
<tr>
<td>5. Inflation Rate (%)</td>
<td>287.3</td>
<td>8.5</td>
</tr>
<tr>
<td>(Annual average rate for consumer prices, 1980-90)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Distribution of GDP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>by Sector (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1989: Agriculture</td>
<td>9</td>
<td>23</td>
</tr>
<tr>
<td>(Forestry)</td>
<td>-</td>
<td>(1)</td>
</tr>
<tr>
<td>Industry</td>
<td>43</td>
<td>37</td>
</tr>
<tr>
<td>Services</td>
<td>48</td>
<td>39</td>
</tr>
<tr>
<td>7. Share of Employment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>by Sector (%) ¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>31.2</td>
<td>53.4</td>
</tr>
<tr>
<td>Industry</td>
<td>26.6</td>
<td>15.9</td>
</tr>
<tr>
<td>Services</td>
<td>42.2</td>
<td>30.7</td>
</tr>
<tr>
<td>8. Terms of Trade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>89.0</td>
<td>159.5</td>
</tr>
<tr>
<td>1985</td>
<td>90.9</td>
<td>135.7</td>
</tr>
<tr>
<td>1987</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>1990</td>
<td>94.4</td>
<td>107.4</td>
</tr>
<tr>
<td>9. Trade ² as a Percentage of GDP, 1988</td>
<td>14.0</td>
<td>41.4</td>
</tr>
</tbody>
</table>


Notes:
¹ Data for Brazil refers to 1980; data for Indonesia refers to 1989.
² Sum of exports and imports for merchandise trade.
increasing and according to some estimates is already responsible for 1 percent of the Indonesian GDP (Hanna 1991). In Brazil, commercial logging accounts for less than 1 percent of the GDP and exports of hardwood products have accounted for no more than 1 percent of Brazilian export revenues. It is also important to keep in mind that forestry in Brazil has a less direct identification with tropical timber than is the case in Indonesia. The exploitation of coniferous trees and eucalyptus -- mainly from industrial plantations -- in the south of Brazil provides the basis for an important segment of the Brazilian forest and wood manufacturing sectors, not to mention the thriving paper and wood pulp industries. Only recently -- in the second half of the 1980s -- hardwood output from the North Region began to account for more than 50 percent of Brazil’s log production.

In both countries, government policies have played a major role in shaping the face of the wood industry. Indonesia has pursued an explicit policy of industrialization focused on its natural resources. Industrial processing of tropical wood has been a high priority in this context (Takeuchi, 1991). Another major policy objective of the Indonesian government has been to secure an adequate share in the economic rent derived from the exploitation of tropical forests. More recently (1980), concerns with the rate of depletion of the local forests have also led the government to introduce a reforestation fee earmarked to finance reforestation efforts.

Over time, the Indonesian government has increased the taxation of logging activities in an effort to expand its share in their large economic rents. Still, most analysts believe that rent capture by the government remains quite low -- in the 20 to 30 percent range according to Hanna (1991). Trade policies, in turn, have been used quite successfully in promoting domestic processing of local wood. In 1978, the government doubled the export tax on logs to 20 percent. In 1980, the government announced a gradual phase-out of log exports with the allocation of export quotas being guided by "domestic processing performance" indices (Takeuchi, 1983). At the end of 1984, a complete export log ban began to be enforced. In 1989, the government introduced minimum export prices for sawnwood and imposed prohibitive taxes on exports of sawnwood (differentiated by the specie of the wood). This measure, which is tantamount to an export ban, raised once again the incentives for the local industry to move upward in the direction of higher value-added activities -- particularly, plywood production.

Amazon region logging and wood processing operations have also benefited from different types of government incentives: fiscal and financial incentives under regional development programs -- such as SUDAM and SUFRAMA -- and export incentives under the general export promotion program. Since 1969, however, Brazil has imposed an export log ban for tropical wood. Export permissions have been occasionally granted in the case of logs from areas soon to be submerged by hydroelectric reservoirs. The log export ban, as in the case of Indonesia, was rationalized as an incentive to the domestic processing wood industry. One can argue, however, that the main incentive to the wood industry in the Amazon region is provided by the quasi-open access to public forests and the poor enforcement of existing regulations controlling forestry activities.

Tables 11-4, 11-5, and 11-6 provide additional information concerning the forest and wood processing sectors in both economies. The outward orientation of the Indonesian wood industry contrasts significantly with the inward orientation of the Brazilian industry. Despite the rapid growth of the Indonesian domestic market over the 1980s, exports have consistently absorbed more than 40 percent of the domestic production.

\textsuperscript{10}It is worth mentioning, however, that most of these incentives have been phased out over the last two years. For further details on governmental incentives to logging operations in the Amazon region in the early 1980s, see Browder (1987).
Table 11-4: Brazil and Indonesia: Wood Production and Trade, 1975-87

<table>
<thead>
<tr>
<th></th>
<th>Roundwood Production (1,000 m³)</th>
<th>Processed Wood Production (1,000 m³)</th>
<th>Paper Production (1,000 m³)</th>
<th>Net Trade In Roundwood (1,000 m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Fuel &amp; Charcoal</td>
<td>Industrial Roundwood</td>
<td>Sawnwood</td>
</tr>
<tr>
<td>Brazil</td>
<td>237,779</td>
<td>39</td>
<td>171,670</td>
<td>25</td>
</tr>
<tr>
<td>Indonesia</td>
<td>158,075</td>
<td>22</td>
<td>129,600</td>
<td>22</td>
</tr>
</tbody>
</table>


Notes:
- Δ% = change in production between 1975-77 and 1985-87.
- Net trade in roundwood = exports minus imports of sawlogs and veneer logs, fuelwood, pulpwood, other industrial roundwood, and the roundwood equivalent of trade in charcoal, wood residues, and chips and particles.
Table 11-5: Indonesia: Production and Exports of Hardwood, 1970-88

<table>
<thead>
<tr>
<th>Year</th>
<th>Logs Production</th>
<th>Logs Exports</th>
<th>Sawnwood Exports</th>
<th>Plywood Exports</th>
<th>Veneers Exports</th>
<th>Processed Products in Exports</th>
<th>Exports in Production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1,000 m³)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(%)</td>
<td>(%)</td>
</tr>
<tr>
<td>1977</td>
<td>22,330</td>
<td>18,560</td>
<td>594</td>
<td>17</td>
<td>0.00</td>
<td>5.7</td>
<td>88.1</td>
</tr>
<tr>
<td>1978</td>
<td>26,620</td>
<td>19,200</td>
<td>756</td>
<td>70</td>
<td>0.00</td>
<td>7.4</td>
<td>77.9</td>
</tr>
<tr>
<td>1979</td>
<td>24,860</td>
<td>17,800</td>
<td>1,283</td>
<td>117</td>
<td>0.00</td>
<td>12.8</td>
<td>82.1</td>
</tr>
<tr>
<td>1980</td>
<td>27,559</td>
<td>14,884</td>
<td>1,203</td>
<td>245</td>
<td>0.00</td>
<td>15.6</td>
<td>64.0</td>
</tr>
<tr>
<td>1981</td>
<td>23,334</td>
<td>6,201</td>
<td>1,171</td>
<td>760</td>
<td>0.00</td>
<td>38.5</td>
<td>43.2</td>
</tr>
<tr>
<td>1982</td>
<td>22,448</td>
<td>3,104</td>
<td>1,222</td>
<td>1,232</td>
<td>0.00</td>
<td>62.0</td>
<td>36.4</td>
</tr>
<tr>
<td>1983</td>
<td>25,470</td>
<td>2,993</td>
<td>1,793</td>
<td>2,106</td>
<td>74</td>
<td>73.4</td>
<td>44.1</td>
</tr>
<tr>
<td>1984</td>
<td>26,958</td>
<td>1,724</td>
<td>2,198</td>
<td>3,021</td>
<td>90</td>
<td>86.6</td>
<td>47.6</td>
</tr>
<tr>
<td>1985</td>
<td>23,500</td>
<td>27</td>
<td>2,166</td>
<td>3,964</td>
<td>91</td>
<td>99.8</td>
<td>56.4</td>
</tr>
<tr>
<td>1986</td>
<td>27,400</td>
<td>27</td>
<td>2,642</td>
<td>4,607</td>
<td>102</td>
<td>99.8</td>
<td>57.0</td>
</tr>
<tr>
<td>1987</td>
<td>36,226</td>
<td>3</td>
<td>2,208</td>
<td>5,648</td>
<td>54</td>
<td>100.0</td>
<td>47.2</td>
</tr>
<tr>
<td>1988</td>
<td>36,226</td>
<td>3</td>
<td>2,983</td>
<td>6,372</td>
<td>54</td>
<td>100.0</td>
<td>55.7</td>
</tr>
</tbody>
</table>

Memorandum items:

- World Total, 1988 (1,000 m³) 284,422 31,956 17,583 12,807 1,739
- Indonesia's shares in World Total, 1988 (%) 12.74 0.01 16.97 49.75 3.11

Source: FAO (1990)

Note:
- Roundwood equivalent coefficients used to estimate reported shares are: logs = 1; sawnwood = 1.82; veneers = 1.90; plywood = 2.30.
Table 11-6: Brazil: Production and Exports of Hardwood, 1970-88

<table>
<thead>
<tr>
<th>Year</th>
<th>Logs Production (1,000 m³)</th>
<th>Logs Exports</th>
<th>Sawnwood Exports</th>
<th>Plywood Exports</th>
<th>Veneers Exports</th>
<th>Share of Processed Products in Exports¹</th>
<th>Share of Exports in Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>11,920</td>
<td>4</td>
<td>405</td>
<td>52</td>
<td>49</td>
<td>99.6</td>
<td>8.0</td>
</tr>
<tr>
<td>1978</td>
<td>12,595</td>
<td>10</td>
<td>391</td>
<td>79</td>
<td>47</td>
<td>99.0</td>
<td>7.9</td>
</tr>
<tr>
<td>1979</td>
<td>14,197</td>
<td>13</td>
<td>593</td>
<td>111</td>
<td>36</td>
<td>99.1</td>
<td>10.0</td>
</tr>
<tr>
<td>1980</td>
<td>16,296</td>
<td>7</td>
<td>622</td>
<td>99</td>
<td>40</td>
<td>99.5</td>
<td>8.9</td>
</tr>
<tr>
<td>1981</td>
<td>16,018</td>
<td>6</td>
<td>569</td>
<td>113</td>
<td>43</td>
<td>99.6</td>
<td>8.6</td>
</tr>
<tr>
<td>1982</td>
<td>16,642</td>
<td>8</td>
<td>394</td>
<td>81</td>
<td>47</td>
<td>99.2</td>
<td>6.0</td>
</tr>
<tr>
<td>1983</td>
<td>17,378</td>
<td>4</td>
<td>455</td>
<td>147</td>
<td>54</td>
<td>99.7</td>
<td>7.3</td>
</tr>
<tr>
<td>1984</td>
<td>17,966</td>
<td>30</td>
<td>446</td>
<td>206</td>
<td>52</td>
<td>97.9</td>
<td>7.9</td>
</tr>
<tr>
<td>1985</td>
<td>17,966</td>
<td>26</td>
<td>421</td>
<td>229</td>
<td>52</td>
<td>98.2</td>
<td>7.9</td>
</tr>
<tr>
<td>1986</td>
<td>18,684</td>
<td>9</td>
<td>375</td>
<td>218</td>
<td>50</td>
<td>99.3</td>
<td>6.9</td>
</tr>
<tr>
<td>1987</td>
<td>18,684</td>
<td>10</td>
<td>486</td>
<td>183</td>
<td>47</td>
<td>99.6</td>
<td>13.8</td>
</tr>
<tr>
<td>1988</td>
<td>18,964</td>
<td>46</td>
<td>533</td>
<td>364</td>
<td>56</td>
<td>97.7</td>
<td>10.3</td>
</tr>
</tbody>
</table>

Memorandum items:

- World Total, 1988 (1,000 m³) 284,422 31,956 17,583 12,807 1,739
- Brazil's shares in World Total, 1988 (%) 0.67 0.14 3.03 2.84 3.22
- Softwood Component for Brazil, 1988 (1,000 m³) 21,299 0.00 119 n.a. n.a.

Source: FAO (1990)

Note:

¹ Roundwood equivalent coefficients used to estimate reported shares are: logs = 1; sawnwood = 1.82; veneers = 1.90; plywood = 2.30.
of industrial roundwood. In the Brazilian case, the share of exports in total production typically does not surpass the 10 percent mark. This sharp divergence is not at odds with the overall trade orientations of both economies -- see Table 11-3. It can also be argued that the overall structure of governmental incentives in the Brazilian economy has not been as favorable to the wood processing industry as it has been in Indonesia, even though available estimates of effective rates of protection for both economies in the 1980s do not offer conclusive evidence in this respect (World Bank, 1983; Braga et al., 1988; Fane and Phillips, 1991; Wymenga, 1991).

I will submit, however, that the observed difference in trade orientation of the Brazilian and Indonesian wood industries mainly reflects the higher competitiveness of the Indonesian hardwood. Ricardian comparative advantages (Indonesian forests are characterized by a higher density of commercially valuable tree species), consumer preferences (the light colors of Asian woods are preferred to the more dark-colored Amazonian species by consumers in the developed countries), conditions of access to the forest, and transportation costs (Japan is the main world importer of tropical hardwood) are the main factors mentioned in the literature to explain Asian dominance in the international market for tropical hardwood (Takeuchi, 1974; Fearnside, 1990).

Table 11-5 provides additional evidence on the "success" of the Indonesian industrialization strategy as far as promotion of domestic processing of natural resources is concerned. The participation of processed products in exports, which was negligible by the late 1970s, reached 100 percent by 1987. As mentioned above, trade instruments played an important role in this process. In the Brazilian case, industry exports have always been dominated by processed products, given prevailing restrictions on the export of nonprocessed logs. The much higher dynamism of the Indonesian wood processing industry is confirmed by an analysis of the evolution of the revealed comparative advantage (RCA) for wood processing industry in these two countries over the last two decades.11 The veneers and plywood sector (SITC 631, Revision 1) presented RCAs of 2.17 and 0.03 for Brazil and Indonesia, respectively, in 1967. Twenty years later, these indices were 1.75 (Brazil) and 53.78 (Indonesia). This dramatic evolution is basically explained by the preferential access granted to the domestic wood processing sector to Indonesia's tropical forests and their highly competitive hardwoods.

It should come as no surprise then that Brazil, despite holding the largest reservoir of tropical wood in the world, is a minor player in the international market for tropical wood. Table 11-7 illustrates how far apart are Brazil and Indonesia in this market. Still, the dynamics of the international market for hardwood, improvements in the transportation infrastructure in the Amazon region, and the depletion of forest reserves in other supplying regions suggest that Brazil may become a major supplier of tropical hardwood (particularly, in processed forms) in the international market (Repetto, 1988). Against this background, the next section analyzes some of the issues raised by international trade in hardwood, in particular, the dangers of following interventionist trade policies from an environmental perspective.

---

11The revealed comparative advantage index was introduced by Bela Balassa in 1965. It is defined as follows: \[ \text{RCA}_{ij} = \frac{x_{ij}/X_{i}}{x_{jw}/X_{w}} \], where:

- \( x_{ij} \) = value of country i's exports of product j;
- \( X_{i} \) = value of country i's total exports of manufactures;
- \( x_{jw} \) = value of world exports of product j;
- \( X_{w} \) = value of world exports of manufactures.

An RCA index above unity is interpreted as indicating that the country has a comparative advantage in the production of product j. For further details see Balassa (1965).
Table 11-7: World Trade in Tropical Timber, 1987
(Percentage share in World total)

<table>
<thead>
<tr>
<th>Major Exporters</th>
<th>%</th>
<th>Major Importers</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaysia</td>
<td>48.6</td>
<td>Japan</td>
<td>28.1</td>
</tr>
<tr>
<td>Indonesia</td>
<td>26.7</td>
<td>China</td>
<td>9.2</td>
</tr>
<tr>
<td>Singapore</td>
<td>5.2</td>
<td>Hong Kong</td>
<td>4.2</td>
</tr>
<tr>
<td>Philippines</td>
<td>3.2</td>
<td>USA</td>
<td>7.5</td>
</tr>
<tr>
<td>Cote d'Ivoire</td>
<td>2.4</td>
<td>Singapore</td>
<td>6.2</td>
</tr>
<tr>
<td>Brazil</td>
<td>2.4</td>
<td>South Korea</td>
<td>6.2</td>
</tr>
<tr>
<td>Gabon</td>
<td>2.0</td>
<td>United Kingdom</td>
<td>4.7</td>
</tr>
</tbody>
</table>

Memorandum Items:

| Asia            | 87.6| Asia            | 54.3|
| Africa          | 8.0 | EC              | 20.1|
| Latin America   | 4.4 |                 |     |

Sources: German Bundestag (1990); Zarsky (1991).

Notes:
1 Shares based on total trade for sawnwood, veneers, and plywood (converted to RWEQ) and logs.
2 Total exports in 1987 = 67.2 million cubic meters.
3 Total imports in 1986 = 56.5 million cubic meters.
4 Transit country.
Trade Policies and the Environment: The Case of Trade in Tropical Hardwood

Let us start by accepting the proposition that logging of tropical hardwood generates negative environmental externalities. For some reason (myopic behavior of private agents, inadequate property rights, misguided government policies), loggers do not take into account the environmental costs of their operations. Will the exposure of this country to international trade necessarily bring a higher level of environmental degradation? The answer to this question, in a more general setting, was provided by Anderson (1991). It is quite obvious that the country's environment can be either improved (if the country turns out to be a net importer of the good) or harmed (if the country becomes a net exporter of the polluting good). But even if the environment is harmed, the overall impact on the country's welfare is ambiguous given the positive welfare contribution associated with the gains from trade.

Figure 11-1 illustrates a similar problem: the impact of growing international prices for tropical hardwood on the Amazon region. As described in the previous section, Brazil is a small player in the international market for hardwood. Accordingly, one can treat international prices as given and ignore eventual effects on the rest of the world. Now, will the expected increase in international prices play environmental havoc in the Amazon region? Of course, the answer to this question depends on the shape of the marginal social cost curve which takes into account the environmental externality. Let us assume that a reasonable estimate of these costs can be made incorporating not only local externalities (e.g., changes in the local microclimate, soil degradation, and "waste" of alternative forest products), but also international externalities (contribution to the greenhouse effect, loss of biodiversity, etc). Curves S′ (local externalities only are considered) and S'' (local and international externalities are considered) in Figure 11-1 portray this situation.

At initial price OPo, the Amazon region is a net exporter of tropical hardwood. It produces OQo, consumes OCo, and exports CoQo. This level of production generates negative environmental externalities which in welfare terms amount to the area "xac" ("xab" if only local externalities were considered). As the international price of hardwood increases to OP1, production increases to OQ1, domestic consumption decreases to OC1, and exports raise to CIQ1. The welfare gain from trade, in turn, would increase by the area hafg while additional environmental costs equivalent to the area acdf would be incurred (abef at local level). Welfare from a cosmopolitan (or internationalist) perspective would change by the area hafg - area acdf, and this change could be either positive or negative. The smaller the divergence between the social and the private costs of production and/or the higher the international competitiveness of the country, the greater the potential for trade expansion to bring a net increase to world welfare despite its negative environmental implications.

The potential for conflict between national and cosmopolitan perspectives is also illustrated by Figure 11-1. It may well be the case that trade expansion will be considered welfare enhancing from the point-of-view of domestic policymakers concerned only with local externalities -- i.e., area hafg - area abef is a positive number -- despite its negative global welfare impact -- i.e., despite area hafg - area acdf being a negative number.3

---

2 The analysis presented in this section relies on Anderson (1991).
3 It is assumed that nationalistic policymakers try to maximize domestic welfare without taking into account the international spillovers of domestic economic activity.
Figure 11-1: The Impact of an International Price Rise for a Small Economy
Now let us assume that under external pressure, Brazil decides to curtail its logging activities in order to diminish environmental externalities. What policy instrument should Brazil use to accomplish this objective? The optimal intervention literature suggests the use of a production tax in order to bring down production to the point were its social cost equals its marginal benefit (the international price). If domestic policymakers only care about local externalities, a production tax $ij$ would accomplish this objective by bringing down production from $OQ_1$ to $OQ'_1$ at the prevailing international price of $OP_1$ -- see Figure 11-2. In this case, the net impact on welfare brought by the introduction of the production tax would be given by area $ief$ - area $ijf$ from a national perspective. If for administrative reasons or for some antitrade bias, domestic policymakers pursued the same objective via an export tax $ij$, the welfare impact at national level would be given by area $ief$ - area $ijf$ - area $grq$. Accordingly, the export tax would be an inferior option, because of the distortion introduced in consumption by this instrument (represented by area $grq$).

From a global point of view, however, the size of the optimal tax should be $kl$, which would bring production down to $OQ''1$. The welfare gain for the rest of the world associated with this further reduction of production would be given by area $tkul$. Domestic policymakers would evaluate this increase in the tax as entailing a welfare cost of area $kijl$ - area $tijl$ if the policy instrument utilized were a production tax or area $kijl$ + area $rsq$ - area $tijl$ if an export tax were the instrument considered. This result suggests that the use of trade instruments to pursue environmental objectives may increase domestic resistance to external pressures devoted to foster global environmental concerns. It also provides an example in which a liberal trade policy cum a production tax characterize the optimal policy mix, not only in terms of efficiency considerations, but also with respect to the pursuit of global environmental objectives.

The Indonesian strategy of fostering higher value-added production in its wood industry via restrictive trade policies also provides some interesting lessons. Contrary to the conventional perception among environmentalists -- see, for instance, comments on this perception in Zarsky (1991, p. 75) -- the Indonesian export taxes and, later on, the log export ban brought additional environmental degradation. By restricting the export of logs -- and more recently sawnwood -- Indonesia increased the effective rate of protection to its wood processing activities -- particularly, furniture production (Wymenga, 1991). It is still open to discussion if this strategic trade policy will eventually pay off from an economic point of view (Repetto, 1988; Takeuchi, 1991). By discriminating in favor of local processors, however, this policy generated a more intensive use of logs per unit of output given the lower level of efficiency of the local processing industry. Hanna (1991, p.13) has estimated that if Indonesian sawmills and plywood were operating at the world technological frontier, the same production of sawnwood and plywood achieved in the second half of the 1980s could be reached with an annual economy of 3.3 million cubic meters of logs -- i.e., annual harvests could fall by approximately 10 percent.

The message here is quite clear: interventionist trade policies are not necessarily environment friendly. Actually, it can be argued that the environmental movement in the industrialized countries should pressure their governments to eliminate the tariff escalation that hinders natural resources-oriented industrialization in developing countries in order to promote sustainable economic development. Without tariff escalation, the Indonesian government would probably be less inclined to rely on trade distorting mechanisms, such as the log export ban, to promote local processing. Accordingly, a more efficient use of Indonesian hardwood and less environmental degradation could be accomplished.

---

"It is important to acknowledge, however, that the choice of second-best policies by Indonesia was not made in a political vacuum. It can be argued that the log export ban was easier to implement, both in political and practical terms, than more efficient policy alternatives. For an analysis of the relationship between tariff escalation and trade policies of raw material exporting countries see Golub and Finger (1979)."
Figure 11-2: Effects of Production and Export Taxes for a Small Economy
An analysis of the proper role of policies in industrialized countries with respect to tropical hardwood trade inevitably raises the issue of the adequacy of controlling imports of tropical woods and products in order to halt tropical deforestation. Several proposals along these lines are currently being discussed in OECD countries. An important example in this context is the Mutingh Proposal approved by the European Parliament in 1989. This proposal, if implemented, will impose annual quotas on exports of tropical hardwood to the EC. Exporters would negotiate their quotas with the EC and countries following sound management practices (from an environmental perspective) would be favored in the quota allocation process. More radical proposals, such as an outright ban of trade on tropical hardwood (Anderson, 1989), are also drawing significant attention.

It is worth remembering that a trade ban on tropical hardwood would only be effective if countries like Japan, China, and the United States were willing to participate -- see Table 11-7. Let us for a moment assume that international cooperation is achieved (something highly unlikely in this case) and that the ban could be enforced. The economics of such an initiative suggest that its environmental impact would probably be negative. After all, the ban would tend to depress the price of tropical wood. As a consequence it would reduce incentives for a proper management of forest resources (Vincent, 1990) and for protecting forests against agricultural conversion (Zarsky, 1991). In addition to that, as discussed in the previous sections, logging is only one of the many agents promoting the depletion of tropical forests. And in the case of Brazil, international trade in tropical hardwood is a marginal player in this process. Summing up, there are clear indications that managed trade initiatives (based on quantitative restrictions) by industrialized countries would be an inefficient way to promote the conservation of tropical forests.

Final Comments

This paper has discussed the impact of international trade on the environment, drawing on the experiences of Brazil and Indonesia as exporters of tropical hardwood. Its main message is that trade instruments do not provide appropriate mechanisms to advance environmental objectives. The common belief that liberal trade fosters environmental degradation has also been discussed. It has been shown that restrictive trade policies (both in theory and in practice), instead of fostering the conservation of tropical forests, may end up promoting their depletion.

To the extent that tropical deforestation is believed to generate international externalities, the debate on the use of trade policies to foster environmental objectives will remain alive in the 1990s. And the potential for growing trade frictions in this area is quite real. Accordingly, the GATT cannot avoid the issue. There is obvious concern that the debate may be captured by protectionist interests disguised as environmentalists. At present, there is no scope for GATT-consistent trade restrictions to advance environmental objectives. And the fact that these restrictions are very blunt mechanisms, as discussed above, speak against a GATT reform designed to address environmental issues.

The GATT, however, cannot simply dismiss environmental concerns as irrelevant. In the case of trade in tropical hardwood, for instance, ecologists have suggested that process standards (determined in terms of the sustainability of forest harvesting systems) should be used to manage trade in tropical hardwood. As Sorsa (1991, p. 13) points out, to allow discriminatory trade practices based on differences in process methods brings into the debate extraterritoriality considerations and can easily degenerate into "a power-led imposition of values across countries ..." which will further endanger the multilateral trade system in its present form.

---

15In this scenario, evolving GATT negotiations on the trade-environment link may end up being christened as TREES -- trade related environmental excuses (for protection).
The GATT Secretariat, however, can play a positive role in promoting comity in the use of trade-related environmental regulations. Negotiations at the level of the Standards Code, for instance, may foster -- via the exchange of relevant scientific information -- the gradual harmonization of environmental regulations at international level. It is also worth mentioning that environmental labelling programmes, when applied in a transparent and nondiscriminatory fashion, are GATT consistent. Such initiatives, by allowing consumers to make the choice, offer a legitimate policy alternative for industrialized countries to encourage sound forest management practices in developing countries.
Discussant's Comments

Judith Dean

There is legitimate concern that the environmental consequences of deforestation be recognized and incorporated into the costs of productive activities related to tropical forests. However, discussion of solutions has become clouded, as trade in tropical timber is seen as a cause of excessive deforestation, and trade restrictions as a useful remedy. Carlos Braga's work contributes clear thinking regarding both root causes of the problem and the inappropriateness of using trade instruments to achieve environmental objectives.

Trade is not the root cause of the problem. Excessive deforestation relative to the socially desirable level is due to the divergence between private costs and true social costs of felling trees. This implies that trade instruments are inappropriate policy responses for two reasons. First, they are more costly than a domestic policy which directly internalizes the cost of environmental externalities into the production process. Second, they will not necessarily achieve the environmental objective. Lack of internalization of environmental costs implies that the private sector underestimates the true costs of harvesting. Because trade restriction shifts sales of logs from the foreign to the home market, it further undervalues logs in the local market. As Braga notes in the case of Indonesia, this has led to increased rather than reduced harvesting.

To the extent that tropical deforestation is thought to contribute to global environmental damage, export restrictions are even more undesirable. Braga's theoretical analysis shows that the excess welfare costs incurred by use of export restrictions rather than an optimal domestic policy grow larger if global external costs are considered. Thus, urging a country to adopt restrictions on log exports is likely to reduce one's ability to convince that country to recognize the global costs of its deforestation.

Braga's empirical evidence strongly supports the idea that poverty (through its link with subsistence agriculture), government development projects, and official incentives for private activities such as logging and cattle ranching, are the major causes of excessive deforestation, with the first being the predominant factor. More information is needed on specific policy reform which could remove these incentives for overuse of forests. At the same time, changes in taxes, stumpage fees, reforestation fees, and terms of contractual arrangements could allow for efficient internalization of environmental costs. Empirical work documenting optimal design of such domestic policies would allay arguments for trade measures which contend that first-best policies are unavailable.

Further analysis of the implications of export bans, tariff escalation and import restrictions is also required. An export ban is a blunt instrument. It can be shown that a ban may lead to too little or too much harvesting. In fact, the larger the divergence between private costs and social costs, the more likely the ban will lead to overharvesting relative to the socially optimal level.

It has been argued that tariff escalation in the industrial world has tended to discourage development of the wood processing industry. Is it then appropriate for Indonesia to ignore environmental externalities, to purposely underprice logs as a "subsidy" to wood processing? Is an export ban, in addition, an appropriate method to further subsidize wood processing? One suspects the answer to these questions is negative. First, the question of whether any subsidy is appropriate must be answered. Second, it should be noted that the export ban actually serves as a subsidy to the use of raw logs in local processing relative to other inputs. It functions as an input subsidy, not a production subsidy. Hence, it is likely to contribute further to excessive deforestation, relative to the socially optimal level.

The use of import restrictions raises the specter of the importer imposing its own environmental goals inappropriately on another country. In addition, as Braga points out, such a tool works by lowering the world
price of logs. Therefore, it succeeds in discouraging logging only if all major buyers cooperate. Furthermore, should it succeed, the lower world price is likely to encourage the clearing of forests for alternative uses. This policy tool may be more undesirable if one considers the welfare of the developing country exporter. It can be shown that the exporter is worse off if faced with an import restriction, than if it implemented its own optimal domestic policy.

Progress in reducing excessive deforestation will occur if the debate is shifted from emphasizing trade instruments to designing direct domestic policies which internalize the true social costs of harvesting. Clearer understanding of the costliness and ineffectiveness of trade instruments in addressing root causes should help facilitate this shift.
Introduction

Industrial growth has traditionally been viewed as damaging to the environment. However, increased output will not necessarily increase pollution if rapid adoption of clean technology simultaneously reduces the pollution intensity of output. In this paper, we investigate the possibility that this "clean margin" is significant in developing countries. We test the proposition that firms adopt low-polluting production technologies much faster when national policies promote internationally competitive industrial growth.

Our test case is wood pulp, an internationally important industry with a record of rapid growth in developing countries, potentially severe environmental impact, and clearly identifiable dirty and clean technologies. Equally important for our purposes is the wealth of available data. An FAO database records technology-specific pulp capacities for 60 countries in the period 1969-1991, augmented by planned installations through 1995.

We focus primarily on a new technology -- thermomechanical pulping (TMP) -- whose rapid emergence during the 1970s (Figure 12-1) was largely due to stricter environmental regulation.¹ The escalating cost of treating air and water emissions from chemical-based pulp technologies clearly provided a strong incentive for innovation and rapid diffusion of the new technology in the OECD economies.²

Clean Process Diffusion in Developing Countries

This direct incentive has been absent in unregulated developing economies. Nevertheless, we can identify several reasons why clean technologies may spread rapidly, and particularly in developing economies whose firms are internationally competitive.

---

¹Environment Department, World Bank.
This paper reports on work co-sponsored by the World Bank and the Center for Economic Studies, U.S. Bureau of Census.

²See the appendix for a detailed discussion of wood pulp process economics and the recent history of technology development in the industry.

²We define control cost in Figure 1 as total deflated pollution and abatement control expenditures for pulp production divided by the FAO reported total chemical-based capacity in each year. Our base cost estimate has some upward bias created by the exclusion of other process capacities from the denominator. This bias must be small, however, because all other processes have a pollution intensity and associated control costs two orders of magnitude lower than those of chemical pulping (See Table 6 and the Appendix).
Chemical, TMP: Chemical and TMP capacity indices (1980=100)
PACE/Unit: Control cost per unit of capacity (1973=100)
(1) **Technology bundling:** New technologies in the OECD economies are now generally cleaner, but still dominant. Internationally competitive firms in developing countries therefore want to acquire them, even if their environmental advantage conveys no economic benefit.

(2) **Green consumerism:** Competitive firms are placing a growing reputational premium on avoidance of environmentally damaging processes. Local branches of multinationals seem particularly sensitive to green consumer sentiment in OECD markets.

(3) **Rapid growth:** Equipment in rapidly growing firms will, on average, be newer and cleaner.

(4) **Anticipation of local regulation:** A trend toward stricter environmental regulation in developing countries has been accelerating since the early 1980s. Even in economies which are as yet unregulated, awareness of this trend may encourage preemptive purchase of cleaner technologies.

**Econometric Analysis**

Such factors constitute a plausible case for clean technology diffusion in developing countries, but an assessment of their significance requires empirical work. Our econometric model has separate equations for first adoption in a country and subsequent adoptions. Its structure reflects our belief that national firms give disproportionate weight to local examples -- expected adoption risk and learning cost are significantly reduced once a technology is demonstrably "onshore."

**Variables**

Our explanatory variables include:

(1) **Changing relative prices for critical inputs:** The thermomechanical (TMP) process is relatively energy intensive and wood saving, so we test for price-based substitution using international price indices for wood and petroleum. We would expect the spread of TMP to be positively related to wood price and negatively related to petroleum price.

(2) **Per capita income:** This is in part a proxy for presumed capability to absorb new technology. It also reflects what is thought to be a close correlation between per capita income and regulatory strictness. We employ per capita income as a proxy because we have no measure of regulatory strictness for most of our sample countries. In each of its two proxy roles, we would expect per capita income to be positively related to both first adoption and subsequent diffusion of TMP.

(3) **Industry scale:** There are two reasons why economies with more pulp capacity could acquire TMP more quickly. The first is deterministic, on the assumption that scale is a proxy for number of firms. Suppose that two economies have pulp-producing firms whose new technology adoption behavior is characterized by the same probability function. The economy with more firms will then have more expected adoptions in each period and a shorter expected delay before first adoption.

Adoption may also be accelerated by agglomeration economies. If industry scale is large, the economy may already be a locus for specialized professional networks, supporting services, etc. Their presence may facilitate relatively rapid, widespread adoption of new technology.

(4) **Policy Regime:** We employ separate dummy variables for the OECD and COMECON economies in the sample. For developing countries, we differentiate among policy regimes using a price level distortion
index developed by Dollar (1990). We have divided Dollar's sample of 95 developing countries into seven rank groups (rank 1 being least distorted). Countries in our own more limited sample retain their general Dollar rankings, as shown in Table 12-1. Since Nigeria is the sole rank-6 country in the FAO database we have excluded it from our regressions.

Although we accept the argument that price distortions will impair competitive industrial development *ceteris paribus*, we do not dismiss the potential relevance of national policies which are explicitly intended to promote industrial competitiveness or rapid diffusion of new technologies. At present, we simply have no adequate proxies for such policies.

### 1. First Adoption

The left-hand variable in our first adoption equation is the number of years in which TMP was available but not adopted by a particular country. This "time not adopted" (TNA) is 18 for countries with no TMP capacity throughout the sample period and 1 for first-movers in the OECD. Right-hand variables are the log of per capita income in 1980; the log of total pulp capacity (a measure of industry scale); dummy variables for OECD and COMECON countries; and Dollar openness price distortion rankings for developing countries.\(^3\)

The regression results are tabulated in Table 12-2; additional experiments revealed no significant interactions among variables. Total pulp capacity in 1990 was the preferred scale proxy, since it incorporated information about those developing countries which began pulp production in the 1980s. Regression (3) employs 1980 capacity as a check, but reveals little difference in the results. Regression (4) reports the final result, including only variables with 95 percent significance or higher.

Both industry scale and policy regime have very significant, large effects, while per capita income has no independent effect. Across the 60 sample countries, the log of total pulp capacity in 1990 has an almost exact normal distribution with a range of 10. This translates to an estimated difference of about 12 years in TNA.

Since our Dollar index variable assigns rank 0 values to OECD and COMECON, the dummy variable results can be interpreted as differences from the hypothetical class which is one rank step higher than the least price-distorted developing economy. The OECD economies fit neatly into this category (not significantly different from rank 0), while the COMECON economies have an estimated TNA which is about nine years greater. The estimated effect of unit increases in Dollar ranking for developing countries is about 2.2 years per class. Over the whole range (1-4), the implied difference is about seven years.

To summarize, our first-stage equation results suggest that relatively closed policy regimes have been far slower to adopt the cleaner process technology. When compared with a representative OECD economy, both COMECON and the most distorted developing countries have a first adoption gap of approximately nine years. For least-distorted economies, the lag behind the OECD is only about two years. Since scale and policy enter independently with large effects and per capita income has no effect, we can infer that a large-scale, high Dollar rank, pulp-producing, LDC economy would adopt clean process technology much sooner than a small-scale OECD economy. This is in fact the case -- Brazil, India and Mexico have TNAs of 5, 6 and 9, while Denmark and Switzerland both have TNAs of 18.

---

\(^3\)Since our input price variables are single international indices, we cannot include relative price effects in the cross-sectional first adoption equation. However, we do use them in panel estimation of the subsequent adoption equation.
Table 12-1: Estimation Sample: FAO Pulp-Producing Countries

<table>
<thead>
<tr>
<th>OECD</th>
<th>COMECON</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>Korea, North</td>
<td>South Africa</td>
<td>Costa Rica</td>
<td>Kenya</td>
<td>Angola</td>
</tr>
<tr>
<td>United States</td>
<td>Vietnam</td>
<td>Mexico</td>
<td>Brazil</td>
<td>Madagascar</td>
<td>Gabon</td>
</tr>
<tr>
<td>Japan</td>
<td>Albania</td>
<td>Colombia</td>
<td>Chile</td>
<td>Morocco</td>
<td>Zimbabwe</td>
</tr>
<tr>
<td>Austria</td>
<td>Bulgaria</td>
<td>Sri Lanka</td>
<td>Peru</td>
<td>Argentina</td>
<td>Swaziland</td>
</tr>
<tr>
<td>Belgium</td>
<td>Czechoslovakia</td>
<td>East Germany</td>
<td>Uruguay</td>
<td>Bangladesh</td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td>Austria</td>
<td>Hungary</td>
<td>India</td>
<td>Indonesia</td>
<td></td>
</tr>
<tr>
<td>Finland</td>
<td>Greece</td>
<td>Poland</td>
<td>Iran</td>
<td>Korea, Republic</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>West Germany</td>
<td>Romania</td>
<td>Malaysia</td>
<td>Philippines</td>
<td></td>
</tr>
<tr>
<td>Ireland</td>
<td>Italy</td>
<td>Yugoslavia</td>
<td>Turkey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>Netherlands</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Zealand</td>
<td>Norway</td>
<td>Portugal</td>
<td>Spain</td>
<td>Sweden</td>
<td>Switzerland</td>
</tr>
<tr>
<td></td>
<td>England</td>
<td></td>
<td></td>
<td></td>
<td>United Kingdom</td>
</tr>
<tr>
<td></td>
<td>Austria</td>
<td></td>
<td></td>
<td></td>
<td>Australia</td>
</tr>
<tr>
<td></td>
<td>New Zealand</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 12-2: Determinants of Adoption Waiting Time: Thermomechanical Pulp Technology

<table>
<thead>
<tr>
<th>Dependent Variable: Adoption Lag, 1977-95</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>Intercept</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Log(Income per Capita, 1980)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Log(Total Pulp Capacity)</td>
</tr>
<tr>
<td>1990</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>1980</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Dollar Index</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>OECD</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>COMECON</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Observations</td>
</tr>
<tr>
<td>Adj. R²</td>
</tr>
</tbody>
</table>

Note:

*** = Significance at 0.99
** = Significance at 0.95
* = Significance at 0.90
We should note that our adoption lag estimates are overly conservative because they suffer from truncation bias. A TNA value of 18 represents our sample horizon, but it is obviously an underestimate of ultimate TNA for the price-distorted or very small-scale economies which have no TMP through 1995.

Suggestive evidence about the degree of bias is provided by Figures 12-2 to 12-4. These show the annual proportion of TMP-adopting economies in six subsamples differentiated by scale (three equal sized classes) and relative distortion (two classes; OECD and Dollar rank 1 countries separated from COMECON and the other LDCs). These can be thought of as cumulative distributions, with representative lags corresponding to the points where half the subsample countries have adopted TMP.

For large- and medium-scale open pulp producers, expected adoption lags are about two and nine years, respectively. Among the small-scale producers, however, the adoption proportion has risen to only 30 percent by 1995. For the relatively distorted economies, in no case does the adoption proportion rise above 25 percent in our sample period. We are tempted to conclude that the true expected adoption lag for relatively price-distorted economies is infinite! This temptation is reinforced by the fact that no East European economy has ever adopted TMP, nor have any Dollar rank 4 LDCs. In addition, the relatively early LDC adopters in our "distorted" subsample are all Dollar rank 2 economies.

2. Diffusion Speed

Our second-stage exercise estimates the impact of scale, policy and relative input prices on within-country diffusion after first adoption of TMP. We base the analysis on the following stock adjustment equation:

\[
\begin{align*}
\text{(1)} \quad \log(\text{TMP}_t) &= a_0 + a_1\text{Time} + a_2\text{Time}^2 + a_3\log(\text{TMP}_{t-1}) \\
& \quad + a_4\log[\text{Total Capacity (TC)}] + a_5[\text{Policy (P)} \times \text{Time}] \\
& \quad + a_6[\log(\text{TC}) \times \text{Time}] + a_7\log[\text{Wood Price (WP)}] \\
& \quad + a_8\log[\text{Oil Price (OP)}]
\end{align*}
\]

To avoid serious autocorrelation bias, actual estimation is performed on the time-derivative of (1), which is specified in annual growth rates.

\[
\begin{align*}
\text{(2)} \quad d\text{TMP}_t &= a_1 + 2a_2\text{Time} + a_3d\text{TMP}_{t-1} + a_4d\text{TC} + a_5P \\
& \quad + a_6d\text{TC} + a_7d\text{WP} + a_8d\text{OP}
\end{align*}
\]

Without the two price variables, it is possible to fit the model to data for the entire sample period through 1995. Table 12-3 therefore presents estimates with and without the price terms. Among developing countries, only countries with Dollar rankings 1, 2 and 3 have TMP adoption, and only one observation exists for a class 3 country. We have therefore defined a new dummy variable, D23, which takes on a value of 1 for Dollar rankings 2 or 3, and 0 otherwise.

The regression results suggest that neither the OECD nor COMECON economies can be differentiated from Dollar rank 1 economies. The two price change variables in regression (4) have the expected sign, given that TMP is relatively wood saving and energy intensive among pulping processes, but the implied elasticities are quite small and not differentiable from 0 at the 95 percent confidence level in any case. Scale is tested in regressions (1-2), again without significant results. However, four variables -- change in

---

*Only the USSR and Vietnam in this sample.*
Figure 12-2

ECONOMIES WITH LARGE PULP OUTPUT:

PERCENT WITH THERMOMECHANICAL CAPACITY

○ Open  + Closed

Year: 73 75 77 78 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95

Percentage: 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
Figure 12-3

ECONOMIES WITH MEDIUM PULP OUTPUT:

PERCENT WITH THERMOMECHANICAL CAPACITY

Open + Closed
ECONOMIES WITH SMALL PULP OUTPUT:

PERCENT WITH THERMOMECHANICAL CAPACITY

Figure 12-4
Table 12-3: Determinants of Diffusion Speed: Thermomechanical Pulp Technology

<table>
<thead>
<tr>
<th>Dependent Variable: Growth Rate of TMP, 1977-95</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>** Intercept</td>
<td>0.105</td>
<td>0.120</td>
<td>0.170</td>
<td>0.164</td>
<td>0.162</td>
</tr>
<tr>
<td>***</td>
<td>(2.12)</td>
<td>(2.68)</td>
<td>(6.81)</td>
<td>(4.26)</td>
<td>(4.21)</td>
</tr>
<tr>
<td>Time</td>
<td>-0.009</td>
<td>-0.010</td>
<td>-0.010</td>
<td>-0.010</td>
<td>-0.009</td>
</tr>
<tr>
<td>***</td>
<td>(4.32)</td>
<td>(4.76)</td>
<td>(5.24)</td>
<td>(2.19)</td>
<td>(2.11)</td>
</tr>
<tr>
<td>Lag dTMP</td>
<td>0.100</td>
<td>0.100</td>
<td>0.103</td>
<td>0.111</td>
<td>0.112</td>
</tr>
<tr>
<td>***</td>
<td>(2.93)</td>
<td>(2.96)</td>
<td>(3.04)</td>
<td>(2.15)</td>
<td>(2.17)</td>
</tr>
<tr>
<td>dTC.</td>
<td>0.940</td>
<td>0.934</td>
<td>0.942</td>
<td>0.897</td>
<td>0.901</td>
</tr>
<tr>
<td>***</td>
<td>(12.15)</td>
<td>(12.14)</td>
<td>(12.27)</td>
<td>(9.15)</td>
<td>(9.18)</td>
</tr>
<tr>
<td>D23</td>
<td>-0.067</td>
<td>-0.075</td>
<td>-0.090</td>
<td>-0.097</td>
<td>-0.095</td>
</tr>
<tr>
<td>***</td>
<td>(2.50)</td>
<td>(2.97)</td>
<td>(3.95)</td>
<td>(3.23)</td>
<td>(3.17)</td>
</tr>
<tr>
<td>OECD</td>
<td>0.015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.73)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMECON</td>
<td>0.041</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>log (TC.)</td>
<td>0.005</td>
<td>0.006</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.23)</td>
<td>(1.33)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dPW</td>
<td>0.159</td>
<td>0.124</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.60)</td>
<td>(1.30)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dPO</td>
<td>-0.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.24)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obs.</td>
<td>306</td>
<td>306</td>
<td>306</td>
<td>175</td>
<td>175</td>
</tr>
<tr>
<td>Adj. $R^2$</td>
<td>0.43</td>
<td>0.43</td>
<td>0.43</td>
<td>0.41</td>
<td>0.40</td>
</tr>
</tbody>
</table>

Notes:

*** = Significance at 0.99
** = Significance at 0.95
* = Significance at 0.90
pulp capacity, lagged change in TMP, Dollar 2/3 status, and time -- yield very robust results. They retain very similar parameter values and extremely high levels of significance across all specifications, even when the sample size is nearly halved by the introduction of wood and fuel price changes.

We adopt regression (3) as the best fit to the data. Our results indicate a generally strong growth performance for TMP after first adoption. The long-run multiplier implied by the lagged TMP term is about 1.11, yielding a greater than unitary elasticity of response to total pulp capacity growth. There is also a large autonomous growth component which has declined significantly over time, slowing at the rate of approximately one percentage point per year. This decline may reflect an approach to some optimal proportion of total pulp capacity, primarily determined by the share of newsprint in the overall demand for pulp. We also speculate, from purely anecdotal evidence, that the "environment shock" of the 1970s produced a surge toward TMP, which in turn spurred regulatory cost-saving innovations in chemical pulping.

Again, the policy regime seems to make a very large difference for developing countries. For relatively distorted (Dollar 2/3) economies, the implied steady-state estimate is a loss of about 10 percentage points in annual TMP growth.

3. Total Pulp Capacity Growth

Our econometric analysis indicates that a nation's policy regime can have a very powerful impact on clean technology adoption, and therefore on the aggregate pollution intensity of new pulp capacity. In general, of course, less distorted policies will also induce faster output growth. The net effect on total pollutant emission depends on relative elasticities. In the case of wood pulp, our results suggest that less distortionary policies have had an unambiguously beneficial environmental impact because they have not increased the rate of total pulp capacity growth. In Table 12-4, we present results for several total pulp capacity growth equations fitted to annual data for the period 1975-1995.

The general effects of policy and time are well-illustrated for the relatively open and closed subsamples by Figure 12-5. The two time series are three-year (period-centered) moving averages of marginal TMP shares (i.e., new TMP capacity in new pulp capacity) during the period 1979-1995. The marginal TMP share is always far lower in relatively distorted economies, although the competitive position of TMP clearly erodes in the 1980s.

Both OECD and COMECON effects are negative and significant (particularly the former), implying displacement of pulp production toward developing countries in the sample period. Annual pulp capacity growth for the developing countries as a group has been around 5.7 percent, while the OECD growth rate has been much slower (1.2 percent) and the COMECON rate intermediate (2.8 percent). However, neither scale nor policy differences among developing countries (Dollar rank dummies 2, 3, 4) have any significant effect.

Simulating the Environmental Impact of Policy Differences

To conclude our analysis, we consider an hypothetical open economy (Dollar ranked 1) whose total installed pulp capacity in 1975 is 1.5 million metric tons annually (about the size of Brazilian capacity in that year).

---

5See the appendix for a detailed discussion of the associated technical issues.
Figure 12-5

THERMOMECHANICAL PULP TECHNOLOGY:
% OF NEW CAPACITY (3-YR. MOVING AVERAGE)

- Open
- Closed
Regression-Based Projections

From regression (4), Table 12-4, we estimate total capacity growth rate at 5.7 percent annually through 1995. Application of regression (4), Table 12-2, to the simulated scale and policy data generates a predicted adoption lag of about seven years. This implies first adoption of TMP in 1984, when simulated total pulp capacity is 2.5 million metric tons (m.t.). In the FAO database, this scale is associated with first-year TMP installations in the range 100-200,000 m.t. -- we assume 130,000 m.t.. After conversion to steady-state values, we apply regression (3), Table 12-3, to obtain annual growth rate estimates for TMP. The results are presented in Table 12-5.

Pollution Intensities of Alternative Technologies

We calculate the pollution-saving potential of TMP under two sets of assumptions:

(1) TMP is used entirely for newsprint production, and the alternative is a weighted mix of two technologies -- 75 percent bleached stone groundwood and 25 percent bleached sulphite (75 percent BSGw/25 percent BSulp) -- the standard furnish for newsprint prior to the widespread adoption of TMP; all other additions to pulp capacity are assumed to be bleached Kraft sulphate -- the current international mainstream technology.

(2) The alternative is only bleached Kraft sulphate.

Since much new TMP capacity replaces stone groundwood in newsprint production, assumption (1) provides a lower-bound estimate of TMP adoption benefit. Assumption (2), on the other hand, provides a rough upper bound. From data on U.S. plant-level capacity (Lockwood-Post, 1987) and toxic release data (U.S. EPA, 1987), we have drawn a sample of plants which are dedicated bleached stone groundwood, bleached sulphite, Kraft sulphate and bleached TMP facilities. Using the methodology explained in Martin et al. (1991), we have developed a risk-weighted sum of total toxic releases by all media (air, land, water) for 320 toxic chemicals. This sum has been divided by annual plant pulp capacity to obtain plant-specific toxic intensity indices. The relevant sample statistics are presented in Table 12-6.

---

6See the appendix for technical details.

7Stone groundwood presents an unfortunate paradox here. It is the cleanest technology, but also the oldest. Its world capacity share has declined steadily because stone groundwood pulp does not meet most contemporary quality standards. TMP was in fact designed to preserve most of the environmental advantage of stone groundwood while providing higher-quality pulp. See the appendix for further technical discussion.

8The procedure assigns weights 1-4 to total releases by chemical, depending on the EPA’s risk weighting. Category 4 chemicals are judged to have the highest risk. To illustrate, consider a plant which releases two chemicals: A, with a risk rating of 1, and B, with a rating of 4. With annual releases of 40 Kg. for A and 10 Kg. for B, the total weighted release for the plant is (40*1 + 10*4), or 80. If the plant annually produces 2,000 metric tons of pulp, then its weighted pollution intensity is 40 Kg. per 1,000 m.t.
<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.074</td>
<td>0.043</td>
<td>0.028</td>
<td>0.057</td>
</tr>
<tr>
<td></td>
<td>(4.31)</td>
<td>(1.54)</td>
<td>(1.45)</td>
<td>(5.90)</td>
</tr>
<tr>
<td>OECD</td>
<td>-0.059</td>
<td>-0.066</td>
<td>-0.058</td>
<td>-0.045</td>
</tr>
<tr>
<td></td>
<td>(3.28)</td>
<td>3.55</td>
<td>(3.59)</td>
<td>3.17</td>
</tr>
<tr>
<td>COMECON</td>
<td>-0.046</td>
<td>-0.045</td>
<td>-0.034</td>
<td>-0.029</td>
</tr>
<tr>
<td></td>
<td>(2.05)</td>
<td>1.98</td>
<td>(1.92)</td>
<td>(1.66)</td>
</tr>
<tr>
<td>Log(TC)</td>
<td></td>
<td></td>
<td>0.005</td>
<td>0.006</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(1.45)</td>
<td>(1.69)</td>
</tr>
<tr>
<td>Dollar Ranking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>-0.016</td>
<td>-0.011</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.82)</td>
<td>(0.57)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>-0.015</td>
<td>-0.004</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.61)</td>
<td>(0.17)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>-0.048</td>
<td>-0.039</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.57)</td>
<td>(1.27)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obs.</td>
<td>1180</td>
<td>1180</td>
<td>1180</td>
<td>1180</td>
</tr>
<tr>
<td>Adj. R²</td>
<td>0.007</td>
<td>0.007</td>
<td>0.009</td>
<td>0.007</td>
</tr>
</tbody>
</table>
Table 12-5: Estimated Impact of Openness on Toxic Pollution from Pulp Production

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Capacity*</th>
<th>Ch. in Capacity*</th>
<th>TMP Capacity*</th>
<th>Ch. in TMP Capacity*</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>1500</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>80</td>
<td>1979</td>
<td>107</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>83</td>
<td>2337</td>
<td>126</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>84</td>
<td>2470</td>
<td>133</td>
<td>130</td>
<td>130</td>
</tr>
<tr>
<td>85</td>
<td>2611</td>
<td>141</td>
<td>152</td>
<td>22</td>
</tr>
<tr>
<td>86</td>
<td>2760</td>
<td>149</td>
<td>177</td>
<td>24</td>
</tr>
<tr>
<td>87</td>
<td>2917</td>
<td>157</td>
<td>203</td>
<td>26</td>
</tr>
<tr>
<td>88</td>
<td>3084</td>
<td>166</td>
<td>231</td>
<td>28</td>
</tr>
<tr>
<td>89</td>
<td>3259</td>
<td>176</td>
<td>260</td>
<td>29</td>
</tr>
<tr>
<td>90</td>
<td>3445</td>
<td>186</td>
<td>290</td>
<td>30</td>
</tr>
<tr>
<td>91</td>
<td>3642</td>
<td>196</td>
<td>321</td>
<td>30</td>
</tr>
<tr>
<td>92</td>
<td>3849</td>
<td>208</td>
<td>351</td>
<td>30</td>
</tr>
<tr>
<td>93</td>
<td>4069</td>
<td>219</td>
<td>379</td>
<td>29</td>
</tr>
<tr>
<td>94</td>
<td>4300</td>
<td>232</td>
<td>406</td>
<td>27</td>
</tr>
<tr>
<td>95</td>
<td>4546</td>
<td>245</td>
<td>431</td>
<td>24</td>
</tr>
</tbody>
</table>

* '000 metric tons

Assumptions:

(1) U.S. 3rd Quartile intensities chosen (see Table 12-6)

(2a) TMP substitutes for 75% bleached stone groundwood and 25% bleached sulphite
(2b) All new capacity is bleached Kraft

<table>
<thead>
<tr>
<th>Total New Capacity ('000 m.t.)</th>
<th>Total New Toxic Pollution (metric tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Closed Economy</strong></td>
<td></td>
</tr>
<tr>
<td>75% BSGw/25% Bulp</td>
<td>430.6786</td>
</tr>
<tr>
<td>Bleached Kraft</td>
<td>1777.744</td>
</tr>
<tr>
<td>Closed Economy Total</td>
<td>38092.7</td>
</tr>
<tr>
<td><strong>Open Economy</strong></td>
<td></td>
</tr>
<tr>
<td>Bleached TMP</td>
<td>430.6786</td>
</tr>
<tr>
<td>Bleached Kraft</td>
<td>1777.744</td>
</tr>
<tr>
<td>Open Economy Total</td>
<td>34218.2</td>
</tr>
</tbody>
</table>
Table 12-6: Toxic Intensity Statistics, U.S. Pulp Plants

(Risk-weighted Kg. of toxic emissions per 1000 metric tons of output)

<table>
<thead>
<tr>
<th></th>
<th>1st Quartile</th>
<th>Median</th>
<th>3rd Quartile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kraft Sulphate</td>
<td>3257</td>
<td>6953</td>
<td>19122</td>
</tr>
<tr>
<td>Sulphite</td>
<td>919</td>
<td>10169</td>
<td>36670</td>
</tr>
<tr>
<td>TMP</td>
<td>63</td>
<td>137</td>
<td>520</td>
</tr>
<tr>
<td>Stone Gw</td>
<td>456</td>
<td>461</td>
<td>466</td>
</tr>
<tr>
<td>75% BSGw/25% BSulp</td>
<td></td>
<td></td>
<td>9517</td>
</tr>
</tbody>
</table>

Notes:

1 48 plants
2 14 plants
3 3 plants (most TMP is installed alongside other processes)
4 2 plants (most stone groundwood is installed alongside other processes)
The large variation in toxic intensities for the sulphite and Kraft plants reflects both measurement error and differences in postproduction treatment of emissions. For our simulation, we assume (perhaps optimistically) that new plants in our hypothetical LDC will have toxic intensities equivalent to U.S. 3rd-Quartile intensities. The difference is clearly huge -- 36,670 Kg. per 1,000 m.t. of annual capacity for bleached sulphite and 19,122 Kg. for Kraft, versus only 520 Kg. for bleached TMP and 466 Kg. for stone groundwood.

Results

We apply these estimates to the capacity figures in Table 12-5 to obtain a final calculation of pollution saving in a Dollar rank 1 developing country. We project 431,000 m.t. of TMP capacity by 1995. Our foil is a rank 4 economy which has no projected adoption of TMP, and instead meets the demand for this quality of pulp using either (a) [75 percent bleached stone groundwood/25 percent bleached sulphite] or (b) Kraft sulphate. In both cases, the residual increment to annual pulp capacity is assumed to be bleached Kraft sulphate. The estimated total pollution increment in the price-distorted regime is 38,100 m.t. of hazard-weighted releases under assumption (a) and 42,200 m.t. under (b); in the rank 1 economy, it is 34,200 m.t. In our simulation, the difference in policy regime alone is therefore responsible for a 10-20 percent reduction in pollution associated with new pulp capacity.

Conclusion

In this study, we have analyzed the international diffusion of thermomechanical technology (TMP), a clean pulping process which first emerged as regulatory costs escalated in the mid-1970s. We have found that adoption timing is fundamentally affected by a country's policy orientation and the scale of its existing pulp industry, but that its development level has no independent effect. We have also found that the impact of policy is compounded in the postadoption period, with less-distorted economies exhibiting much faster growth of TMP. Conversely, we have found no significant impact of either policy or scale on the growth rate of total pulp capacity.

We have illustrated the implications of our results by comparing projected pulp-related toxic pollution in relatively price-distorted and undistorted policy regimes. We find that openness is unambiguously environment saving, reducing total new pulp-related pollution by 10-20 percent during an experimental period of slightly more than one decade. Thus, for pulp production at least, the environment gets a significant "free ride" from openness even in an economy with no explicit environmental regulation.

Although our story has a generally happy ending, we would be irresponsible not to close on a strongly cautionary note: clean technology is a complement to regulation, not a substitute. TMP would not have been developed at all without strict OECD environmental regulation, and its adoption in developing countries will not solve the environmental problem for the pulp industry. In our simulation, for example, TMP represents only 10 percent of installed capacity after a decade of rapid growth; Kraft sulphate effluent clearly remains a major problem for regulation.
I. INTRODUCTION TO PULPING TECHNOLOGIES

The principal raw material in the manufacture of paper is fiber. The separation of fiber from wood is the first stage in paper production. This may be achieved by a range of chemical and/or mechanical means. Prior to the widespread commercial adoption of thermomechanical pulping (TMP) after 1974 some 67 percent of the world's wood pulp was produced by chemical means, 25 percent by mechanical, and the remaining 8 percent by various combinations of the two, categorized as semi-chemical processes.

Before the introduction of TMP, mechanical pulp was produced either by the stone groundwood (SGW) process or by refiner mechanical pulping (RMP). In the SGW process, the earliest form of mechanical pulping, whole logs are forced against a revolving grindstone in the presence of water. In contrast RMP pulp is produced by grinding wood chips between revolving discs, with the significant advantage that sawmill waste such as offcuts, sawdust and shavings may be pulped.

There are also two principal routes to the production of chemical pulp, the alkaline sulphate (Kraft) process and the acid sulphite method. Until about 1935 sulphite pulp was dominant, being cheaper and easier to produce. However the development of a Kraft chemical recovery cycle and advances in bleaching technology promoted the growth of Kraft pulping from the 1940s onwards, to the extent that by the early 1970s it accounted for about 85 percent of all chemical pulp produced, making it the predominant pulping technology with some 56 percent of total production.

Semi-chemical pulping methods were developed primarily to take advantage of the hardwood species unsuited to other treatments. Although something of a catch-all, it is useful to distinguish various subcategories under the general heading of semi-chemical pulping. Most easily identified is the neutral sulphite semichemical (NSSC) process, in which about half the lignin is broken down chemically before the pulping is completed by RMP. Wood may also be pretreated with standard sulphite solutions, in which case the process is termed either high-yield sulphite or chemi-groundwood depending on the yield of pulp obtained from a given weight of wood. Kraft semi-chemical pulp may also be produced, using a sulphate pretreatment.

A. The Choice of Pulping Technology

The choice of a particular technology for pulping wood is determined by several factors, including raw material characteristics, product quality, technological complexity and input costs. Environmental control expenditures are an important subcategory of the latter.

1. Raw Materials

The key raw material consideration is the appropriateness of a given technology for a particular species of wood. The broadest distinction is between softwoods and hardwoods, although fine-tuning of the pulping process to optimize pulp yield and quality is required to accommodate variations between individual species and such factors as source, age and moisture content. As has been mentioned, a semi-chemical
process is often applied to hardwoods which would otherwise render a poorer quality pulp under conventional mechanical pulping. An additional reason for the prominence of the Kraft process is its versatility, making it suitable for use with most wood species. In contrast, sulphite pulping is suitable for only a few species of wood, a major reason for the dwindling popularity of this process.

2. Product quality

The intended use of the pulp is also a crucial determinant of pulping technology choice, since different processes produce pulps with significantly different characteristics. Some of the chief product categories for the end-use of wood pulp are newsprint, other printing/writing paper, packaging paper, tissue, case-makings and other board. Each of these products requires a pulp or pulp mixture (furnish) of a particular quality as measured on the key parameters of density, strength, printing properties and brightness. The mechanical processes damage the fibers to a greater extent but the yield is higher, producing a weaker but bulkier pulp than that produced chemically. However the chemical processes produce a darker pulp, which generally requires more bleaching to meet the higher product standards to which the stronger, denser pulp is suited.

3. Input costs; technological complexity

Aside from the raw material and product quality considerations, the pulping technologies are widely differentiated according to pulp yield, capital cost, technological complexity and requirements for energy, chemicals and labor. A simplified indication of these differences is presented in Table 12-7. In broad terms the mechanical processes have a lower capital cost, are less technically complex and allow a higher pulp yield on wood, but are more energy and labor intensive than the chemical technologies. Indeed the chemical recovery cycle of the Kraft process not only allows the recycling of the chemicals used to digest the wood, but enables the process to be almost energy self-sufficient by burning the organic material left in the spent pulping liquor. The substantial organic content of the spent liquor means that the pulp yield on wood is only about 50 percent, compared with more than 95 percent achieved by mechanical processes. While chemical recovery is economically essential for the Kraft process, it is not usually undertaken on economic grounds in sulphite pulp mills. This is another significant reason for the sulphite process’s declining popularity.

4. Environmental control considerations

A final cost consideration is the expenditure necessary to meet environmental control requirements. This grew to signal importance for the pulp and paper industry in North America, Europe and Japan in the mid-1970s. Without addressing actual costs at this juncture (since these depend on the degree of regulatory control), it is important to note that there are significant variations between pulping technologies in the sources, characteristics and amount of the discharges to water and air.

The principal source of biological oxygen demand (BOD) and toxicity in the effluent from the pulping process itself is the soluble organic material separated from the raw wood. Although the pulp yield is far higher from mechanical than chemical processes, the recovery of the pulping chemicals and burning of the organic material in the spent liquor from the Kraft process means that the organic content of the effluent from the pulping stage is usually lower than mechanical pulp effluent, depending on the efficiency of the recovery and washing process.

However, the BOD and toxicity of pulp mill effluent is substantially increased by the effluent from the bleaching process. Kraft pulp requires more bleaching than mechanical pulp for two reasons. Firstly the unbleached pulp is substantially darker than mechanical pulp, and secondly the higher grade applications to
Table 12-7: Comparison of Softwood Pulping Processes

<table>
<thead>
<tr>
<th></th>
<th>Mechanical Pulping</th>
<th>Chemical Pulping</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stone Groundwood</td>
<td>Refiner Groundwood</td>
</tr>
<tr>
<td>Yield on Dry Wood</td>
<td>96-97%</td>
<td>94-95%</td>
</tr>
<tr>
<td>Energy Requirements</td>
<td>energy intensive</td>
<td>Nearly energy self-sufficient</td>
</tr>
<tr>
<td>Pulp Strength</td>
<td>lowest</td>
<td>increasing to highest variable</td>
</tr>
<tr>
<td>Technological Complexity</td>
<td>lowest</td>
<td>increasing to highest</td>
</tr>
<tr>
<td>Capital Cost</td>
<td>lowest</td>
<td>increasing to highest</td>
</tr>
<tr>
<td>Labor Requirement</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>Water Pollution</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>Air Pollution</td>
<td>nil</td>
<td>nil</td>
</tr>
</tbody>
</table>

which chemical pulp is put generally require a brighter furnish. In the case of a bleached Kraft mill the conventional bleaching process may contribute about half of the total BOD and much of the toxicity of the mill's total effluent. A further reason why the bleaching of mechanical pulp contributes far less to total mill effluent BOD is that the objective is to decolorize the pulp without dissolving the lignin, which is the main BOD source in Kraft bleach plant effluent. Concern over the toxic properties of bleach plant effluent has focused on the chlorinated organic compounds generated by the bleaching of chemical pulps. During the 1970s chlorinated phenols attracted particular attention, which switched in the 1980s to dioxins. Again, mechanical pulps are at an environmental advantage over chemical pulps, as bleaching is carried out using either hydrosulphite or peroxide, producing no chlorinated effluent.

Of the atmospheric emissions from pulp mills, by far the largest problem is posed by malodorous releases of reduced sulphur compounds from the Kraft process. These compounds include hydrogen sulphide, methyl mercaptan, dimethyl sulphide, dimethyl disulphide, and oxides of sulphur, collectively termed Total Reduced Sulphur (TRS) emissions. Without control equipment, the major source of TRS from Kraft mills is the furnace used to recover the pulping chemicals from the spent liquor. As this source is controlled, fugitive emissions from a number of exhausts and vents along the pulp line become increasingly significant. Sulphite pulping generates similar emissions, the total potential release increasing if liquors are burned to allow recovery of the pulping chemicals. In contrast, the only potential air pollutants of concern from mechanical pulping processes are particulates, sulphur dioxide from power generation, and a small quantity of organics from the vents of thermomechanical refiners.

II. THE RISE OF TMP IN EUROPE AND NORTH AMERICA

In the 1930s there was a brief surge of interest in a pulping process being developed by Arne Asplund, in which wood chips were softened with a steam pretreatment prior to conventional mechanical pulping. The aim was to reduce the amount of mechanical pulping that had to be applied, thus minimising damage to the fibers and enhancing pulp quality. Interest quickly died as the resulting pulp proved usable only for low-quality roofing products. Only thirty years later was it discovered that if the pressure (and thus the temperature) of the preheater was lowered to avoid melting the lignin, a mechanical pulp of superior quality could be produced. In 1968 a Swedish mill initiated this process, which came to be known as thermomechanical pulping (TMP). Early diffusion was sluggish; in 1974 there were still only four TMP mills in the world.

After 1975, however, TMP suddenly took off. By the end of 1977 there were 50 installations worldwide, with another 30 on order or being installed. Growth in TMP capacity continued at over 20 percent throughout the 1970s, so by the end of the decade installed TMP capacity stood at over 5 million tons per year. This was still small in comparison to the global capacity of chemical pulp, which was over 93 million tons, but TMP's new popularity was evident in its large share of new pulp capacity (see Figure 12-5, above). By 1980, almost half the addition to pulping capacity in the OECD was TMP.

A. Causes of Growth in TMP Capacity

It is impossible to identify a single factor that caused the remarkable growth in TMP capacity in the OECD economies from 1975 onwards. Rather, the answer must be sought in a combination of market and
regulatory pressures. One of these was the increasing level of spending necessary to meet new environmental control requirements. Explicit regulatory costs are dealt with separately below, following a discussion of other cost factors and their association with economy-wide environmental controls.

1. Basic production costs

Price increases in two key inputs were particularly important in driving the search for alternatives to chemical pulp. In the mid-1970s the price of nearly all pulping chemicals increased by 50 percent or more due to increased costs of energy and base chemicals. Undoubtedly some of the latter had regulatory sources, since the chemical industry itself has high environmental control costs. At the same time a shortage of wood fiber (also associated with new environmental concerns) drove wood prices up.

All these changes improved the competitive position of TMP. In its basic form the process uses no chemicals. Although from an early stage a number of mills applied chemical treatments to increase pulp brightness, this cost was minor compared to that of the chemicals used in chemical pulping processes. However this saving was offset to a significant extent by the higher energy requirements of the TMP process. In 1977, Jaakko Poyry (a Finnish consultant) estimated that the external energy consumption of TMP was about 19 GJ/ton pulp, compared with less than 5 GJ/ton for bleached Kraft. The trade-off between the savings on chemicals and higher energy costs is further complicated by the difference in pulp yields between the two processes. The yield of TMP pulp from wood is over 90 percent compared with sulphite pulp's best of 75 percent and Kraft's maximum of barely 50 percent. Moreover, the substitution of TMP for chemical fiber confers the additional benefit of reducing capital outlay when new capacity is added. Jaakko Poyry estimated in 1977 that the capital cost for TMP installations was only about 20 percent that of chemical pulps for mills of equivalent size. Poyry's full comparison of the relative costs of manufacturing Kraft, TMP and stone groundwood in 1977 is given in Figure 12-6.

On the demand side, one of the most hopeful prospects for thermomechanical pulp in the mid-1970s was its use in the production of newsprint. World supplies of all grades of paper and board were tight in the early 1970s, encouraging the expansion of capacity. Prior to the widespread adoption of TMP, the standard pulp furnish used in the production of newsprint was 15-25 percent sulphite and 75-85 percent stone groundwood. The groundwood portion contributed bulk, while the addition of chemical pulp ensured the necessary strength. However, with the rising price of chemicals and wood there was strong incentive to replace some or all of the chemical fiber content. The superior strength of thermomechanical pulp made this a realistic possibility. Although most newsprint furnish still included a small percentage of chemical fiber, the first newsprint operation in the world designed to run with zero percent chemical pulp started up in Quebec in 1976. At the end of that year 60 percent of global production of TMP was used for newsprint, although there were big regional variations. In Canada, for example, 95 percent was for newsprint, while in Sweden less than half the TMP output was used in this grade.

A succinct graphical presentation of the cost savings associated with the use of TMP for newsprint is provided in Figure 12-7. Although the use of groundwood reduces the energy requirement (from A to B), saving $12/ton of newsprint furnish, this is more than offset by the lower chemical pulp requirement

---

9Poyry, 1977.

10Ibid.

Figure 12-6: Total Manufacturing Costs of Various Pulps

Jaakko Pöyry's views and predictions on mechanical pulp.

Difference in stock cost due to specific energy consumption and percent of chemical pulp in furnish. Cost of semibleached kraft pulp is US$500/ton; mechanical pulp is US$225/ton. Electrical energy cost is US$0.03/kwh.

represented by the move from A to C, which saves $27.5/ton. For a plant with a capacity of 200,000 tons/year, the shift from A to C represents a saving of $3.1 million per year. Furthermore, for a plant of the same size the use of 100 percent TMP as newsprint stock rather than a 20 percent/80 percent chemical/groundwood furnish (D compared to B) enables an annual saving of $8.6 million.

2. The rising cost of environmental control

The 1970s witnessed an unprecedented frenzy of legislative activity in the OECD countries aimed at tightening control of industrial pollution. The clearest indication of rising concern over industrial effluent on a Europe-wide scale during this period was the adoption by the European Community (EC) of Directive 76/464/EEC (1976) on pollution caused by certain dangerous substances discharged into the aquatic environment. Although only a framework directive, placing few immediate obligations on member states, it served to stimulate much regulatory activity at the national level and to create the expectation of further, more specific directives. For the European pulp industry these expectations would have focused in particular on the control of chlorinated organic compounds, which are of far greater concern in chemical pulp effluent than TMP discharges.

The measures that most severely impacted the pulp and paper industry in the United States were The Clean Water Act of 1972 and its 1977 amendments, and the Clean Air Act of 1970. As required by the Clean Water Act, the EPA established Best Practicable Technology Standards to control conventional pollutants from the pulp and paper industry in 1974 and 1977. These included guidelines for allowable levels of Biological Oxygen Demand (BOD) and Total Suspended Solids (TSS) in pulp mill effluent that were based on an assessment of the capabilities of available internal (process) modifications and treatment systems. As amended in 1977 the Clean Water Act identified 129 toxic pollutants, and required control of their release by the establishment of Best Available Technology effluent standards. The final standards for the pulp and paper industry were issued in 1982, and included limitations for two chlorinated phenols.

The Clean Air Act of 1972 had two major impacts on the pulp and paper industry. Firstly it required the EPA to establish ambient air quality standards. The most significant of these for pulp mills were the particulate and sulphur dioxide standards issued in 1971. Subsequently the EPA issued Total Reduced Sulphur (TRS) standards for new sources (1978) and existing sources (1979) that had a significant impact on the operation of Kraft mills.

Because of the significantly lower pollution load generated by the TMP process in comparison to chemical pulping, the rapidly rising environmental costs of the 1970s conferred an important advantage on TMP mills. With no chemicals to recover, they did not need to install equipment to meet particulate, sulphur dioxide and TRS standards for gaseous emissions from recovery furnaces. TMP pulp for newsprint needed far less bleaching (if any at all) than the chemical pulp used in the furnish for the same product, so effluent BOD levels were cut by 50 to 90 percent. Further, the bleaching that was applied did not entail the use of chlorine, substantially reducing the expenditure related to control of toxic substances. These environmental advantages played an important role in the choice of new pulp capacity. For example, the U.S. trade journal Pulp and Paper reported in 1974 that Weyerhaeuser Co. had decided to convert its sulphite mill at Everett, Wash., to a TMP process because of the lack of viable alternatives to pollution control requirements. Individual mill decisions such as this were reflected at national and international levels by the rising share of TMP in addition to total pulping capacity. While recognizing the importance of the nonenvironmental factors discussed above, it is therefore clear that the rocketing pollution abatement costs of the 1970s (see Figure 12-1) played a major role in the rise of TMP.

III. THE ADOPTION OF TMP IN DEVELOPING COUNTRIES: ADDITIONAL CONSIDERATIONS

Our econometric results strongly highlight the impact of scale and policy on TMP adoption in developing economies. Some additional factors should be mentioned, however.

A. Production Cost and Product Quality Issues

The significance of TMP's higher yield depends in part on the relative abundance of domestic wood reserves. However, LDCs' generally smaller domestic markets and higher capital costs clearly favor TMP's lower critical scale. TMP is also less technology intensive than purely chemical processes, although improvements since the 1970s have been achieved by the addition of some chemicals. Chemithermomechanical pulping (CTMP) permits raising the pulp quality from conventional fiber sources by increasing the proportion of long fibers as well as the pulp's brightness and bulk.

CTMP has been readily adopted by firms in developing countries. For example, Melahoramentos in Brazil began producing printing and writing paper from 100 percent CTMP in 1984. CTMP has also enabled the production of pulp for a number of paper grades from non-wood fibers. In 1986 Tamil Nadu Newsprint and Papers Ltd. (TNPL) in India used CTMP to become the first company in the world to produce newsprint from sugarcane bagasse.

For developing countries, the quality advantage of CTMP has undoubtedly accelerated the adoption of thermomechanical pulping by enhancing its appeal for domestic users. In an interview with Pulp and Paper International in 1985, the FAO's Leo Lintu noted:

"...in developing countries, the converting and printing industries have the latest equipment and cannot use low-quality paper - even if it is made domestically."\(^{13}\)

B. Environmental Considerations

Environmental regulation and enforcement in developing countries generally lagged behind OECD standards throughout the 1970s and 1980s. Even in the absence of explicit sanctions, however, environmental concerns had some impact on TMP adoption decisions in the 1980s. Two illustrations, for Turkey and Brazil, are drawn from the trade journal Pulp and Paper International:

(1) 1982: "SEKA, the Turkish state pulp and paper corporation, recently started up its sawmill and 300-ton/day newsprint and thermomechanical pulp (TMP) mill at Balikesir...The first studies were for an integrated mill to make bleached Kraft pulp and printings/writings. Concern arose about the environmental impact of such a mill and subsequent studies recommended a TMP/newsprint mill instead."\(^{14}\)


(2) 1987: A bleached hardwood Kraft mill operated by Cenibras in Brazil planned to spend $25 million installing secondary effluent treatment to meet new government guidelines. This investment was to coincide with a far larger investment ($700 million) to double the mill’s capacity to 700,000 tons per year.\(^5\)

Thus it is apparent that pulp mills in developing countries have not been immune from environmental pressure. One factor that is likely to have been particularly significant is the sheer size of the investment entailed in commissioning a pulp mill. In 1983 a Swedish consultant estimated that the total investment required for a new bleached Kraft pulp mill of the minimum economic size (1,200 tons per day) was $800 million.\(^6\) The financing of an investment of this size in a developing country would ensure national and international scrutiny of the project, including in most cases at least some consideration of its environmental impact.

An indication of the importance of such international environmental concerns in promoting the adoption of TMP is given in a 1985 article by Friedrich Luhde of the International Finance Corporation. Discussing the advantages of investing in CTMP installations rather than Kraft mills in developing countries, Luhde notes that:

- CTMP is much more friendly to the environment; it requires much less fresh water and releases less effluent. This, in turn, greatly reduces the need for fresh water sources and receiving water.
- CTMP emits no particulates or gases, where the Kraft pulp process emits fly ash, and gases like hydrogen sulphide and mercaptans into the atmosphere and needs expensive pollution control equipment.\(^7\)

In this fashion, the environmental concerns that helped promote the adoption of TMP in the OECD have been transferred to developing countries via the environmental policies of international investors.


Discussant's Comments

Ishac Diwan

This is a provocative paper. Reading it, one is left with the strong impression that analytical work on issues of pollution can be very productive. There is a wealth of untouched data-bases in this field with seemingly astonishing structure and regularities. This paper will no doubt prompt researchers to dwell more into the hidden rationality of pollution and technology transfers, and this can only enlighten us as increasingly thorny dilemmas present themselves in these areas.

By looking carefully at the experience of a cross section of countries with one eminently polluting industry, that of wood pulp production, the authors show that openness has been an important determinant of technological choice while income per capita and more generally, the level of development is not. In the remarks below, I will question the generality of these results.

A widely held presumption (developed in the paper by Diwan and Shafik in this volume) is that richer societies choose cleaner technologies because they value environmental goods--which are thought to be normal goods--more than poor societies.

This paper however finds that the level of development did not matter as much as openness for the case of the paper industry. The hypothesis presented in the introduction can be termed the competitive pressure hypothesis. It states that new technologies, being developed in the West, result in cleaner production as well as efficiency improvement. Open economies face competition from abroad which puts pressures on their firms to adopt quickly the newest technologies. As a side product, more open economies end up polluting less.

Is the "widely held presumption" incompatible with the "competitive pressure hypothesis"? The question is really whether poor countries cannot compete more effectively with richer countries by choosing technologies that are cheaper but possibly dirtier. If such technological choices exist, and given the presumption that poor countries care less than rich ones about their environment, than the South could develop a competitive edge at the cost of added pollution. Now if this is the case, then we should find that the level of development does matter and possibly, that openness leads to more pollution because competitive pressures generated by openness could be resisted by using the cheaper, but unfortunately dirtier technology.

The result of this puzzle seems to be that the new technology developed in the paper industry in the 1970s (TMP) is both cleaner and more cost effective than other existing technologies. Thus, for the paper industry, the clean technology simply dominates the older ones. It is then for this reason that competitive pressures, i.e., openness, have indeed led to a quicker adoption. Moreover, the level of development in this case is not that relevant since the valuation of the environmental good does not enter in the equation.

I suspect however that in the majority of other industries, the choice between cost of production and environmental restraint is more meaningful, and that for such industries, the level of development would matter.

However, I also suspect that the results of the paper do have an element of generality, at least for industries that are prone to fast technological innovations. In a world dominated by the North (which produces 79 percent of world output with only 24 percent of the world population) and where intellectual property rights are not protected in the South, technological innovation caters to the needs of the North, and not of the South. New inventions almost always result in efficiency improvements. Recently, new techniques have also tended to be cleaner. Thus, efficiency and cleanliness have been bundled together to satisfy the demand of Northern
firms. Often, and with increasing frequency, the South will simply lack a choice between two technologies, one cheaper and dirtier, and the other more expensive but cleaner. Unless the South upgrades its technological skills, or intellectual property rights become protected in the South, cheap and dirty machines and processes will not be developed in the North.

In any event, an important policy issue is whether it would be reasonable to rely on such exclusionary mechanisms to ensure the good health of the planet.
The Political Economy of Trade and the Environment in the United States Senate

Craig VanGrasstek

Introduction

The emerging linkage between trade and the environment raises the possibility for abuse. While there is no reason to question the sincerity of environmental organizations, and their efforts to protect natural resources and endangered species, economic interest groups may view trade-related environmental proposals from a more jaundiced perspective. Like other goals that become linked to trade, such as workers' rights and food safety, environmental protection could offer the temptation for opportunism and rent seeking.

Congress plays a key role in trade and environmental issues, and has the capacity to make or break U.S. policy in both of these areas. The legislature will face multiple demands in the coming years from environmental organizations, domestic industries, the executive branch, and U.S. trading partners. These groups will variously request that Congress: safeguard the environment by enacting restrictions on some economic activities; refrain from inhibiting the business climate or interfering with free enterprise; and ratify some international agreements that limit the permissible scope of national economic regulations, while consenting to others that set multilateral restrictions on polluting industries. Legislators will also be asked to resist the natural temptation to mold or alter these proposals to meet the interests of their separate constituencies. Given the inherent conflicts among these demands, it seems unlikely that the legislative branch will please all — or even most — of the demandeurs. More to the point, the environmental issue could offer an indirect opportunity for "dirty" industries to restrict competition from imports. Whenever governments propose that some class of economic activity be regulated, taxed or prohibited, there will be producers who seek to evade or exploit the rules for their own advantage. Introducing the international element means increasing the temptation to fiddle the rules, as legislators find it easier to impose costs on foreign rather than on domestic producers. Manipulation can move in either direction: discriminatory trade barriers can be imposed in the name of environmental protection, and liberal trade rules can be used to evade environmental controls. Examples of both types can be readily cited; the question is whether these maneuvers are exceptional or endemic.

I address the question empirically, by asking whether the record supports the claim that protectionism is more attractive to legislators, when it is presented in environmental guise. The Senate offers a particularly good arena for conducting this test, insofar as it generates a large number of dependent variables (in the form of floor votes),¹ and the composition of senatorial constituencies (i.e., the 50 states) offer a ready supply of

¹I use the data reported in the Congressional Quarterly, which includes pairs, stated intentions to vote, etc. In keeping with convention, I treat these observations the same as votes.
independent variables. These data allow us to test hypotheses regarding the influences on senators’ voting behavior, through a three-step series of regressions. The first two steps are to determine legislators’ decision-rules for "ordinary" trade policy, and for purely domestic environmental initiatives. The third step is to find which rule determines outcomes when the Senate considers issues that straddle both trade and the environment.

The method I use is probit analysis. Probit is more suitable than other methods of regression, such as least squares, because the dependent variable (i.e., the yes-or-no votes of individual legislators) is dichotomous. This technique was originally developed, appropriately enough, to test the efficacy of pesticides (an insect's life or death being a dichotomous dependent variable), and today is commonly employed by political scientists as a means of assessing the influences on congressional voting behavior. The purpose of the analysis is not to find a "best predictor" for each individual vote, nor indeed to forecast the outcome of future votes, but instead to confirm or disconfirm hypotheses about the influences on legislative decision making. The first such hypothesis we address is interest-group pluralism, and its influence on trade policy.

The Political Economy of Trade Policy

Before assessing the consequences of the trade-environment linkage, we must first understand how the Senate decides on "normal" trade proposals. The data confirm that senatorial voting behavior obeys the dictates of interest-group pluralism, in which legislators' votes are a function of the positions taken by industries that account for significant employment in their home states.

While the conventional wisdom recognizes this relationship, it does not always appreciate the implications that spring from it. Congress is widely viewed as a parochial institution that -- if not restrained by its own leadership and the executive branch -- would revert to old patterns of rampant protectionism. This description is only half right: legislators are indeed parochial, in the sense that their electoral fortunes depend upon solicitude towards their constituents' economic interests, but it is a mistake to equate parochialism with protectionism. It is not attention to local interests per se that inspires protection, but attention to a limited range of local interests. The infamous Smoot-Hawley Tariff of 1930, for example, was a product of "reciprocal noninterference," in which interest groups tacitly agreed not to interfere with one another’s rent-seeking demands (Schattschneider, 1935). Interest-group pluralism is truly plural today, such that protectionist initiatives are almost always opposed by industries that depend upon imports for their own use.\footnote{It is assumed throughout this paper that readers are generally familiar with the role and structure of the Senate. For those who are not, three facts are most salient: (a) the U.S. Government is based on a presidential system of divided powers, rather than a parliamentary system, (b) the two major political parties have very weak control over their elected officials, and (c) senators are popularly elected from geographically distinct constituencies (i.e., each state elects two senators). The chief implication of these three points, for purposes of this analysis, is that the imperatives of reelection will lead rational legislators to pay more attention to the perceived interests of their constituents, than to the wishes of their party leaders or the President (if there are distinctions among these positions). It should also be noted that the Senate is co-equal with the House of Representatives, which is distinguished from the Senate by its larger size (435 versus 100 members), smaller and less diverse constituencies (House districts are drawn according to population), stricter parliamentary rules, and shorter terms of office (senators serve six-year terms, and House members serve two-year terms). While each of these differences could affect legislative outcomes, the distinctions between the two chambers have narrowed in recent years (Sinclair, 1989). It is reasonable to assume that, in the absence of evidence to the contrary, the observations made here regarding the influences on senatorial voting patterns generally apply to the House as well.}
production, and by exporters who stand to lose if markets are closed. While the opposition from these groups
does not prevent the erection of all trade barriers, it does reduce the incidence of legislated protection, and
persuades many industries to adopt an essentially defensive strategy (i.e., seek the maintenance of existing
protective barriers, rather than demanding higher levels of protection). Legislators still seek special favors
for their home industries, much as they did in the days of unfettered protectionism, but today these favors
concern exports more often than imports. When a lawmaker makes a demand on the trade bureaucracy, he
is more likely to ask that specific foreign barriers to U.S. exports be targeted under a "reciprocity" policy,
or assisted by subsidies, than to urge import protection for a domestic industry. Perhaps most important,
Congress is not in a position to grant these favors by legislative fiat, and must instead delegate authority to
the executive, and bargain with the president over U.S. negotiating objectives.

This characterization of congressional trade policy making is supported by empirical evidence. In the
pages that follow, I present and test a model of interest-group pluralism for votes on trade proposals. The
model shows that legislators do vote according to the expressed interests of industry groups in their
constituencies. In each case, the dependent variables consist of individual senators' floor votes, together with
other dichotomous choices that are functionally equivalent to votes (i.e., a senator's decision to co-sponsor
legislation). Whenever possible and appropriate, I pool similar votes together in order to increase the sample
size (and include a dummy variable to distinguish between the component votes). The independent variables
represent employees per capita in each state, among industries that took part in the debate, with all
supporters and all opponents of a proposal being aggregated into two opposing variables. The logic behind
this choice of variables is simple: legislators are presumed to equate employees with voters, and to heed
industries that account for appreciable levels of employment in their home states.

The structure and interpretation of probit equations can best be understood by examining a specific
case. The first set of data in Table 13-1 concerns recent fights over sugar import quotas, and demonstrates
the relative influence of pro- and antiprotectionist interests. Sugar-using industries consistently lost their
attempts in the 1980s to relax or remove sugar quotas, but the data confirm that they were able to influence

3The dummy is temporal when the votes take place over a span of time, and spacial when votes that are
cast in close proximity involve different aspects of the same issue. For a discussion of pooled data sets, and
the use of dummy variables, see Stimson (1985).

4Nearly all of these data are derived from economic censuses in SIC categories (at the 2-, 3-, or 4-digit
level, depending on the diversity of the interests involved). The independent variables are derived from the
1987 Census of Manufactures, Census of Mineral Industries, Census of Agriculture and Census of Service
Industries. Per capita figures were calculated by dividing the data by each state's total population in 1987,
as estimated by the Census (and reported in the Statistical Abstract). The results are then presented as
"employees in industry X per thousand residents," so as to avoid using independent variables with very small
values (which make for tables that are difficult to read). Data are unavailable for some industries, especially
those that are very obscure or are almost extinct. If an industry is not represented in the economic census,
or cannot be reliably broken out from a larger SIC category, I simply do not use it. Similarly, I make no
effort to represent individual companies.

5There are several reasons for aggregating variables. One is the need to overcome collinearity among
similar independent variables: because many of the industries on one side of an issue are closely related to
one another, the probit function has difficulty assigning a separate influence to each one. For example,
industries A, B and C might each appear unimportant when plugged individually into an equation, but the
coalition ABC will be correctly signed and significant. Moreover, lobbies tend to aggregate anyway through
the formation of ad hoc or permanent coalitions; this approach fits in with the assumption that legislators
perform an "adding machine" function when considering an issue; and it makes the presentation and
interpretation of results much more simple (both for individual equations and when reviewing the results of
several equations).
Table 13-1: Probit Values for Senate Votes on Selected Trade Policy Proposals

<table>
<thead>
<tr>
<th>Influence</th>
<th>Expected Coefficient (S.E.)</th>
<th>2-Tail Signif. Mean</th>
<th>Min.</th>
<th>Low</th>
<th>High</th>
<th>Max.</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUGAR QUOTAS:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SWEETEN</td>
<td>+ 0.0969 (0.0404)</td>
<td>0.0176</td>
<td>1.4462</td>
<td>54.8</td>
<td>54.8</td>
<td>72.5</td>
<td>95.5</td>
</tr>
<tr>
<td>SUGARUSE</td>
<td>- 0.7164 (0.4181)</td>
<td>0.0883</td>
<td>0.1503</td>
<td>65.3</td>
<td>45.3</td>
<td>54.3</td>
<td>32.9</td>
</tr>
<tr>
<td>1990</td>
<td>- 0.2713 (0.1883)</td>
<td>0.1512</td>
<td>0.5000</td>
<td>66.2</td>
<td>66.2</td>
<td>55.8</td>
<td>55.8</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>0.3709 (0.1559)</td>
<td>0.0184</td>
<td>1.0000</td>
<td>61.1</td>
<td>61.1</td>
<td>61.1</td>
<td>61.1</td>
</tr>
<tr>
<td>Root mean squared error: 0.4748</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TRADE-REMEDY AMENDMENTS: | | | | | | | |
| PROTRADE | + 0.0013 (0.0074) | 0.0743 | 13.9992 | 54.7 | 55.2 | 67.0 | 82.6 | ** |
| TRAC | - 0.0167 (0.0069) | 0.0158 | 13.6844 | 69.1 | 68.5 | 53.5 | 29.7 | ** |
| ESCAPE | - 0.7599 (0.1626) | 0.0000 | 0.3333 | 70.2 | 70.2 | 41.8 | 41.8 | | |
| CONSTANT | 0.5745 (0.1787) | 0.0015 | 1.0000 | 61.2 | 61.2 | 61.2 | 61.2 | | |
| Root mean squared error: 0.4610 |

U.S.-CANADA FREE TRADE: | | | | | | | |
| ACTECAN | + 0.0630 (0.0373) | 0.0948 | 20.4435 | 78.0 | 87.8 | 98.3 | 99.7 | ** |
| ANTIFA | - 0.0628 (0.0326) | 0.0574 | 3.2132 | 96.8 | 96.8 | 89.6 | 33.5 | ** |
| CONSTANT | 0.5569 (0.7246) | 0.4441 | 1.0000 | 95.0 | 95.0 | 95.0 | 95.0 | | |
| Root mean squared error: 0.2561 |

Key

**: Sign correct and significant
*: Sign correct but insignificant
<: Sign incorrect but insignificant
<: Sign incorrect and significant

Number of observations: 189 (sugar), 289 (trade-remedy), and 95 (Canada).

Dependent variables: Sugar Quotas are a pool of one motion in 1985 and another in 1990, to table amendments permitting a relaxation of sugar import quotas; the restrictive position is "yes." Trade-Remedy Amendments are a pool of three motions to table proposed amendments to tighten the antidumping law and the escape clause, offered during debate in 1987; the restrictive position is "no." U.S.-Canada Free Trade is the vote to approve the U.S.-Canada Free Trade Agreement Implementation Act of 1988; the restrictive position is "no."

Independent variables: SWEETEN consists of industries that grow and process sugar and corn sweeteners. SUGARUSE consists of major sugar-using industries (e.g., candy). 1990 is a temporal dummy variable. PROTRADE consists of industries represented by the Protrade Group, or in other industries that opposed the amendments. TRAC consists of industries that were represented in the Trade Reform Action Coalition. ESCAPE is a spatial dummy variable for the vote dealing with the escape clause. ACTECAN consists of industries that were members of the American Coalition for Trade Expansion with Canada. ANTIFA consists of industries that either opposed or expressed serious reservations regarding the FTA.
votes in the Senate. A probit test supports the hypothesized influence of a variable, when the sign of the coefficient is as predicted, and the variable is significant (i.e., the two-tailed significance is less than or equal to 0.100). The figures show that votes to maintain quotas were positively correlated with the level of employment in the sweetener industry (i.e., the sign is positive), and negatively correlated with employment in the sugar-using industries (i.e., the sign is negative). The data further suggest that the results for SWEETEN and SUGARUSE are not merely coincidental; the likelihood of these relationships arising by pure chance is just 1.8 and 8.8 percent, respectively.

Probit also permits us to weigh the apparent importance of distinct variables, ceteris paribus, on the legislators' voting decisions. The columns under the heading "Influence" show the calculated probability that a hypothetical senator will vote "yes," when (a) the variable is set at a representative range of values, and (b) all other variables are set at their means. The chosen values are the "minimum" (based on the lowest value in the sample), "low" (one standard deviation below the mean), "high" (one standard deviation above the mean), and "maximum" (highest value in the sample). The range of values for dummy variables is limited to zero and one, and there is by definition only one value for the constant. The area between the low and the high suggests the range of probabilities for the majority of the legislators, assuming that the variable is normally distributed,6 while the minimum and especially the maximum illustrate the probabilities for outliers. In the case of the sugar quotas, the forecasts indicate that sugar users were almost as influential as sweetener producers, even though the industry employed far fewer people in the average state. The temporal dummy shows that the average senator's willingness to maintain sugar quotas declined slightly between 1985 and 1990.

The pluralist model is particularly useful in testing the common assertion that protrade interests fail to exercise coherent intervention when proposals are "generic." Amendments to the trade-remedy laws, for example, are believed to attract less effective opposition than the more blatant forms of sector-specific protection (Destler and Odell, 1987). Table 13-1 shows the probit results for a pool of three motions to defeat amendments to the antidumping statute and the escape clause. The data indicate that the opponents of these amendments (the Protrade Group) were persuasive, and only slightly less influential than the supporters (the Trade Reform Action Coalition); indeed, two of the three amendments were defeated. The vote to ratify the U.S.-Canada Free Trade Agreement (FTA) offers another test for the pluralist model. Trade agreements, like the trade-remedy laws, similarly involve the interests of multiple industries. In this instance, the members of the broad-based American Coalition for Trade Expansion with Canada anticipated increased exports to Canada, and lobbied actively for the accord, while producers of footwear, lead, zinc, uranium and wheat were concerned that the FTA would lead to increased import competition. Both supporters and opponents swayed the Senate, but only those senators with high concentrations of anti-FTA constituents were likely to vote against ratification.

Taken together, these three cases offer strong support for the pluralist model. The cross-sectional variance of senatorial voting behavior can be explained according to the positions taken by affected industries, and the relative weight of these industries in each state. Moreover, the data confound the common belief that legislators are predisposed to support protectionist measures; to the contrary, framing a proposal as a trade issue invites the active, influential, and (often) successful intervention of antiprotectionist coalitions. The next

---

6There are a few peculiarities in the data that are worth noting. The minimum and low values will often be the same, due to the geographic concentration of industries (and hence the tendency for the standard deviation to exceed the mean). I will not set a "low" value below zero, nor will I set it lower than the minimum value; this means that both the minimum and the low will often be zero. Conversely, my high value will never be greater than the maximum, but maximums tend to be outliers and hence there will usually be a difference -- and sometimes a substantial one -- between the high and the maximum values.
question is whether the pattern observed for trade policy can be applied to other issues involving specific industrial sectors, such as environmental protection.

The Political Economy of Environmental Policy

Environmental policy bears several similarities to trade. It involves proposals that are intended to provide general benefits for the country, but do so by imposing disproportionate costs or offering disproportionate benefits for specific industries. This suggests that senatorial decisions on domestic environmental issues can be shown, like trade, to be a function of industry demands. Senators from states with large concentrations of dirty industries, for example, can be expected ceteris paribus to vote against proposals that would ban, tax or strictly regulate those industries. The environmental issue differs from trade, however, in one crucial respect: whereas industries and their surrounding communities often share a common interest in specific trade proposals, relations on environmental issues can be more complicated. Communities may be divided by the competing goals of preserving jobs and preserving the environment. From the perspective of common citizens, the consequences of bad environmental policy are more visible and objectionable than the consequences of bad trade policy. The same consumers who will silently endure artificially high prices for apparel might become quite vocal when a local factory pollutes the air, land or water -- or even when an oil tanker spoils a distant ecosystem that they may never see with their own eyes. The higher political profile of environmental issues is amply demonstrated in public opinion polls, and in the content of electoral campaigns.

Analysts generally agree that the collective-goods problem prevents consumers from participating effectively in trade debates, and that legislators are thus inclined to follow the dictates of passionate minorities over the interests of passive majorities. It is difficult to test this proposition, however, for want of adequate independent variables. The only trade cases in which I can meaningfully measure these interests are those in which there is a regional distinction in the consumption of a finished product, and hence there is state-based data with a suitably wide range of values. Most products that are subject to protection are either materials that are not immediately consumed by end-users (e.g., steel), or are consumed in roughly equal quantities everywhere (e.g., clothing). Oil is the only product that is frequently the focus of protectionist proposals, and is (in refined form) subject to special regional patterns of consumption (i.e., northeastern states depend heavily on heating oil during the winter). I have found in probit regressions that votes on oil import fees are indeed a joint function of employment in the oil industry and per capita consumption of residential fuel oil.

Fully 89 percent of respondents in a recent poll stated that they considered themselves to be environmentalists (Environment Opinion Study, Inc., 1991); another poll found 80 percent of the public identifying themselves in this way (Hart-Teeter, 1991). The first poll also asked that respondents identify which one of five problems "will pose the greatest threat to the well-being of future generations of Americans;" more than twice as many respondents cited "environmental problems" (28 percent) as "foreign economic competition" (12 percent). Pollsters routinely ask respondents to name the leading problems in the country; environmental concerns are almost always in the top-ten list (and are often high on it), but trade-related concerns are rarely on the list at all.

In content analysis of campaign commercials aired by Senate candidates in 1988, I found that the environment was the third most commonly cited topic (after Social Security and education), while trade held the tenth place on the list. Perhaps more important, from the perspective of the rational and risk-averse legislator, is the potential use of environmental issues in "negative" campaigns. Of the 17 challengers in the sample who aired "negative" ads (i.e., commercials that criticize the incumbent's record), eight cited environmental issues, but only two cited trade. These data support the contention that senators might safely confine their attention to economic interest groups when considering trade issues, but must be more careful to follow public opinion when making decisions on environmental issues.
Environmental organizations play an important role in arousing public awareness of these issues, and in channeling that awareness into support for specific measures. When legislators know that their records will come under closer scrutiny by the electorate, and that the public places a high value on clean air and water, they may feel less inclined to follow the dictates of specific industries. It is important to recognize, however, that the environmental movement is not monolithic. Any issue that has such widespread appeal is bound to attract the interests of diverse social groups, and the array of groups that are involved in this topic is large and diverse (Wenner, 1990; National Wildlife Federation, 1991). The spectrum of opinion ranges from ad hoc neighborhood groups with the limited goals of NIMBY (not in my back yard), to global altruists whose objectives sometimes verge on BANANA (build absolutely nothing anywhere near anyone). Between these extremes are many mainstream organizations, such as the Sierra Club and the Audubon Society, whose leaders are an experienced part of the Washington establishment. Working alone or (more often) in coalitions, these organizations frequently offer an effective counterweight to economic interest groups that represent major industries. They cannot be ignored by politicians and should not be excluded from our tests.

How can we adapt the pluralist model in order to take these environmental concerns into account? The ideal approach would be to use state-based measures of activism, such as the number of members per capita in environmental organizations, but these data are simply unavailable. A second-best solution is to work from the assumption that environmental activism is a function of local environmental conditions. The reasoning here is that while many environmentalists take a broad view of their mission, their initial forays are often prompted by enlightened self-interest. Local problems inspire citizens to organize; some among them will be socialized to view the issue in national or global terms, but activism will generally be highest in the most heavily polluted areas. Using pollution data as a proxy for environmentalism might appear to confuse industrial with environmental variables, if pollution is indeed higher in areas where dirty industries are located, but the migratory character of pollutants and polluters vitiates this problem. Automobile emissions, for example, are more concentrated where cars are heavily used (e.g., Los Angeles) than where cars are produced (e.g., Detroit). Pollutants may be footloose (e.g., chemical wastes that are dumped in a river), or the polluting industry itself may take flight (e.g., bankrupt producers leave a legacy of toxic wastes). In each of these cases, the costs and benefits of hosting a dirty industry are separated by time and/or space. In some instances, therefore, it is appropriate to include one environmental variable as a measure of local dependence on dirty industries, and another to measure the damage done by pollution.

These propositions can now be tested, using probit models that incorporate both industrial and environmental variables. Table 13-2 shows the results of three such tests. The first and most simple case concerns standards for corporate average fuel economy (CAFE), which since 1975 have mandated certain fleet-wide mileage standards for each carmaker. Hypothetically, the issue could be manipulated for protectionist purposes, as unions sometimes demand, but domestic and foreign automotive producers are united in their opposition to strict CAFE standards. The costs and benefits are unevenly distributed, such that cities suffering the worst air pollution have the most to gain, at the expense of the automotive industry and consumers in less polluted areas. We would therefore expect -- and the data confirm -- that votes in favor of stricter standards will be a positive function of air pollution, and a negative function of automotive

---

10 These data are not published in the annual reports of the major environmental groups, and the organizations that I contacted could not otherwise supply this data on a state-specific basis.

11 The source for this data is Table 353 of the Statistical Abstract of the United States, 1990 (U.S. DOC, 1990(d)).
### Table 13-2: Probit Values for Senate Votes on Selected Environmental Proposals

<table>
<thead>
<tr>
<th></th>
<th>Expected</th>
<th>Influence</th>
<th></th>
<th>Sign Coefficient (S.E.)</th>
<th>2-Tail Signif.</th>
<th>Mean</th>
<th>Min.</th>
<th>Low</th>
<th>High</th>
<th>Max.</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
</tr>
<tr>
<td><strong>CAFE STANDARDS:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
</tr>
<tr>
<td>CARS</td>
<td>-</td>
<td>-</td>
<td></td>
<td>0.0592 (0.0301)</td>
<td>0.0498</td>
<td>0.7810</td>
<td>57.9</td>
<td>57.9</td>
<td>51.8</td>
<td>31.7</td>
<td>**</td>
</tr>
<tr>
<td>CARBON</td>
<td>+</td>
<td>0.0982 (0.0420)</td>
<td>0.0197</td>
<td>1.0800</td>
<td>51.9</td>
<td>51.9</td>
<td>61.3</td>
<td>76.9</td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>-</td>
<td>0.0163 (0.1118)</td>
<td>0.8843</td>
<td>0.3333</td>
<td>55.9</td>
<td>55.9</td>
<td>55.0</td>
<td>55.0</td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONSTANT</td>
<td>0.0882 (0.0810)</td>
<td>0.2766</td>
<td>1.0000</td>
<td>56.1</td>
<td>56.1</td>
<td>56.1</td>
<td>56.1</td>
<td>**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root mean squared error:</td>
<td>0.4925</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
</tr>
<tr>
<td><strong>CLEAN AIR ACT:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
</tr>
<tr>
<td>CAWG</td>
<td>-</td>
<td>-</td>
<td></td>
<td>0.0644 (0.0143)</td>
<td>0.0000</td>
<td>5.7022</td>
<td>84.6</td>
<td>83.7</td>
<td>62.6</td>
<td>25.8</td>
<td>**</td>
</tr>
<tr>
<td>SMOKE</td>
<td>-</td>
<td>-</td>
<td></td>
<td>0.0203 (0.0055)</td>
<td>0.0003</td>
<td>11.7483</td>
<td>81.0</td>
<td>81.0</td>
<td>65.6</td>
<td>24.8</td>
<td>**</td>
</tr>
<tr>
<td>ACIDRAIN</td>
<td>+</td>
<td>0.8690 (0.1913)</td>
<td>0.0000</td>
<td>- 4.8190</td>
<td>59.3</td>
<td>61.8</td>
<td>84.3</td>
<td>88.3</td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PASSAGE</td>
<td>0.8562 (0.1895)</td>
<td>0.0000</td>
<td>0.2000</td>
<td>68.5</td>
<td>68.5</td>
<td>91.0</td>
<td>91.0</td>
<td>**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONSTANT</td>
<td>5.2765 (0.9798)</td>
<td>0.0000</td>
<td>1.0000</td>
<td>74.3</td>
<td>74.3</td>
<td>74.3</td>
<td>74.3</td>
<td>**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root mean squared error:</td>
<td>0.4185</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
</tr>
<tr>
<td><strong>SUPERFUND:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
</tr>
<tr>
<td>ANTITAX</td>
<td>-</td>
<td>0.3069 (0.1022)</td>
<td>0.0029</td>
<td>0.5303</td>
<td>81.8</td>
<td>81.8</td>
<td>68.1</td>
<td>16.6</td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>POLLUTERS</td>
<td>+</td>
<td>0.0463 (0.0231)</td>
<td>0.0465</td>
<td>4.8979</td>
<td>69.8</td>
<td>70.5</td>
<td>100.0</td>
<td>100.0</td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SITES</td>
<td>+</td>
<td>0.0718 (0.0259)</td>
<td>0.0059</td>
<td>6.3090</td>
<td>64.2</td>
<td>65.1</td>
<td>86.3</td>
<td>99.4</td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PASSAGE</td>
<td>0.7063 (0.1919)</td>
<td>0.0003</td>
<td>0.3333</td>
<td>69.5</td>
<td>69.5</td>
<td>88.8</td>
<td>88.8</td>
<td>**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONSTANT</td>
<td>- 0.0076 (0.2042)</td>
<td>0.9696</td>
<td>1.0000</td>
<td>77.2</td>
<td>77.2</td>
<td>77.2</td>
<td>77.2</td>
<td>**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root mean squared error:</td>
<td>0.4168</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
</tr>
</tbody>
</table>

**Key**

- **:** Sign correct and significant
- *:** Sign correct but insignificant
- o: Sign incorrect but insignificant
- oo: Sign incorrect and significant

Number of observations: 577 (CAFE), 490 (Clean Air), 290 (Superfund).

Dependent variables: CAFE is a pool of four votes in 1985 and two in 1990 on proposals to tighten automotive fuel-economy standards; the environmental position is "yes." Clean Air Act is a pool of four votes to amend and one to enact the Clean Air Act of 1990; the environmental position is "yes." Superfund is a pool of two votes to amend and one to reauthorize the Superfund program in 1985; the environmental position is "yes."

Independent variables: CARS consists of the automotive industry. CARBON consists of the number of cities in each state that exceeded EPA standards for carbon monoxide levels. 1985 is a temporal dummy variable. CAWG consists of industries comprising the Clean Air Working Group. ACIDRAIN is the average pH level for precipitation (expressed as a negative number). SMOKE consists of the per capita production of airborne pollution. POLLUTERS consists of the oil, chemical and petrochemical industries. ANTITAX consists of industries that sought exemption from a manufacturers' tax. SITES is the number of Superfund sites per capita. PASSAGE is a spacial dummy distinguishing amendments from final votes to enact bills.
employment. Senators were influenced in roughly equal (but opposite) measure by these concerns, which jointly provide a more accurate estimation than an equation based solely on the industry variable.\(^\text{12}\)

The pluralist-environmental model also helps to explain senatorial votes on the more complicated issue of acid rain. In this instance, the pollution that is generated by factories and power plants in some sections of the country (particularly the midwest) comes down in the form of acidic precipitation elsewhere (particularly the northeastern United States and eastern Canada). We will turn to the divisions between the United States and Canada shortly; our immediate concern is over the domestic dispute. The Clean Air Act of 1990 was intended to abate air pollution by restricting the sulphur content of coal used by power plants, and establishing comparable regulations for other dirty industries. Numerous environmental organizations supported these proposals, but were opposed by the Clean Air Working Group (CAWG). This coalition, complementary to, but distinct from, CAWG; it can be seen as an index of a community's interest in maintaining lax standards. The results show once again that votes are influenced jointly by industrial and which represented, inter alia, producers of coal, chemicals, steel and automobiles, argued that the proposed restrictions would cost thousands of jobs. The equation for Clean Air Act votes is based on one industry variable and two opposing environmental variables. SMOKE measures the toxics that are spewed into the air, while ACIDRAIN measures the consequences of this pollution.\(^\text{13}\) The first of these variables is complementary to, but distinct from, CAWG; it can be seen as an index of a community's interest in maintaining lax standards.\(^\text{14}\) The results show once again that votes are influenced jointly by industrial and environmental variables: senators from states that depend on dirty industries (i.e., have high values for CAWG and/or SMOKE) tend to oppose restrictions, and senators from states that suffer the worst acid rain tend to support restrictions.

\(^\text{12}\)It should be noted that the root mean squared error (RMSE) is not comparable to \(R^2\) in least-squares regressions as a means of assessing an equation's explanatory power. The RMSE is simply the average residual (i.e., difference between the actual vote and the forecast probability of voting "yes") for all senators. It is useful in comparing different equations that seek to explain a common dependent variable, but offers no insight when comparing equations that deal with distinct dependent variables. In this particular case, the improvement is modest. The RMSE for an equation based on CARS alone is 0.4949, while the RMSE for CARBON alone is 0.4942; when used together, the RMSE is 0.4925.

\(^\text{13}\)Readers will recall that lower pH values denote higher acidity. In order to reduce confusion in the tables, I express pH values as negative numbers. This means that the positive coefficient in the probit estimation denotes a positive correlation between the acidity of a state's precipitation, and votes in favor of restrictions.

The data for each state were derived from an isopleth map published by the National Atmospheric Deposition Program (1990). The map measured 1989 annual precipitation-weighted mean hydrogen ion concentrations. The isopleth data are preferable to observations gathered by discrete measuring stations, as they are based on computer modeling that takes into account topographical and atmospheric factors. My tests showed that the pH data are a slightly better predictor than the estimated hydrogen ion deposition for each state (also calculated by NADP).

\(^\text{14}\)It is a matter of interpretation, whether one wishes to view SMOKE as a measure of the surrounding community's dependence upon dirty industries (as employers, contributors to the tax base, producers of electricity, etc.), or as a multiplier for CAWG (i.e., an indicator of the most dirty producers within its constituency). In either case, it is clear that this particular measure of environmental damage is not a proxy measure for environmental activism.

The justification for using both CAWG and SMOKE in the equation is twofold. First, the two variables clearly measure distinct phenomena, as their correlation coefficient is a mere 0.1291. Second, including SMOKE in the equation increases the accuracy of the estimation. The RMSE for the equation shown in Table 13-2 is 0.4185, but without SMOKE the RMSE is 0.4258.
The final case examines a different type of cost that environmental initiatives might place on industries. The Superfund, which was first established in the 1970s, finances the cleanup of abandoned waste sites. Congress and the Reagan administration fought over the size of this program when it was reauthorized in 1985-1986, but the amount of the budget was less contentious than the means for financing it. The House of Representatives favored taxes that targeted the oil and chemical industries, while the Senate proposed a uniform 0.8 percent tax on all manufacturers. The Senate plan attracted support in states where the polluters had come and gone (leaving behind their detritus), and in those states where the same industries still survived (but would face higher taxes if the House prevailed). The strongest opposition to the broad-based tax came from producers of agricultural inputs. The data show that senators were indeed influenced as predicted. Votes were a positive function of environmental demands (as measured by waste sites per capita)\textsuperscript{5} and employment in the chemical/petrochemical industries, and a negative function of employment in the industries that opposed the tax. The votes on these proposals did not resolve the difficult issue of Superfund finances, however, as we will see in the next section.

The evidence all points in the same direction: the decision-rule for environmental proposals differs from the decision-rule for trade proposals. Votes on these initiatives are not determined solely by the positions that industries take, but also by the environmental interests in a constituency (as approximated by measures of pollution). Environmental variables might work either in conjunction with or in opposition to the industrial variables, depending upon the nature of the specific proposal, but they must be taken into account in either event.

The Trade-Environment Linkage

Having established the distinct decision-rules for trade and environmental proposals, the question then arises: what happens when trade meets the environment in the legislative arena? When legislators consider proposals that tie these two issues together, which decision-rule will dominate? The preceding analysis implies that, contrary to the conventional wisdom, the trade rule would be more likely to maintain open markets. Antiprotectionist forces can, but do not always, counterbalance the pressure of protectionists. In the case of environmental protectionism, the antiprotectionist interests would be forced to overcome opposition on two fronts.

There are three distinct ways in which Congress might link trade and environmental issues, at the behest of domestic interest groups. These include (a) taxing imports in order to offset the costs of domestic environmental programs, (b) extraterritorial application of U.S. environmental regulations (including restrictions or bans on imports that do not meet these standards), and (c) opposition to further trade liberalization, on the grounds that liberal commercial rules might undermine or overturn environmental standards. Each of these approaches merits separate attention, based on recent episodes. Unfortunately, the small number of votes that has been cast on such issues requires that we rely on anecdotal evidence to fill some of the quantitative blanks.

Congress has already proven that it is willing and able to impose import taxes in order to finance domestic environmental programs. The Superfund debate of 1985-1986 showed that taxes are at least as politically unpopular as hazardous waste. The Senate was internally divided over how to finance this cleanup program, with only a bare majority preferring the broad-based tax on manufactures over the more specific fees proposed by the House of Representatives. Conferees from the two chambers spent several months in 1986 arguing over their differences, before devising the following compromise: taxes would fall most heavily on the oil and chemical industries, as the House wanted, but the oil industry and its congressional allies would

\textsuperscript{5}The source for this data is Table 354 of the \textit{Statistical Abstract of the United States, 1990} (U.S. DOC, 1990 (d)).
be mollified by a higher rate on imports. Domestic oil would be taxed at the rate of 8.2 cents/barrel, while imported crude would pay 11.7 cents. Legislators from the northeastern states might ordinarily object to an oil import fee in any form, but they viewed the 3.5 cent difference as a small enough price to pay for the Superfund.

This case might be cited as a clear example of environmental protectionism, but there are a few observations that modify this conclusion. The first is that the differential was more symbolic than substantive, at least from the perspective of U.S. producers. They would prefer an import fee measured in dollars rather than pennies, and the compromise appears to have "bought" only a few votes from senators in the oil-producing states. The compromise passed by an overwhelming margin (88-8) when the Senate voted on it in late 1986, but the oil-rich states accounted for a disproportionate share of the dissenting votes. The second mitigating factor was the congressional willingness to bring the fee structure into conformity with U.S. obligations, after a panel ruled in 1987 that it violated GATT Article III:2. Congress did not express serious opposition to the GATT panel report, and remedial legislation in 1989 equalized the fee at 9.7 cents/barrel for both domestic and imported oil. Finally, legislators did not exploit other exercises in environmental taxation as opportunities to discriminate. Congress made no distinction between domestic and imported oil in a 1986 tax of 1.3 cents/barrel (used to fund an oil-spill liability trust fund), and applied identical fees on domestic and imported ozone-depleting chemicals in 1989. The Superfund experience might therefore have had a certain didactic value. If Congress considers other environmentally inspired fees in the future, the Superfund experience may discourage the enactment of discriminatory imposts.

The second and more troublesome category concerns efforts to extend the territorial application of U.S. environmental standards. These initiatives can be divided between apparently legitimate efforts to apply standards on a nondiscriminatory basis (but which may nevertheless be considered GATT-illegal), and illegitimate attempts to exploit environmentalism to achieve protectionist ends. We will review examples of each in turn.

The extraterritorial application of bona fide environmental measures provokes a sharp difference of opinion between U.S. and foreign policymakers. American industries, environmentalists and legislators would all agree with the general proposition that any restrictions placed on U.S. industries should be equally applied to imported products, but foreign producers and their governments often view such restrictions as simple protectionism and haughty unilateralism. The conservation rules governing American fisheries offer several examples. These laws require, for example, the use of protective devices or procedures when harvesting shrimp (in order to protect sea turtles) and tuna (to save dolphins), and set minimum size limits on lobsters; Congress enacted legislation requiring that each of these rules be applied to foreign seafood. The GATT-legality of these laws remains a matter of controversy. A binational panel established under the U.S.-Canada Free Trade Agreement (FTA) found in a split decision that a 1989 law banning imports of undersized lobster did not violate Canada's rights under the FTA or the GATT, but a GATT panel ruled in 1991 that the United States violated Mexico's trade rights when it banned imports of tuna that are not dolphin-safe. While the legal issues surrounding these laws are still subject to interpretation, the political consequences are not. Trade-based challenges to U.S. laws arouse the anger and opposition of environmental groups, which have come to view liberal trade rules as a threat to hard-won laws and regulations. It is for this reason that environmentalists made common cause with unions in 1991, in order to oppose a new trade negotiating authority (a topic that we will examine shortly).

---

16Space does not permit an additional table assessing the vote on the Superfund compromise. Suffice it to say that probit analysis confirms that votes against the compromise were positively and significantly correlated with per capita employment in the oil industry.

17Because legislators consider the extraterritorial application of these rules to be noncontroversial, there were not contested votes on any of these amendments. Without recorded votes, we cannot conduct probit analyses.
Other putatively environmental proposals are more obviously protectionist in nature. These include several bills proposed in 1990 and 1991 that would impose trade sanctions on products that are produced without adequate environmental safeguards. These proposals take many forms; some are patterned after the countervailing duty statute or the section 301 retaliatory trade law, and amount to pollution-abatement equalization taxes, while others would deny preferential trade treatment to developing countries that fail to meet specified standards. None of these bills have advanced far in the legislative process, and hence we cannot judge the degree of support that they might receive. We can gain some insight into their potential popularity, however, by examining three comparable amendments that were proposed to the Clean Air Act of 1990. The votes on these proposals, as assessed in Table 13-3, provide the most persuasive evidence that Congress may indeed be willing to enact protectionist barriers in the guise of environmentalism.

Table 13-3: Probit Values for Senate Votes on Environmental Import Restrictions

<table>
<thead>
<tr>
<th>Influence</th>
<th>Expected Sign Coefficient (S.E.)</th>
<th>2-Tail Signif.</th>
<th>Mean</th>
<th>Min.</th>
<th>Low</th>
<th>High</th>
<th>Max.</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CANADIAN ELECTRICITY (TRADE):</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACTECAN (+)</td>
<td>0.0453 (0.0202)</td>
<td>0.0274</td>
<td>20.4635</td>
<td>25.3</td>
<td>35.2</td>
<td>62.1</td>
<td>77.9</td>
<td>**</td>
</tr>
<tr>
<td>ANTICAN (-)</td>
<td>-0.4779 (0.2110)</td>
<td>0.0239</td>
<td>1.1222</td>
<td>81.3</td>
<td>81.3</td>
<td>6.7</td>
<td>0.0</td>
<td>**</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>-0.3882 (0.4546)</td>
<td>0.3953</td>
<td>1.0000</td>
<td>48.5</td>
<td>48.5</td>
<td>48.5</td>
<td>48.5</td>
<td></td>
</tr>
<tr>
<td>Root mean squared error: 0.4343</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CANADIAN ELECTRICITY (TRADE AND ENVIRONMENT):**

<table>
<thead>
<tr>
<th>Influence</th>
<th>Expected Sign Coefficient (S.E.)</th>
<th>2-Tail Signif.</th>
<th>Mean</th>
<th>Min.</th>
<th>Low</th>
<th>High</th>
<th>Max.</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTECAN (+)</td>
<td>0.0403 (0.0226)</td>
<td>0.0784</td>
<td>20.4635</td>
<td>27.6</td>
<td>36.6</td>
<td>60.7</td>
<td>75.2</td>
<td>**</td>
</tr>
<tr>
<td>ACIDRAIN (-)</td>
<td>-0.0001 (0.4069)</td>
<td>0.9999</td>
<td>4.8192</td>
<td>48.6</td>
<td>48.6</td>
<td>48.6</td>
<td>48.6</td>
<td></td>
</tr>
<tr>
<td>ANTICAN (-)</td>
<td>-0.4779 (0.2110)</td>
<td>0.0239</td>
<td>1.1222</td>
<td>69.0</td>
<td>69.0</td>
<td>8.0</td>
<td>0.0</td>
<td>**</td>
</tr>
<tr>
<td>SMOKE (-)</td>
<td>-0.0322 (0.0175)</td>
<td>0.0688</td>
<td>11.7483</td>
<td>62.7</td>
<td>62.7</td>
<td>33.2</td>
<td>1.6</td>
<td>**</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>-0.0555 (2.2644)</td>
<td>0.9805</td>
<td>1.0000</td>
<td>48.6</td>
<td>48.6</td>
<td>48.6</td>
<td>48.6</td>
<td></td>
</tr>
<tr>
<td>Root mean squared error: 0.4253</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DIRTY IMPORTS (TRADE):**

<table>
<thead>
<tr>
<th>Influence</th>
<th>Expected Sign Coefficient (S.E.)</th>
<th>2-Tail Signif.</th>
<th>Mean</th>
<th>Min.</th>
<th>Low</th>
<th>High</th>
<th>Max.</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROTRADE (+)</td>
<td>0.0022 (0.0087)</td>
<td>0.7989</td>
<td>13.9916</td>
<td>68.9</td>
<td>69.0</td>
<td>70.8</td>
<td>73.5</td>
<td>*</td>
</tr>
<tr>
<td>CAWG (-)</td>
<td>-0.0171 (0.0192)</td>
<td>0.3740</td>
<td>5.7022</td>
<td>81.5</td>
<td>81.2</td>
<td>76.1</td>
<td>67.5</td>
<td>*</td>
</tr>
<tr>
<td>BAN</td>
<td>0.9127 (0.1977)</td>
<td>0.0000</td>
<td>0.5000</td>
<td>63.4</td>
<td>63.4</td>
<td>89.3</td>
<td>89.5</td>
<td></td>
</tr>
<tr>
<td>CONSTANT</td>
<td>0.1306 (0.2228)</td>
<td>0.5304</td>
<td>1.0000</td>
<td>69.9</td>
<td>69.9</td>
<td>69.9</td>
<td>69.9</td>
<td></td>
</tr>
<tr>
<td>Root mean squared error: 0.4320</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DIRTY IMPORTS (TRADE AND ENVIRONMENT):**

<table>
<thead>
<tr>
<th>Influence</th>
<th>Expected Sign Coefficient (S.E.)</th>
<th>2-Tail Signif.</th>
<th>Mean</th>
<th>Min.</th>
<th>Low</th>
<th>High</th>
<th>Max.</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROTRADE (+)</td>
<td>0.0042 (0.0092)</td>
<td>0.6441</td>
<td>13.9992</td>
<td>84.7</td>
<td>84.6</td>
<td>82.2</td>
<td>77.8</td>
<td>o</td>
</tr>
<tr>
<td>CAWG (-)</td>
<td>-0.0086 (0.0214)</td>
<td>0.6861</td>
<td>5.7022</td>
<td>72.2</td>
<td>72.1</td>
<td>69.0</td>
<td>64.3</td>
<td>*</td>
</tr>
<tr>
<td>ACIDRAIN (-)</td>
<td>-0.1822 (0.2850)</td>
<td>0.5236</td>
<td>4.8190</td>
<td>73.5</td>
<td>73.0</td>
<td>68.0</td>
<td>66.6</td>
<td>*</td>
</tr>
<tr>
<td>SMOKE (-)</td>
<td>-0.0250 (0.0088)</td>
<td>0.0093</td>
<td>11.7483</td>
<td>78.7</td>
<td>78.7</td>
<td>60.1</td>
<td>16.6</td>
<td>**</td>
</tr>
<tr>
<td>BAN</td>
<td>0.9534 (0.2024)</td>
<td>0.0000</td>
<td>0.5000</td>
<td>52.5</td>
<td>52.5</td>
<td>84.5</td>
<td>84.5</td>
<td></td>
</tr>
<tr>
<td>CONSTANT</td>
<td>-0.4333 (1.3998)</td>
<td>0.7561</td>
<td>1.0000</td>
<td>70.5</td>
<td>70.5</td>
<td>70.5</td>
<td>70.5</td>
<td></td>
</tr>
<tr>
<td>Root mean squared error: 0.4299</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Key**

**:** Sign correct and significant  
*: Sign correct but insignificant  
o: Sign incorrect but insignificant  
oo: Sign incorrect and significant

**Dependent variables:** Canadian Electricity is the vote to kill an amendment that would have restricted imports of Canadian power; the restrictive (and ostensibly environmental position) position is "no." Dirty Imports is a pool of two motions to table proposed amendments to the Clean Air Act of 1990, that would have restricted or banned imports of products that did not meet the standards set by the act for U.S. products; the restrictive (and ostensibly environmental position) position is "no."

**Independent variables:** ACTECAN consists of American Coalition for Trade Expansion with Canada industries. ANTICAN consists of the coal industry and coal-fired midwestern power plants. ACIDRAIN is the average pH level for precipitation (expressed as a negative number). SMOKE is the per capita release of toxics into the air. CAWG consists of Clean Air Working Group industries. PROTRADE consists of Protrade Group industries. BAN is a dummy for the vote to ban dirty imports.
The first such proposal would have banned imports of electricity from any Canadian power plant that did not meet U.S. environmental standards. The amendment had a retributive quality, as its proponents -- representing coal-producing states and the industrial midwest -- blamed Canada for much of the opposition to acid rain. Segments of the U.S. coal industry had long accused Canadian electrical producers of exaggerating the environmental threat in order to capture a larger share of the U.S. electrical market. Environmental groups did not participate in the debate on this amendment, but several senators that favored close U.S.-Canadian trade relations spoke in opposition. The motion to table (i.e., kill) the amendment passed by a relatively close margin (57-40). The probit estimations in Table 13-3 assess the outcome, using both the pluralist and the pluralist-environmental models. The first approach shows that the voting followed the classic pattern for trade proposals: the advocates of trade restrictions attracted intense support, but could not defeat the larger antiprotectionist interests (represented here by the pro-FTA coalition from Table 13-1). The second equation implies, however, that the environmental linkage worked to the benefit of the protectionists. Senators from high-polluting states (measured by SMOKE) supported the proposal, and this environmental variable was just as influential as the industry measure (ANTICAN). One might expect the states that suffer from acid rain to oppose this proposal, insofar as it could lead to even greater production of pollutants in the midwest (and hence more damage to their own region), but ACIDRAIN was absolutely uninfluential and insignificant. The environmental side of the equation was thus entirely one-sided, and favored import restrictions. These data suggest not the political influence of environmentalists per se, but rather the ability of pollution-dependent communities to use the environmental issue to their perceived advantage.

The Senate considered another pair of amendments to the Clean Air Act, that would have penalized imports of unspecified products that did not meet the standards set in the bill. An amendment to ban such imports altogether was killed on a lopsided tabling motion (81-16), but the vote against a tax on violating imports was much closer (52-47). The first test of these votes follows a pluralist model of trade policy. Neither of the amendments explicitly listed the products that might be subject to bans or taxes, and antiprotectionist groups did not have enough advance warning to offer detailed opposition to the proposals (although several senators denounced the amendments as GATT-illegal). For want of more specific data, the supporters and opponents are represented here as CAWG (per Table 13-2) and PROTRADE (per Table 13-1), respectively. The results show only weak support for the pluralist model; the coefficients point in the right directions, but the variables are neither significant nor influential. By contrast, the next test recognizes the support that environmental organizations extended to the second amendment, by including the same two environmental factors from our earlier Clean Air Act case. We would expect import restrictions to be favored in communities that depend on their own dirty industries (SMOKE), as well as in communities that are sensitized to the consequences of pollution (ACIDRAIN). SMOKE is in fact the only significant variable; senators were more likely to favor import restrictions if communities in their own states were dependent upon dirty industries. The data thus offer partial confirmation of the hypothesis that environmental claims make protectionist proposals more attractive to legislators.

The third category of linkage could prove to be the most contentious in the future. Environmental organizations may seek to block further trade liberalization if it is viewed as a threat to their objectives. Some groups are concerned not only that increased production and commerce will contribute to environmental degradation, especially in the developing countries, but also that liberal trade rules will be used to blunt or evade legitimate environmental regulations. The dispute over dolphin-safe tuna, coupled with other environmental and food safety issues in U.S.-Canadian trade, galvanized environmental and consumer organizations. Their concerns were aired during the debate in early 1991 over the extension of authority to complete the Uruguay Round and negotiate a North American Free Trade Agreement (NAFTA) with Canada and Mexico. At issue was the so-called "fast track," which establishes special procedures for expedited
ratification of trade agreements. Environmental groups viewed the fast track as a dangerous and antidemocratic procedure, by which Congress might approve Trojan horse agreements without full consideration of their consequences. They therefore joined forces with labor unions and other fast-track opponents, to urge congressional rejection of the President's request. This campaign was ultimately unsuccessful, as the resolution to deny fast-track extension was defeated by a vote of 36-59 in the Senate (and by a narrower margin of 192-231 in the House of Representatives), but the Bush and Salinas administrations were obliged to make concessions. By pledging in an "action plan" to address bilateral environmental issues, the White House won at least grudging support from some environmental groups, and temporarily defused a source of opposition to the NAFTA.

The Senate vote on fast-track extension merits close examination to determine whether environmental considerations had an appreciable effect on the outcome. The data in Table 13-4 report the results of three pluralist and pluralist-environmental tests. Equation No.1 treats the issue purely from the perspective of trade policy, based on the positions of economic interest groups. The pro-extension coalition was large and diverse, including some industries that have traditionally been wary of import competition (e.g., steel). The strongest sectoral opposition came from dairy, sweetener and textile producers; some of the other groups that ordinarily oppose trade liberalization seemed to view extension as a foregone conclusion, and did not participate actively. The one unusual aspect of this equation is the ambiguous position of grain farmers. Agricultural organizations were vocal but divided, with some groups anticipating expanded exports, and others fearing the loss of price supports; there is thus no explicit forecast for GRAINS. The results for Equation No.1 provide very strong support for the pluralist model. PROFAST and ANTIFAST are both correctly signed and highly significant (with ANTIFAST having a much greater range). The data also imply that rural legislators heeded the more pessimistic voices in the agricultural community. These results are certainly consistent with the pattern of other trade votes examined in Table 13-1.

The fast-track provision, as written into section 102(b) of the Trade Act of 1974, essentially consists of a preapproved closed rule that is binding upon both chambers of Congress. It permits no amendments to the implementing legislation, and further requires that the bill be voted upon within 90 legislative days of its introduction. These provisions were used to approve the Tokyo Round results (in 1979), and the FTAs with Israel (1985) and Canada (1988).

The AFL-CIO's newfound environmentalism was purely a matter of convenience. The organization had previously shown indifference or even hostility to domestic rules that might discourage economic activity, and hence reduce employment for its members (Wenner, 1990, pp. 8-9). The union's decision to stress this issue appears to have been encouraged by the results of its polling, which showed that favorable opinions towards a NAFTA could be reversed when environmental questions are raised (Garin-Hart, 1991).

Unionization per se does not appear to have been influential. I tried alternate equations, using AFL-CIO membership per capita as a proxy measure for fast-track opposition (both alone and in conjunction with other variables); the results were not significant. This stands in contrast to the results that I obtained in tests of votes on proposed amendments to the Trade Expansion Act of 1962. The AFL-CIO supported trade liberalization at that time (in part because losses attributable to import competition would be compensated by a new trade adjustment assistance program), and its membership per capita was the only good estimator of opposition to protectionist amendments.

Table 13-4: Probit Values for Senate Vote on Extension of Fast-Track Negotiating Authority

<table>
<thead>
<tr>
<th>Equation No.</th>
<th>TRADE</th>
<th>TRADE AND ENVIRONMENT</th>
<th>TRADE AND DIRTY INDUSTRIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probit Values</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Influence</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected Sign</td>
<td>Coefficient (S.E.)</td>
<td>2-Tail Signif. Mean</td>
<td>Min.</td>
</tr>
<tr>
<td>EQUATION No. 1 (TRADE):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROFAST</td>
<td>0.0568 (0.0177)</td>
<td>0.0016</td>
<td>28.0847</td>
</tr>
<tr>
<td>GRAINS</td>
<td>0.0354 (0.0105)</td>
<td>0.0009</td>
<td>6.5521</td>
</tr>
<tr>
<td>ANTIFAST</td>
<td>0.0960 (0.0108)</td>
<td>0.0000</td>
<td>8.5746</td>
</tr>
<tr>
<td>SPONSOR</td>
<td>0.9158 (0.2306)</td>
<td>0.0001</td>
<td>0.5000</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>0.2595 (0.4424)</td>
<td>0.5581</td>
<td>1.0000</td>
</tr>
<tr>
<td>Root mean squared error: 0.3746</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EQUATION No. 2 (TRADE AND ENVIRONMENT):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROFAST</td>
<td>0.0815 (0.0210)</td>
<td>0.0012</td>
<td>28.0847</td>
</tr>
<tr>
<td>GRAINS</td>
<td>0.0489 (0.0135)</td>
<td>0.0004</td>
<td>6.5521</td>
</tr>
<tr>
<td>ANTIFAST</td>
<td>0.0944 (0.0203)</td>
<td>0.0000</td>
<td>8.5746</td>
</tr>
<tr>
<td>ACIDRAIN</td>
<td>1.0445 (0.3794)</td>
<td>0.0065</td>
<td>-4.8190</td>
</tr>
<tr>
<td>SITES</td>
<td>-0.1085 (0.0371)</td>
<td>0.0039</td>
<td>6.3099</td>
</tr>
<tr>
<td>WATER</td>
<td>-0.1079 (0.0722)</td>
<td>0.1364</td>
<td>3.3049</td>
</tr>
<tr>
<td>SPONSOR</td>
<td>-0.0001 (0.2453)</td>
<td>0.0001</td>
<td>0.5000</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>6.7589 (2.1255)</td>
<td>0.0017</td>
<td>1.0000</td>
</tr>
<tr>
<td>Root mean squared error: 0.3532</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EQUATION No. 3 (TRADE AND DIRTY INDUSTRIES):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROFAST</td>
<td>0.0781 (0.0205)</td>
<td>0.0002</td>
<td>28.0847</td>
</tr>
<tr>
<td>GRAINS</td>
<td>0.0464 (0.0119)</td>
<td>0.0001</td>
<td>6.5521</td>
</tr>
<tr>
<td>ANTIFAST</td>
<td>0.1031 (0.0203)</td>
<td>0.0000</td>
<td>8.5746</td>
</tr>
<tr>
<td>DIRTY</td>
<td>0.3468 (0.1401)</td>
<td>0.0142</td>
<td>1.0470</td>
</tr>
<tr>
<td>SPONSOR</td>
<td>0.9450 (0.2360)</td>
<td>0.0001</td>
<td>0.5000</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>0.3554 (0.5257)</td>
<td>0.4331</td>
<td>1.0000</td>
</tr>
<tr>
<td>Root mean squared error: 0.3690</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Key**

**: Sign correct and significant
*: Sign correct but insignificant
oo: Sign incorrect but insignificant
oo: Sign incorrect and significant

Dependent variable: pool of (a) decision to sponsor a resolution denying President Bush's 1991 request for a two-year extension of his fast-track authority, and (b) actual Senate vote on the resolution. The restrictive (and ostensibly environmental) position is "yes."

Independent variables: PROFAST consists of pro-extension industries. ANTIFAST consists of industries that opposed extension. GRAINS consists of the major export grains. ACIDRAIN is the pH value of rainfall (expressed as a negative number). SITES is per capita Superfund sites. WATER is per capita listings of polluted waterways. DIRTY consists of high-polluting industries that face competition from Mexico. SPONSOR is a dummy for the decision to sponsor the resolution.
Can a pluralist-environmental model improve upon the explanatory power of the pluralist model? The second and third equations in Table 13-4 attempt to do so by including two different types of environmental measures. Equation No.2 tests the hypothesis that senatorial votes on fast-track extension are a joint product of (a) the expressed interests of economic groups in their constituency, and (b) the level of environmental degradation suffered by their home states’ air, land and water (a proxy measure for the influence of environmentalists). The results of this test are ambiguous: one of the variables implies that fast-track opposition was indeed higher in states that suffer from pollution (ACIDRAIN), but another variable points in the opposite direction (SITES), while a third is insignificant (WATER). Even the two significant variables can be discounted, as neither one is nearly as influential as the economic variables.

Equation No.3 takes an altogether different approach by asking whether votes to deny fast-track extension were positively correlated with employment in dirty industries. The hypothesis here is based on the observations made above regarding the Clean Air Act votes: environmentalists per se were not influential, but senators feared that dirty constituent industries might lose market share if they faced competition from producers who are less strictly regulated (and hence have a price advantage). These consist of industries that (a) paid pollution abatement operating costs in excess of 0.5 percent of their output (Low, 1991), (b) faced at least $10 million worth of imports from Mexico in 1990, and (c) are not already represented in either PROFAST or ANTIFAST. This last proviso is important, as several of the otherwise dirty industries were part of the pro-extension coalition; the remaining high-polluting industries included metal smelters, and producers of glass, cement, cutlery and hand tools. The data in Table 13-4 indicate that DIRTY industries were indeed associated with opposition to fast-track extension. Moreover, the addition of this variable improves the significance of other industrial variables, and reduces the root mean squared error for the equation. These data are, however, subject to interpretation. All of the industries that comprise DIRTY have a history of opposing trade liberalization. The only reason that they are not included in ANTIFAST is that they were not active in this specific debate. It is therefore a matter of judgment whether these data confirm the importance of environmental-industrial concerns, or simply indicate that these protectionist industries influence votes even when they are not vocal.

In either event, the environmental angle may provide additional arguments for these industries if they participate in future debates over trade liberalization.

Conclusions

The evidence is strong, though admittedly not consistent, that environmental concerns can act to limit congressional support for liberal trade. Linking trade with environmental issues can make import protection more attractive to legislators than it might be if treated as a "pure" trade issue. The linkage might also make trade liberalization less attractive than it might otherwise be; the data supporting this statement is limited and inconclusive, but strong enough to merit our attention. In each case, the inclusion of environmental considerations expands the range of arguments, and the array of interests, with which protrade forces must contend.

The preceding analysis helps to define the realm of possibilities but cannot predict outcomes. Confirmation of the hypotheses does not tell us whether environmental protectionism will find its way to the floor, in the form of specific proposals, nor does it tell us whether these initiatives will be enacted into law. The political connection between trade and the environment is still evolving, and future congressional action on this issue will be strongly influenced by developments away from Capitol Hill. The challenge to trade negotiators and environmentalists is to overcome the apparent tensions between open trading regimes and strict environmental regimes. If trade negotiators can demonstrate their willingness and ability to accommodate legitimate environmental concerns, then the chances for legislative activism will be diminished. Alternatively,
developments such as the 1991 GATT panel report on tuna import restrictions suggest a growing conflict between economic and ecological objectives. If this conflict cannot be contained, then the momentum towards new legislative initiatives will build. The environmental connection is thus no different from other topics in trade policy: the international community can resolve its differences by consensus, but Congress may step in if negotiations fail.
Discussant's Comments

David Vogel

The continued prohibition of the sale of alcohol in various counties in the southern United States has been supported by a coalition of Baptists -- who favor prohibition on religious grounds -- and bootleggers -- whose income rests on illegal sales. VanGrasstek has uncovered a similar "Baptist-and-bootlegger" coalition on various issues which involve both trade policy and environmental protection. He has found that senators were more likely to support trade restrictions that sought to protect the environment, and environmental regulations that protect domestic producers, when there are substantial numbers of both "Baptist," environmentalist, and "bootleggers," unions and companies faced with foreign competition, in their states.

VanGrasstek's conclusions will come as no surprise to students of American environmental policy. Political scientists have long recognized that virtually every environmental regulation invariably makes some firms and industries better off and some worse off. Accordingly, alliances between environmentalists and segments of industry that have stood to gain from particular regulations have been a common feature of regulatory politics in the United States.

For example, in 1970, Englehard Minerals and Chemical Corporation, which produced a critical component for the catalytic convertor, favored the enactment of automotive emission standards that could only be met by this particular kind of abatement technology. To cite another example, in 1977, environmentalists and the producers of high sulphur coal successfully fought for a provision in the 1977 Clean Air Act Amendments that required utilities to use scrubbers, thus discouraging eastern utilities from switching to low-sulphur coal. More generally, the various trade associations representing the manufacturers of pollution control equipment have invariably supported, albeit quietly, stricter and in some cases technology-forging pollution control requirements in order to increase the market for their products.

Until recently these alliances focused exclusively on domestic environmental policy. What is new -- and here VanGrasstek's paper makes an important contribution -- is the emergence of Baptist-and-bootlegger coalitions in the area of trade policy. While public interest groups have long been critical of American exports of various "bads," such as hazardous wastes and drugs and pesticides products not approved for use in the United States, they have historically been relatively uninterested in American trade policy.

As recently as three years ago, most environmental and consumer groups had probably never heard of the GATT, yet alone "fast-track" approval. Now it is impossible to attend a meeting of environmentalists or read an environmental publication without being exposed to an extensive discussion of the environmental implications of world trade in general and American trade policies in particular.

The bitterly fought Congressional battle over the Bush Administration's request for an extension of fast-track approval for a free trade agreement between the United States and Mexico in 1991 was the first time in more than 200 years of American trade policy that environmentalists were active participants. The struggle marked an historical watershed: any future trade agreements entered into by the United States are likely to be intensively scrutinized for their environmental impact.

Why have environmentalists suddenly become so interested in American trade policy? Part of the explanation has to do with the specifics of U.S.-Mexican relations: the recent environmental deterioration of many communities along the U.S.-Mexican border raised concerns among American environmentalists about the impact that increased investment in Mexico would have on the environment of the American southwest. More fundamentally, a distinctive feature of the upsurge of interest in environmental issues that occurred
during the late 1980s was its global focus. A concern with global warming and strategies to ameliorate it rather easily translates to an interest in the global economy and the rules that govern international trade.

To the extent that American environmentalists have taken a position on trade policies, they are invariably found on the side of those who favor protectionism. Why? There are a number of explanations. They include environmentalists' general mistrust of markets and economic activity -- international as well as domestic, their belief that increased economic development in the poorer regions of the world will result in a deterioration in the quality of the environment of both the third world and the world as a whole, and their fear that international trade agreements will undermine the American government's authority over the setting of domestic environmental regulations -- thus in turn reducing their own influence over American environmental regulations.

The phenomena that VanGrasstek has documented in the U.S. Senate are not confined to the United States. Coalitions between environmentalists and prop protectionist producers have also emerged in a number of other capitalist democracies. For example, in both Germany and Japan environmentalists have joined with farmers to oppose agricultural trade liberalization on the grounds that farming plays a vital role in preserving the rural landscape. Within the European Community, Danish environmentalists have supported national legislation restricting the sale of soft drinks and beer in nonrefillable bottles. One result of this legislation -- which the European Court has upheld on the grounds that nontariff barriers that serve a legitimate environmental objective do not violate the Rome Treaty's provisions on free intra-EC trade -- has been to restrict the imports of beverages into Denmark from other EC member states.

The number of producer-environmentalist alliances can be expected to increase. For their part, producers opposed to trade liberalization are increasingly finding themselves on the defensive, intellectually as well as politically. They need to find both new arguments and new allies. Defending trade restrictions on the grounds that they are necessary to protect environmental quality fills both needs. Environmentalists on the other hand, are engaged in a continual search for additional ways of imposing restrictions on business. "Eco-protectionism" offers environmental lobbyists an important advantage: the producers harmed by environmental trade restrictions are foreign companies who have limited opportunity to participate in American domestic politics.

Nonetheless, it is important not to exaggerate the long-term political impact of eco-protectionism. The number of issues on which domestic producers and environmentalists will find common ground is limited. Baptist-and-bootlegger coalitions are likely to be more successful at maintaining existing trade restrictions than imposing new ones. Moreover there are powerful countervailing forces at work.

National and international institutions responsible for managing the international economy are likely to increase their efforts to prevent the use of environmental regulations as nontariff barriers by establishing forums for adjudicating trade disputes that stem from divergent national environmental regulations -- such as the United States and Canada have done. More importantly, while the use of environmental regulations as nontariff barriers is increasing, so are the efforts of national governments to harmonize health, safety and environmental standards.

The contemporary resurgence of environmentalism may well make the maintenance and expansion of a liberal economic order more difficult; there is little likelihood, however, that it seriously threatens it.
The Political Economy of Trade and the Environment in Western Europe

Gernot Klepper

Introduction

The interplay between trade policy and the quality of the environment on a national as well as global scale is highly complex. Several approaches have been made to incorporate the environment—or the services which the environment supplies—into traditional models of international trade (see, for example, Baumol, 1971; Pethig, 1976; Siebert et al., 1980; Rauscher, 1991). If one considers the relatively complex structure of impacts on the international division of labor which result from such models, one can suspect that the incorporation of politico-economic considerations in such frameworks may become insurmountable.

This paper therefore tries to shed some light on the issues which appear in the discussion in Western Europe only—and particularly in Germany—but it will not present a consistent model of the political economy of trade and the environment as developed for pure trade policy issues (see, for example, Anderson and Baldwin, 1981; Brock and Magee, 1978; Mayer, 1984). The existing literature on the political economy of protection has predominantly focused on the institutional structure of the United States whereas the situation in Western Europe can hardly be explained in the same way. The political decision-making structure in Germany, for example, leads to quite different relations between governments and interest groups.

The links between trade and the environment have become more relevant the more environmental policy measures influence industrial activity. It is therefore no surprise that the impact of environmental policy upon the international division of labor has attracted the attention of economists. In the United States this issue has entered the political debate, e.g., in connection with the trade agreements with Mexico and Canada (Low, 1991; Low and Safadi, 1991). The purpose of this paper is to see how this trade-environment link is perceived in Western Europe and how it enters the activities of interest groups. It turns out that an important determinant of the political economy of trade and the environment is differences between the Commission of the EC and the national governments. In addition, the Single European Market to be established in 1992 will create a different situation for competition. Transaction costs of the movement of goods as well as factors and financial flows are significantly reduced through the Single Market, hence the spillovers of national environmental policies would be stronger inside the EC than between the EC and nonmember countries.

The paper is organized as follows. After a short discussion of the background of trade and environmental policy the institutional framework in which these policies are enacted is presented. Special emphasis is given to the changes laid out in the Single European Act which will determine policies and economic activities in the European economy after 1992. The next part seeks to identify the position of different interest groups with respect to the international implications of environmental policies. Industry associations, labor unions, agriculture and environmental groups are considered. Finally, the interplay of the different groups with the political decision makers for environmental and trade policies is discussed.
One word of caution should be spelled out at the outset. In Europe, there seem to be surprisingly few official statements about the issues in question which could be a result of the secrecy of interest group activities, of the still minor importance of the issues, or of as yet undecided positions inside the different interest groups. After having researched the issues, the author would favor the last explanation although the others may have an impact as well. For this reason, and because the internal market in the EC is not as yet working, the conclusions of this paper necessarily reflect these uncertainties and make them rather speculative.

Environmental Policy and Competitiveness

Although our lack of statistical information makes it almost impossible to prove it, one can confidently argue that most countries seem to pursue environmental policies which are less demanding than a special cost-benefit analysis would require. Hence, any analysis of environmental policy should take into account that it deals with inefficient policies. Also, most of these policies are not implemented strictly enough, although degrees of strictness vary. It is extremely difficult to determine empirically which country follows most closely an efficient environmental policy since this depends not only on the physical absorptive capacity of the environmental resources of that country, but also on the available technologies, and, more importantly, it depends on the different incomes and preferences of the citizens.

Environmental policy has at least two distinct effects on the international division of labor. It changes the comparative advantage of specific sectors and it can create barriers to market entry. The first impact is due to the fact that environmental policy raises the price or restricts the availability -- i.e., raises the shadow price -- of the environment. Industries using environmental resources relatively intensively will therefore be affected more strongly than others. Hence, the comparative advantage of "dirty" industries facing stricter environmental policies will deteriorate vis-a-vis the "clean" industries. As far as international competitiveness is concerned, one can therefore not expect the industries to exhibit common interests with respect to environmental policies. At least, this is what theory predicts. This should be taken into account when one tries to identify the interest groups in the arena of environmental policy.

The market segmentation effect of environmental policy is mostly attributable to the imposition of product standards in a country. If these standards differ from those in the rest of the world, goods cannot be moved freely anymore. Specific requirements for product quality may in the extreme prohibit trade. Although this may not be intended, environmental policy can thus create barriers to trade. Their effect is just the opposite of the above-mentioned effect of environmental policies such as pollution charges: they partly protect the domestic industry from competition from the rest of the world if meeting these standards increases costs beyond what exporters can bear.

Whereas in the first case dirty export industries lose export markets and dirty import industries lose domestic market shares, in the case of standards dirty import industries gain protection and gain domestic market shares. Dirty export industries which are subject to product standards might be forced to export cleaner products or to produce different varieties thus incurring higher costs than their foreign competitors. The political goal of such industries could therefore be to either object to the product standards or to demand a harmonization of product standards across countries. The discussion about environmental policy in the internal market in the EC centers around this issue.

Seen from a purely sector specific perspective, rather complex interactions of interests in different industries can occur. They will depend on the relative intensity of the use of environmental services in the industries as well as on the type of environmental policy chosen. Also one should consider the political side of these policies and in particular their political intentions, such as: (i) trade policies which are disguised as environmental policies; (ii) inefficient policies which can be exploited by firms as nontariff trade barriers; (iii)
environmental policies which necessarily need to be supported by trade policy; and (iv) the impact of environmental policies on comparative advantage and trade patterns.

It is therefore apparent that the folklore view of two or three antagonistic interest groups -- the environmentalists vs. industry and labor -- is surely inadequate for understanding the political economy of trade and the environment. And indeed, some unexpected coalitions between specific industries and environmental groups can be observed which are rational from the perspective of the particular groups in the political situation but seem strange when viewed separately.\footnote{An example is the opposition of environmental groups together with the coal industry to a tax on emissions of carbon dioxide in Germany. The environmentalists fear an overwhelming competitive advantage for nuclear power if such a tax is introduced. The coal industry fears it will lose its market even faster than is already the case.} Analyzing such a complex politico-economic structure becomes even more demanding when one considers that models with just two interest groups already produce a rather rich structure (e.g., Hahn, 1990). Future research on case studies of particular policy initiatives may shed some more light on these issues.

The Institutional Framework in Europe

Most of Western Europe is organized in the European Community. Membership in the EC takes away some of the national authority in economic policy matters and gives it to the Commission of the EC or requires coordination among governments. This institutional situation is changing at the moment. The provisions enacted in the Single European Act in preparation for the internal market in Europe which is to be implemented by the year 1992 have considerably changed the freedom to pursue policies from a purely national perspective. This also changes the political economy of economic policy in the member countries. In many circumstances the restrictions on national policies have been used by policymakers who want to deny demands of lobbies as arguments for their inability to grant protective measures. The automobile protection against Japanese imports or changes in the Common Agricultural Policy are just two examples where internal protectionist rhetoric is paired with liberalization which is blamed on supranational authorities.

The increased authority of the EC decision-making bodies also encompasses environmental policy matters but not to the same extent as in the case of competition policy or industrial policy. It is therefore necessary to describe the institutional framework in which environmental policies are enacted inside the EC.

Provisions of the Single European Act

For the completion of the single market five objectives have been adopted in the Single European Act: (i) the development of economic and social cohesion; (ii) improvements in health and safety of workers; (iii) the strengthening of science and technology; (iv) monetary and economic cooperation; and (v) protection of the environment.

This is the first time that an explicit legal basis is provided for environmental policy (Folmer and Howe, 1991). The previous three action programs from 1975, 1977-81, and 1982-86 had already prepared some of the principles which then entered the Single European Act.

The completion of the single market was to be achieved through the removal of three types of barriers which hamper the free movement of goods and factors among the member states of the EC. These barriers
are physical barriers, i.e., border controls; fiscal barriers; and technical barriers, i.e., product norms, technical regulations, legal requirements etc. Once these barriers are removed, uniform economic conditions are expected to prevail throughout the EC.

Environmental policies are based on principles accepted by all governments such as the Prevention Principle (Art. 130r(2)), the Polluter-Pays Principle (Art. 130r(2)), or the Subsidiarity Principle (Art. 130r(4)). For the Single European Market, the Subsidiarity Principle plays an important role. It states that a particular -- e.g., environmental -- problem should be handled by giving the primary responsibility and the decision-making authority to the lowest possible level of the political hierarchy. From an environmental policy point of view this principle delegates the problem to the nearest authority which can effectively internalize it. Hence in theory, the EC intervenes in environmental matters if the problem can only be solved adequately at the community level.

The Subsidiarity Principle is reflected in the Single European Act by two different paths through which environmental policy can be enacted. In the first path, Art. 36 allows environmental regulation made on a national or regional level for the protection of life and safety of people and the protection of fauna and flora. This also includes the imposition of limits on the free movement of goods (Salzwedel and Viertel, 1989).

Art. l00a and Art.130s, on the other hand, provide the rules for community action in environmental affairs. Community actions are binding for the member countries. Actions according to Art.100a in effect set maximum standards, since a member country cannot impose tighter regulations than those at the community level. Regulations according to Art.130s, on the other hand, give national governments the freedom to impose stricter limits than the community directive in their sphere of influence. Thus the Subsidiarity Principle can again be used if national preferences require stricter action than in the rest of the EC.

The Balance Between Trade Policy and Environmental Policy

Since community actions naturally do not provide any barriers to trade inside the EC, only national regulations according to Art.36 or Art.130s may possibly be in conflict with the free movement of goods and factors. The regulations must take into account the provisions of Art.30 which prohibits all measures that actually or potentially, directly or indirectly restrict the free movement of goods. The decision whether national regulations meet the requirements of Art.30 has in effect been transferred to the European Court which up to now has already decided a number of cases.

The basic philosophy of most decisions is that measures according to Art.36 or Art.130s are legal if they do not discriminate against foreign suppliers or if no better policy can be implemented which may be less discriminatory. In economic terminology, this means that in cases where first-best policies cannot be enacted discriminatory second-best policies are acceptable. Hence, trade barriers within the EC and towards third countries may in such circumstances be used. Italy, for example, restricts through a directive the content of phosphates in detergents. Since this presents a substantial environmental problem but does not discriminate between domestic and foreign suppliers and since alternative detergents exist, the regulation does not violate Art.30 (Krämer, 1990). Ireland, on the other hand, had planned a ban on beer in cans by arguing that aluminum cans impose environmental problems. This is without doubt; however, since other beverages in cans such as soft drinks create the same problem, one must suspect that other intentions may also be responsible for the regulation. Similarly, Germany was considering a deposit/refund system for beverages in plastic containers. It did, however, withdraw the directive after the EC threatened to go to court against this regulation. The Commission’s position was influenced by the fact that Italian and French mineral waters
predominantly were subject to this regulation. It therefore suspected trade policy instead of environmental policy objectives, especially since other environmentally harmful containers such as aluminum cans were not subject to regulation (Michaelis, 1991). In the "Danish Bottles" case, however, the European Court of Justice endorsed the decision of the Danish government to require for environmental reasons that imported beverages be sold in standard returnable containers (Schneider, 1989). The court did not see a discrimination of particular modes of packaging or particular producers beyond the desire to protect the environment. A similar German regulation in connection with waste management is being disputed among EC governments. In the "Dual System" for managing packaging waste minimum percentages for the use of refillable bottles for beverages are prescribed. Foreign supplies claim that these percentages act as trade barriers since the use of refillable containers is not profitable for suppliers with high transport costs, i.e. predominantly foreign suppliers. And indeed, there are signs that German producers have increased their own share of nonrefillable containers such that the quantity for importers is restricted. Although the regulations in the "Dual System" are less restrictive than the Danish regulation, it seems clear that the domestic German suppliers of beverages use these regulations in order to impose trade barriers. The rulings of the European Court recognize that there is an inherent conflict between the Subsidiarity Principle according to which local, or national problems should be solved at the local or national level including the setting of the standards, and the free movement of goods for which the country of origin principle is guiding the policy in the EC. Although there are some cases in which the court has identified trade protection as the primary objective in environmental regulations, market segmentation strategies are not always so important for national governments or interest groups. This is not surprising since the rulings of the European Court of Justice are binding and -- more importantly -- the court did place a high value on the free movement of goods such that regulations which did arouse the slightest suspicion of trade-related objectives could not pass. The cases which are still pending will most likely undergo the same careful test about their potential discrimination of foreign suppliers (Krämer, 1990). It is therefore unlikely that interest groups will benefit from investing in the implementation of protectionist policies. In addition, market segmentation is not always a good strategy, especially when the industry is strongly export oriented, as it will become apparent below.

**Locational Competition and Environmental Standards**

Another issue which arises from the application of the Subsidiarity Principle and the Country of Origin Principle is concerned with the competing away of environmental quality. The problem is as follows: if most environmental policies remain decentralized the country with the least strict regulation will be most successful in attracting investment in the internal market. This in turn is believed to induce governments to reduce already existing environmental standards or to impose less than necessary ones. That is, governments will be forced to balance environmental policy against industrial policy in a world without barriers to trade or to investment and decentralized environmental regulations.

Again, different environmental regulations produce opposite results. Regulations concerning production processes reduce the competitiveness of the domestic industry and the attractiveness of the country as a location for investment, whereas regulations concerning product standards which induce a potential for market segmentation improve the competitive position of domestic firms vis-a-vis their foreign competitors. All industries which use environmental services relatively intensively would therefore oppose the regulation of production processes. On product standards, however, industries producing goods for which the country is a net importer would welcome some market segmentation more than industries which also export significant proportions of their output. An example for product standards was the introduction of the German requirement to use catalytic converters in cars in order to get tax refunds. It was not opposed by the German industry but heavily challenged by French and Italian exporters who did sell their cars at home without catalytic converters. How these effects will influence the objectives and actions of interest groups as well as those of governments is disputed for national policies and practically unknown for the political economy of
interest groups. Siebert (1991) argues that decentralized environmental policies will push governments to set low standards only in the short run. In the medium and long run, he argues, locational and institutional competition will lead to an equalization of standards and regulations across countries since they want to prevent a deterioration of their environment through the relocation of "dirty" industries from countries with stricter environmental policies and since they want to impose high option values on their environment in order to keep it attractive for future locational decisions. Siebert's optimistic view of the political process was challenged by Folmer (1991) who argues that similar decentralized policies in the United States did not turn out successful. He also suspected that -- especially in low-income countries -- political processes do not reflect intertemporal preferences very well. This controversy can only be evaluated by looking at the position of the interest groups which are subject to the environmental policies and the impact of competitiveness.

Interest Groups

Four interest groups are discussed: industry, labor unions, agriculture and environmental groups. Although they are not homogeneous internally they usually act independently from each other and often they collectively present their demands to the public. Political decision makers on a different level of the political hierarchy and voters as the ultimate decision makers will be considered in the last part of the paper.

Industry

It has been stressed in the politico-economic literature that there are marked differences between countries in the way in which interest groups are organized. This is also true for industry groups. Great Britain exhibits much less corporatism than Germany; in France, the government-industry relationship seems more important than the industry-labor union relationship, in contrast to Germany. These factors influence the way in which the industry is organized across sectors and inside sectors. It is therefore too simplistic to assume that the hierarchy of firms, sectoral industry associations, and associations across sectors at the national and European level is the same throughout Western Europe. The organizational structures, however, determine the way in which demands enter the political process. If one were to do justice to these factors, case studies for different industries and issues should be performed which describe the incentives of the different actors and take account of the strategic issues at hand. We do not have such studies.

As mentioned at the outset, environmental policy affects the comparative advantage of industries, hence some industries gain and some lose. As far as sectoral industry interests are concerned it is then clear that industries which face the threat of losing their comparative advantage through environmental policy will oppose such policies. They can, however, become more effective if they can convince global industry associations to support their cause. The question therefore is how the interests of the different industries are aggregated. Presumably they depend on the power structure inside the association which in many cases is biased toward the old and often less environmentally friendly industries. In general, the new environmental industry -- the biggest gainer of environmental policy -- is not organized at all. National industry associations therefore have a tendency to be biased against national unilateral environmental policies.

On the other hand, if firms are organized along sectoral lines, but have only a weak umbrella association across sectors, it is more likely that sector-specific interest will be voiced rather than the interests of the umbrella association. In a system like the German, the BDI (Federal Association of the German Industry) seems to balance sector-specific interests with the overall interest of the industry and it seeks to prevent lobbying of industries against each other, since this would constitute a wasteful way of rent seeking from an industry perspective. This system has the tendency to be more long-run oriented and thus opposes environmental policies less than more decentralized systems. The advent of the Single European Market will lower the cost of moving factors and of trading goods such that differences in production costs due to
environmental policies will increase the pressure to relocate firms or to lose market shares otherwise. The reaction of the BDI has been to advocate a harmonization of environmental standards throughout the EC in order to eliminate these competitive disadvantages. It also favors giving more regulatory power to the EC in environmental matters in the hope that this will also harmonize environmental standards. A representative of the BDI underscores these demands with the argument that national environmental policies as far as they concern product standards would inevitably segment the market and thus create new trade barriers (Meller 1989, 1990).

Industry associations in Western European economies with relatively less strict environmental policies will probably tend to demand less harmonization. This, however, is not as clear as it may seem at first. Whereas in the past environmental policies often have induced investment in end-of-pipe technologies to reduce emissions, the tightening of emission limits increasingly goes hand in hand with changes in process technologies with lower emission factors. Industry representatives claim that company strategies for reducing emissions which rely on process changes instead of end-of-pipe measures will in the long run harmonize the emission factors in industries across countries at a similar technological level (Meller, 1989). The reason is that investment in new technology automatically will include more environmentally friendly production processes. The new investments relative to the old capital stock, however, will be the more profitable the stricter the environmental regulations are. Hence, even in economies without strict environmental policies expanding firms may have an incentive to push for tighter regulations in order to reduce the profitability of the firms with an old capital stock.

The position of national industry associations towards environmental policy in the emerging internal market will be influenced not only by the ambivalent impact of environmental policies which regulate production processes. National product standards which -- as described above -- can segment markets because firms have to supply different product qualities in different markets are also ambivalent. Especially in industries which experience scale economies nonharmonized standards can lead to a loss of competitiveness in foreign markets. This becomes more important the smaller are other trade costs. It is therefore likely that in Europe the incentive to oppose stricter environmental regulations because of the threat of losing comparative advantages is not as strong as it might at first seem. The more integrated the European economies are the more one can expect to see a demand for harmonized environmental regulations even if this led to stricter policies in some member countries.

Labor Unions

The position of labor unions with respect to environmental policy has undergone a considerable change since the 1960s. The primary objective of securing or increasing the number of jobs was believed to be endangered by environmental policies (Holzinger, 1987). In the meantime, the official position of the labor unions has changed because this conflict between jobs and environment is not seen anymore. To the contrary, the new program of the DGB, "Umweltschutz und Qualitatives Wachstum" (Protection of the Environment and Qualitative Growth) (DGB, 1990, p.15) explicitly argues that in the long run no industrialized country can shirk from implementing effective environmental policies. Since the costs of implementation increase the later a country introduces environmental policies, the DGB advocates that Germany imposes stricter policies than its competitors. In addition, the DGB stresses that irreversibilities can be prevented thus improving the attractiveness of Germany as a location for investment in the long run.

The DGB also denies that costs of environmental regulation are an important determinant of the locational choice of companies. A representative notes: "Today we know that environmental policy leads neither to repressed investment behavior, nor to a reduction in output or to dislocation of production; environmental protection endangers neither international competitiveness nor employment" (Schneider, 1988,
Consequently, the advantage of countries with strict environmental policies in end-of-pipe technologies and clean process technologies is seen as a competitive advantage which extends into the future.

In the United Kingdom a similar process seems to be at work where British Labor Unions also seek to cooperate on a global basis with industry to improve the environmental status of products and processes (Hackett, 1991).

This environmentally friendly position of the DGB as an umbrella organization of the sectoral labor unions naturally differs from the position of some of its members. The coal miners union, for example, strongly opposes carbon dioxide taxes or certificates since it would further reduce the competitiveness of German coal.

More important in terms of international competitiveness is the situation of the chemical industry, an industry showing high RCAs especially in Germany. It has already been subject to tight regulations with respect to emissions into air and water which so far do not seem to have hampered its competitiveness significantly. Still, chemical companies and unions complain about the tightening of regulations in general. The growing waste management problem in Western Europe and the initiatives to reduce especially packaging waste through the "Dual System" (Klepper and Michaelis, 1991) whereby the reprocessing of all packaging material is the responsibility of both packers and fillers and the packaging industry. This system puts pressure on the packaging industry to develop packaging material which is easy to recycle, but may be more costly to produce. This is especially important for the chemicals industry, since firms will probably be forced to harmonize product lines because the reprocessing of plastic waste containing different materials is difficult. These efforts would not be necessary for exports to non-EC countries but it is unlikely that chemical firms will segment their activities according to EC and non-EC markets, hence they will export easily recyclable products even if the export markets do not demand such product qualities. This can result in a loss of competitiveness and thus should unite labor unions and capital owners in opposing such regulations. This is a two-edged sword, however. The chemical industry is a strong net exporter. Hence tighter standards, especially if they are self-imposed by the industry help to segment markets, and thus there is a chance that foreign competition is reduced through such environmental policy initiatives. So far, the labor union of the chemical industry has not opposed the new waste policies; possibly it has not made up its mind whether this policy is a net benefit due to less competition, or a net loss because the losses in the competitiveness on world markets dominate the gain in market power.

These examples illustrate that even on a single industry basis the relation between environmental regulation and international competitiveness is not at all clear cut. Consequently, labor unions organized along industry lines may not have clearly defined objectives with respect to environmental policies. It is therefore natural that the umbrella organization will use the freedom of not having to balance the job interests of members in specific industries versus the environmental amenities for the rest of the members by favoring stricter environmental regulations. Such a position also fits nicely into the ideology of labor unions that capital owners must be forced not only to pay adequate wages but also to supply non-monetary benefits such as a cleaner living environment.

**Agriculture**

The situation in the agricultural sector strongly differs from that in other sectors and interest groups. Compared with the manufacturing and service industries, the political influence of agriculture relative to its economic importance is extremely high. The historical factors which have led to this situation differ from

---

2In France a similar system is planned and the EC is also considering such approaches.
country to country but the result is the same for all Western European countries: agriculture is one of the most protected sectors of the economy, often the most protected. The political influence of agriculture extends not only to trade policy matters but also to internal policies such as environmental policies. In most European countries, farmers' organizations have succeeded in softening up the polluter-pays principle to such an extent that farmers are compensated for changes in production practices which have a positive effect on the environment regardless of whether the original negative effects were caused by agriculture or not. So there is little danger that environmental policies will negatively affect agriculture. On the contrary, farmers are likely to benefit by receiving subsidies for complying with environmental standards.

The political situation for agriculture, therefore, is determined not so much by the threat of losing international competitiveness -- a large part of European agriculture is not competitive on world markets anyway -- but by the upcoming changes to agricultural policy in connection with the current GATT round which will most likely drastically reduce the current EC import barriers and the export restitution payments to European farmers. The resulting trade liberalization has an ambiguous impact on the position of agriculture on environmental matters. On the one hand, it is not at all clear whether and by how much trade liberalization will solve rural environmental problems through extensification, thus alleviating the need to impose further regulations. On the other hand, fewer environmental problems will mean reduced subsidies for avoiding negative externalities. The market-driven discontinuation of production on marginal land because of lower output prices at the same time reduces the need to subsidize set-aside schemes or to implement production quotas.

This negative effect on farmers' income through the interplay of improved environmental quality and liberalization of agricultural policies -- especially the CAP -- makes it difficult for farmers to determine their position with respect to trade and environmental policy matters. This is reflected in diverging views among different farmers' organizations. A group of large farmers and landowners in Germany argues that the protection of agriculture through the CAP will necessarily be phased out and hence marginal land will inevitably be taken out of production. The idle land, they argue, cannot be left alone, not least because the historically determined man-made landscape in Germany has to be preserved. Consequently, landowners should be compensated for producing environmental services. So the distributive function of the CAP could be taken over by an appropriate environmental policy thus making this group of farmers and landowners supporters of environmental subsidies. There is also a large group of farmers using conventional farming methods who oppose this view of farmers as producers of environmental services and who -- perhaps correctly -- fear that in the future the elimination of the CAP, paired with stricter environmental regulations such as taxes on nitrates and other agro-chemicals, will put a strain on agriculture which cannot be compensated sufficiently through environmental subsidies. The fall in prices for agricultural products is also feared by farmers using "eco-farming" techniques. They could not compete at world market prices and therefore demand "fair" prices which they seem to define as current production costs for ecologically sound commodities.

The advances in environmental policy in Western Europe have been made mostly in the industrial sector where point pollution into water and air has been reduced considerably. This success has focused attention on the remaining polluters which increasingly come from the agricultural sector. Groundwater pollution, eutrophication of waterways, lakes and the sea, as well as the contamination of soils with heavy metals and toxic organic compounds have started to change the public perception about agriculture such that

---

3For a review of effects, see Kuch and Reichelderfer (1991).

4The preservation of historical landscapes is also a major concern in the United Kingdom (Weizsäcker, 1988).
it is doubtful whether in the future the agricultural interest groups will be able to sustain the victim-pays principle for environmental policies in the agricultural sector.

These developments make it difficult to identify a single position for interest groups in the agriculture sector. It seems that agricultural interest groups are in a period of transition in which they need to redefine the role of agriculture in a liberalized world trading system and a more environmentally conscious public. If one were to speculate about the consensus which will emerge from these interest groups, it could be that the proposal for "fair prices" which was put forward to establish the CAP 20 years ago will become rejuvenated as "ecologically fair prices" and will be used as a new argument for protection.

Environmental Groups

Environmental interest groups have varying importance and influence in Europe. In the south of Europe and in France, they have little impact on the political process. The other extreme is in Germany where the Green party is represented in practically all parliaments, from the communal to the federal level. In addition, a large number of nonparliamentary groups fight for stricter environmental policies. These range from an international organization like Greenpeace to neighborhood associations which are concerned with their local problems.

The political position of the different groups varies considerably; they therefore rarely have unanimous demands. On the question of the interplay between environmental policy and the international division of labor this is most pronounced. A clear and general statement cannot be found. This is due not only to the diversity of the political positions of the groups but also to the fact that this issue has entered the discussion only recently. Previously, domestic environmental problems and foreign environmental problems were seen as distinct. With the emergence of the climate problem it became clear that environmental effects cannot be separated. The analysis of these issues also led to the conclusion that, in addition to transfrontier pollution effects, indirect effects through international trade in either direction can occur. The catchword "eco-dumping" has become fashionable.

Discussion about the underlying interdependencies of environmental degradation and the international division of labor is only beginning. Although it is a significant simplification, one can characterize two groups in the environmental movement which follow different strategies on most policy issues (Huber, 1988). There are, on the one hand, those who subscribe to the belief that -- mainstream -- economics and ecology are not antagonistic, i.e., ecological considerations can be incorporated into a market-oriented system. In Germany, this group is called the "Realos" because of their realistic approach of improving the environment within the institutional structure of the society.

The other group has a more fundamental critique -- that is why they usually have the name "Fundis"-- based on the belief that "the system," "industry," or capitalism is by its very nature responsible for the deterioration of the environment. This position also includes the belief that the international division of labor is detrimental to the countries involved (Busch, 1986). Consequently, a reduction in trade, i.e., exports as well as imports, even without transfrontier pollution or eco-dumping, would increase welfare in the industrial countries and the Third World.

Whereas this position rarely appears in the day-to-day discussion of economic policy, it provides the ideological background for some protectionist demands such as the protection of the domestic agricultural sector against low-priced foreign products. Most other protectionist demands are intended not to protect domestic activities and environmental resources but foreign ones like tropical rain forests.
The Political Market

The effectiveness with which a particular interest group can influence the political decision maker depends not only on its own input relative to those of other groups. It is also determined to a large extent by the general political climate. The literature on the political economy of protection subsumes the general political climate under the supply side parameters for protection. These parameters determine the costs which politicians incur when they implement unpopular policies.

The political climate with respect to environmental concerns is rapidly moving towards a strongly environmentalist stance. This process has started in Germany, the Netherlands and Denmark and is becoming increasingly important in the other member countries of the EC. An example is the last election campaign in the Netherlands where environmental issues predominated. Voter preference for comparatively strict environmental policies naturally restricts the ability of political decision makers to be soft on environmental issues.

Another factor determining supply side behavior in this political market is the strongly mercantilistic view about trade policy matters in the public and to some extent among the political decision makers. Under such a view the demand for protectionist measures increases as the trade balance deteriorates and simultaneously the supply parameters become more favorable towards protection since the general public considers these demands to be more justified. This explains protectionist tendencies in the political process in the United States during its period of negative trade balances.

In the EC the trade balance of the manufacturing sector with respect to extra-EC trade has been positive throughout the 1980s such that only the slight slump in surpluses around 1983 could have created such mercantilist sentiments. It is therefore unlikely that a general protectionist consensus could have developed in the EC. Consequently, demands for protection because of the threat of a loss in competitiveness due to strict environmental regulations are not credible as long as these high trade surpluses prevail. This is exactly the position of the German Federation of Trade Unions (DGB) who argue that as long as German industry in general -- and the chemicals industry in particular -- experiences trade surpluses of such magnitudes as in the 1980s, there is no reason to suspect that environmental policy has been harmful for the international competitiveness of Germany. If one subscribes to the notion that the public debate is dominated by mercantilist ideas, the supply conditions in the political market for granting protection for environmental reasons or for reducing the strength of environmental policy are weak -- if not in absolute terms, then surely relative to the United States.

The outcome of the politico-economic interaction between different interest groups in each country, between them and national authorities and the authorities of the EC is difficult to disentangle and illustrate in a simple framework. The discussion of the demand side of the political market for environmental and trade policies has already shown that even within the interest groups no clear-cut objectives can be identified. At most, it is possible to characterize areas in which several groups have a similar interest, such that some consensus in terms of the demand for policies and a positive supply response can be expected.

Even if the observation that decision-making processes in the EC countries have become increasingly complex may preclude causal models and predictions, the influence of a "European black box" decision structure can be characterized. Presumably, it is becoming increasingly difficult for interest groups to predict the necessary inputs and the outcome of their lobbying activities. Rising uncertainty about the returns to investment in lobbying activities will probably reduce the optimal input into lobbying, since the expected returns are lower. Hence, one would predict \textit{ceteris paribus} that, in member countries of the EC and directly
at the European Commission, less lobbying would take place than in economies with only one national decision-making level.

In the case of agricultural policies trade liberalization in connection with the Uruguay Round is inevitable. Large parts of agriculture together with the environmental movement still favor "fair," i.e., high, product prices. Since this is practically impossible under future GATT rules, the same coalition will probably demand subsidies for all kinds of environmentally friendly activities. National as well as EC decision makers could support such demands since they present a convenient way of securing the survival of farms which under world market prices would become unprofitable. The role of the CAP in providing income transfers to the agricultural sector could thus be maintained through an extensive subsidization of environmental services or environmentally friendly production techniques.

The chances for such a system to emerge are good. Environmental groups would like environmental policy as strict as possible throughout Europe; farmers' interests in securing sufficient income redistribution are met in such a system; and finally, the increasing demand for so-called "bio-products" by consumers might help them to accept above world market prices. If, in addition, this system could be implemented without violating GATT rules even industry could change its position on agricultural issues. Because of the threat of agriculture destroying the world trading system, German industry associations have openly criticized the protection of the agricultural sector, contrary to their practice of not taking a position against the protection of one particular sector of the economy. The BDI could return to its neutral position in agricultural policy.

As far as industrial products are concerned one should distinguish between intra-EC and extra-EC issues. The interaction of environmental regulations and international competitiveness vis-a-vis non-EC countries is hardly addressed by industry or labor unions, at least in Germany. An exception are climate policies which are discussed below. Public statements and lobbying activities seem to concentrate on intra-EC policy issues which could be explained by the fact that foreign trade in manufacturing is dominated by intra-EC trade. European environmental policy is therefore most important.

For the internal market there is widespread consensus among labor unions, industry associations and environmental groups in Germany that environmental policy should be centralized and harmonized as much as possible. It goes without saying that this concurrence in demands does not come from a concurrence in objectives. Therefore, one cannot speak of a coalition of interests in the classical sense where common goals are expressed in a coordinated fashion. Seen from the perspective of decision makers, there are rather independent but identical demands for specific types of policies. Whether such coalitions also exist in the other member states is difficult to tell. In any case, the demand for harmonization nicely fits the interests of European bureaucracies to extend their influence to new policy fields. The inherent conflict between the free movement of goods and the Subsidiarity Principle in the EC would be avoided by working for the removal of potential market segmentation through harmonized regulations.

The diminishing role of the Subsidiarity Principle has significant consequences. Optimal environmental policies depend among other things on the absorptive capacity of the environment which determines the shadow prices of environmental services. Therefore, policies should be defined across a relevant problem shed, such as a river basin for water quality policies. The more independent environmental media are subject to the same policy, the greater is the probability that the policy is inefficient because it does not take into consideration different absorptive capacities of different media, and thus does not adequately differentiate the user prices for these media. Similar arguments apply to the evaluation of environmental damage in different countries.
The general tendency towards a convergence of incomes and preferences in the EC would tend to lower the threat of losing competitiveness due to environmental policies, hence one would expect less concern about the relocation of firms and capital flight from countries with relatively strict environmental policies. Yet, there seems to be a widespread consensus among industry associations and labor unions that the internal market of the EC in 1992 will reduce transaction costs of factor mobility to such an extent that capital and labor mobility will increase faster than the economies converge in terms of income and preferences. Hence, the need to protect domestic industries increases.

The option to use market segmentation and other trade barriers works only for extra-EC competition and only for industries with a strong home market bias. As far as the manufacturing industry is concerned, stricter environmental policies tend to be imposed on export industries or on industries which face intra-EC competition. It is therefore natural not to ask for protection against cheaper imports, but to demand an increase in production costs of foreign competitors by imposing stricter environmental regulations. This can be done comparatively easily in the EC framework, firstly, because the EC has the authority to do so and secondly, because national governments can more easily endorse such policies since consumer interests are better served through harmonized environmental policies than through trade protection which also raises prices but does not improve the environment.

The only publicly debated environmental problem which goes beyond EC boundaries is the global climatic change and the policies necessary to prevent catastrophic developments in the coming decades and centuries. There is consensus that this problem has a different dimension from previous changes in the environment and that it can be solved only through a major change in the way in which resources are allocated worldwide away from fossil fuels and through changes in production technologies towards low energy technology. This problem is so large that a unilateral approach by one country would not only not solve the problem but it would also severely change its international competitiveness. It is therefore clear that only an internationally coordinated approach would be approved by industry and labor unions. The proclaimed unilateral steps of the German government and the Commission of the EC seem to be cosmetic, if one considers the planned energy tax rates, and tactical in order to gain a better bargaining position in negotiations about an international climate policy.
Discussant’s Comments

Jim Rollo

Gernot Klepper faced a difficult task in dealing with a subject as broad as this in a context as disparate as that of Western Europe. It is also clear that the debate in Europe—to the extent that there is one—is not as sharp or as coherent as it is in the United States. Western Europe has neither the dolphin/tuna issue nor the Mexican Free Trade agreement to crystallize opinions. Finally, the wide range of jurisdictions in Western Europe and the real obscurity within which EC policy in particular is made also make it difficult to apply rigorous techniques to distinguish the clash of environmental and trade policy objectives from protectionist pressures disguised as environmental concerns.

Within that framework of constraints, the paper gives an overview of the legislative framework and the main action and discusses a number of specific cases. It also restricts itself to the EC despite the importance of environmental concerns in the Nordic countries and in Austria. Inevitably therefore the paper suggests more questions than answers.

There are a number of issues that would benefit from a more precise and detailed analysis than was possible in these circumstances. At a legislative level an analysis of the activities and where relevant the voting behavior of the Green party in the German parliament, for example, might throw some light on whether there is evidence of “uncholy alliances” between producer groups and greens.

Equally, I would appreciate a detailed discussion of the processes behind the EC Commission decision to go for an energy tax/carbon tax mix rather than a pure carbon tax as the chosen instrument to meet greenhouse gas targets. How far does the outcome potentially favor traded goods over nontraded goods? How far was it possible to discern producer groups at work and how far did the green lobby drive the compromise? A more explicit discussion of the decision-making process in this case and its vulnerability or otherwise to capture by interest groups would also be helpful.

A detailed case study of how environmental objectives have come to the fore in discussion of future EC agriculture policy might also be instructive. Through the 1980s traditional justifications for the Common Agricultural Policy carried less and less weight. This owed something to the way in which burgeoning budget costs limited freedom of policy action as new priorities for the EC emerged. Partly, it owed something to the analysis of the real costs of agricultural support by the OECD secretariat and the World Bank. Finally, the Uruguay Round negotiations revealed some of the political and economic costs in external relations. At some point the environment emerged as a justification for continued subsidization. Who originated this idea, when and by what means it was promulgated, how it was translated into policy proposals and with what likely effect on trade would be a fascinating and instructive study.

These two examples draw on personal interest. There are others—the nuclear versus coal issue noted in the paper has trade implications. Similarly, the campaign for a ban on trade in tropical hardwoods and the role of the European Parliament is worthy of a political economy study.

This is an area of policy which has not yet fully blossomed in Europe. Gernot Klepper’s paper suggests potentially fruitful areas for study which would help policymakers confronting the many dilemmas the subject raises.
Investment, Technology and the Global Environment: Towards International Agreement in a World of Disparities

Ishac Diwan and Nemat Shafik

Introduction

Debates about global environmental problems have been dominated by North-South conflicts. The North is responsible for the bulk of carbon emissions and has much of the wealth while the South has most of the people. Sixty-one percent of total emissions and seventy-five percent of world output are produced in the North where per capita emissions of carbon are seven times greater than in the South. Tables 15-1 and 15-2 present the stylized facts that characterize the differences between the North and the South (and selected centrally planned economies, CPEs) in a cross section for 1985. How can these facts be reconciled with the intuitive statement that with higher incomes, societies demand improvements in environmental quality (i.e., that the environment is a "normal" good)?

The key to this paradox is the changing relationship between local and global pollution. For most of history, local pollutants have been highly correlated with global pollutants. Thus with rising incomes, movement up the "fuel ladder" to increasingly cleaner burning energy sources resulted in a less polluted local and global environment. Under these conditions, both the local and the global environment were normal goods. But this changed with the introduction of environmental legislation to reduce local pollutants in many countries. Technologies emerged that reduced the local pollution associated with burning dirty energy sources such as high sulfur coal. However, since legislation was not directed at global pollutants (since they were not perceived to have local consequences), negative international externalities often continued to be imposed. Thus the availability of technologies that delink local and global pollution eliminated many of the automatic benefits for the global environment from addressing local concerns. The North can now achieve improvements in local environmental quality while continuing to impose negative externalities internationally. Decomposing per capita carbon emissions into per capita capital stocks (a quantity effect) and emission per unit of capital stock (a quality effect) is informative. The capital stock per capita is almost fourteen times greater in the North than in the South, reflecting vastly greater wealth. However, carbon emissions as a proportion of capital stocks are one third lower in the North where policies, technologies and preferences result in cleaner production. But despite the substantial gains in local air quality in the North, global emissions of carbon have continued to rise. Essentially, the quantity effect has vastly dominated the quality effect.

This paper explores the scope for structuring international agreements given these stylized facts. We develop a framework to analyze the factors that determine decisions about carbon emissions in rich and poor countries to shed light on the types of international arrangements that are likely to be most successful. How does environmental awareness interact with investment choices? What are socially optimal emission levels from a domestic point of view and how is this choice related to a country's wealth? What level of emissions

*We would like to thank Charles Blitzer, Jeremy Bulow, Michael Hoel and Ning Zhu for inspiring discussions, and Sushenjit Bandyopadhyay for superb research assistance in this project.
Table 15-1: Indicators of Carbon Dioxide Emissions, Capital Stock, Population and Output, 1985

<table>
<thead>
<tr>
<th>Variables</th>
<th>Units</th>
<th>North</th>
<th>South</th>
<th>Centrally Planned Economies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per Capita Emissions</td>
<td>Tons</td>
<td>2.93</td>
<td>0.42</td>
<td>2.74</td>
</tr>
<tr>
<td>Emissions/Income</td>
<td>Tons/Dollar</td>
<td>0.24</td>
<td>0.29</td>
<td>1.19</td>
</tr>
<tr>
<td>Investment/Income</td>
<td>Ratio</td>
<td>0.23</td>
<td>0.23</td>
<td>0.29</td>
</tr>
<tr>
<td>Capital/Population</td>
<td>Dollars/Person</td>
<td>40958</td>
<td>2956</td>
<td>10399</td>
</tr>
<tr>
<td>Emissions/Capital</td>
<td>Tons/Dollar</td>
<td>0.08</td>
<td>0.12</td>
<td>0.19</td>
</tr>
</tbody>
</table>

Note:

Capital stock data is available for only two centrally planned economies: Hungary and Yugoslavia; and eleven North economies, Spain, Hong Kong, Israel, Japan, Singapore, U.S.A., United Kingdom, Germany, France, Canada and Finland.
Table 15-2: Share of World's Emissions, Population, GNP and Capital Stock, 1986

<table>
<thead>
<tr>
<th></th>
<th>Emissions</th>
<th>Population</th>
<th>Output</th>
<th>Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>61.8</td>
<td>24.3</td>
<td>78.8</td>
<td>68.7</td>
</tr>
<tr>
<td>South</td>
<td>38.2</td>
<td>75.7</td>
<td>21.2</td>
<td>31.3</td>
</tr>
<tr>
<td>Developed</td>
<td>50.7</td>
<td>15.6</td>
<td>74.8</td>
<td>-</td>
</tr>
<tr>
<td>Developing</td>
<td>42.8</td>
<td>80.6</td>
<td>22.2</td>
<td>-</td>
</tr>
<tr>
<td>Oil Exporters</td>
<td>6.4</td>
<td>3.7</td>
<td>3.0</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes:

The shares of North and South are computed by weighted averages of the sample countries, where population shares of North and South are used as weights.

The shares of Developed, Developing and Oil Exporters are from Whalley and Wigle (1991).
will occur in the absence of an international agreement? What role do international markets play? What types of transfers could support particular agreements to limit global emissions while benefiting all parties involved?

**Background**

Climate change is a truly global issue because the actions of any one country affect all other countries. The incentive to reduce national emissions of greenhouse gases or to slow the rate of deforestation is lower than the social optimum because global externalities cannot be readily internalized without international coordination. Because of these international spillovers, there have been numerous appeals for the use of international instruments, such as trade or financial policy, to enforce global agreements. But the effectiveness of such instruments depends entirely on factors such as countries' endowments, intertemporal preferences and tastes. Without an understanding of how these differences across countries affect economic decisions, effective international agreements cannot be designed.

Any agreement to reduce global warming is likely to contain efforts to reduce the consumption and increase the efficiency of fossil fuel use, and reduce the rate of deforestation. While the objective of an agreement would be to increase global welfare, it is likely that some countries would gain while others would lose. The agreement would have to ensure that the losers are properly compensated, and that it is in their own interest to abide by the agreement over time. In this paper, we abstract from many of the characteristics that determine how countries are affected by an agreement on greenhouse gas emissions (geography, endowment of fossil fuels and rain forests) in order to concentrate on the effect of income levels, so as to highlight the North/South dimension.\(^1\) While this is not the only factor that needs to be considered, we believe that it is an important one and likely to dominate the political debate on environmental issues between industrial and developing countries.

In addition to the usual difficulties in coordinating private action for the public good, achieving a consensus on global environmental issues is thwarted by the existence of fundamental differences between rich and poor countries. Although there is a growing consensus that economic policy must take environmental externalities into account, there are very different environmental priorities across countries. The North tends to be more concerned with climate change, biodiversity loss and deforestation. The South's priorities tend to be those directly related to developmental objectives -- access to clean water and sanitation, raising agricultural productivity, and local pollution. Having solved many of its most pressing local externalities, the North has moved on to worrying about global externalities; meanwhile, the South's environmental agenda is still crowded with local issues.

The use of financial pressure to force developing countries to address the environmental concerns of the North has also been a source of conflict. The South argues that since addressing international externalities benefits the North more, the South should be compensated with external financing at levels that are additional to existing capital flows. The North is unwilling to give additional aid for environmental purposes without some conditionality to guarantee that their environmental objectives are met. And while the South would like cheap technology transfer, the North (where most of the technologies are developed) is concerned about patent protection and the incentives to innovation.

We attempt in this paper to make sense of these differences that divide North and South on environmental issues. Previous attempts to analyze negotiations over emissions reductions have focused on

---

\(^1\) In the text, we stick for simplicity to a dual characterization of countries as belonging to either the South or the North. This is only meant to be illustrative of more general considerations about the effect of wealth on environmental decisions.
identical players in a game with a single activity. Several papers by Hoel have highlighted the "prisoner's
dilemma" aspect of climate change negotiations and have analyzed the merits of agreements based on
international carbon taxes versus tradable permits (Hoel, 1990a,b,c; 1991). In a Stackleberg leader-follower
game, Low and Safadi (1991) have shown that a commitment by the leader to environmental action, combined
with a credible threat results in an equilibrium that is superior to non-cooperation.

The innovations introduced in this paper are: (1) countries are differentiated according to wealth so
as to address North-South issues, and (2) the choice of optimal emissions level is linked to decisions about
both investment and technological choice. In the text, we stick for simplicity to a dual characterization of
countries as belonging to either the (rich) North or the (poor) South. While the dynamics are analyzed in
terms of reducing carbon emissions, much of the intuition can be generalized to other transborder externalities.

The paper is organized in the following way. In the next section, we describe a simple framework
of optimal investment/emission decisions. Then we present empirical work that sheds light on the relationship
between carbon emissions and wealth. The following section presents some simulations that illustrate the
potential consequences of capital mobility and emissions trading on countries' choices with respect to
emissions. Finally we analyze the implications for international agreements and conclude with an assessment
of policy options.

North-South Choices - Investment, Technology and Emissions

In general, a country's emissions will depend on how it values the local effects of its own emissions,
on the economic costs involved in reducing emissions, and on the way it values the trade-off between the side
effects of emissions and abatement costs. The preferences are manifested in decisions about investment and
technology that reflect intertemporal preferences with respect to consumption and environmental quality.

The desire to reduce carbon emissions in the past was motivated by the local effects of energy use.
These include the adverse health and productivity consequences of sulfur dioxide and particulate emissions.
These local pollutants were highly correlated with the global pollutants, such as carbon dioxide, through both
energy efficiency and through the use of cleaner burning fuels. Thus biomass or coal burning emit more local
and global pollutants than do cleaner burning fuels such as oil and natural gas. An exception is where
technologies have been developed that remove local pollutants, but not global ones. These include electrostatic
precipitators for particulates and scrubbers and various clean coal technologies for sulfur dioxide. However,
these technologies are relatively recent and have not entered the capital stock on a sufficiently large scale to
affect conclusions about the past. Moreover, as concerns about global warming have increased, reducing
carbon emissions has become a direct, rather than an indirect, objective of policy and technology could play
a critical role at the margin in the future.

We posit that the process of production results in useful output as well as greenhouse emissions, but
that more advanced--and more expensive--technology can reduce the emission to output ratio. Countries can
reduce their emissions by reducing energy use, either by reducing production, or by adopting cleaner
technologies that emit less per unit of output. Clean technologies emit less, but they also usually cost more.
The type of energy used in production is a good example. The burning of coal, which costs approximately
$2 per million BTU of crude oil equivalent, emits 0.0251 tons of carbon. For oil, the costs are $2.5-6.0 with
emissions of 0.0203, and for electric backstops with no emissions such as renewables, costs are approximately
$20 per million BTU of crude oil equivalent. These estimates are from Manne and Richels (1990).
The costs of achieving emissions reductions in countries that have already shifted to clean technologies is substantially higher because they are further along their rising marginal cost curve for abatement. A recent analysis by the OECD explored the costs of achieving a 20 percent reduction in 1990 levels of carbon dioxide emissions in various regions of the world using a global model. The costs were highest for regions such as Japan and Europe because substantial gains have already been made in energy efficiency. In contrast, the cost was lowest in China where large reductions in carbon emissions could be achieved with relatively small outlays. These differences in costs are reflected by the size of the carbon tax necessary for achieving a given emissions reduction. In the Pacific region (dominated by Japan), a carbon tax of $950 per ton is necessary for achieving the target of a 20 percent reduction; in China the tax was only $60 per ton.\footnote{OECD (1991a).}

Consider a hypothetical country populated by profit maximizing individuals making decisions about their level of capital investment (and implicitly the level of intertemporal consumption) as well as the type of technology to use in production.\footnote{A formal model is in Diwan and Shafik (1992).} Consider further that physical capital has two components: (i) a productive component that produces useful goods and as a side product, polluting emission; and (ii) an emissions cleaning component that adds costs to production.\footnote{Another interpretation delivers a similar model: machines can use two types of energy A and B, where A is cheap but has a high emission content, while B is expensive but emits less. The country’s choice can then be pictured as between the type of energy to use rather than the type of technology.} In this framework, public policy is assumed to influence local emissions by setting an emission tax, quotas on emissions, or other regulatory devices aimed at reducing total emissions. The goal of public policy then is to maximize national welfare over time by influencing private choices about the quality and quantity of machines. The trade-off is between the "goods" (consumption) and the "bads" (polluting emissions) produced as a result of the production process.

Economic theory tells us that, for a given technology, investment is optimal when the total cost of a machine, evaluated at the current marginal utility of consumption is equal to the increase in consumption tomorrow, evaluated at the future marginal utility of consumption, plus the marginal disutility of the corresponding emissions, evaluated at the marginal disutility of emissions tomorrow. Analogously, the optimal technology is reached, for a given investment level, when the marginal cost of technological improvements evaluated at the marginal utility of consumption today is equal to the emission saved, evaluated at the marginal disutility of emissions tomorrow. Intuitively, just as the rate of time preference mediates between current and future consumption, the rate of emissions abatement trades off current for future utility from environmental quality. Thus, the use of dirtier technology can be pictured as a "loan from nature" that allows for higher welfare today in exchange for lower welfare tomorrow.

How does current income affect optimal behavior? A poorer country optimally consumes a larger share of its current income and invests a smaller share if it is liquidity constrained. It will also choose an inferior technology (that emits more per unit of capital). From the country's perspective, such behavior is comparable to borrowing against future income, i.e. trading current against future utility. Thus, because it cannot borrow from a perfect capital market, a poor country borrows from nature. As the country gets richer, it shifts part of this gain to the future by optimally investing more of its current resources and by using a cleaner technology. The two factors affecting total emissions--investment and technology choice--work in opposite directions, so it is not possible to say a priori whether rich or poor countries emit more per capita. Poor countries may choose dirtier technologies, but they have fewer machines. Rich countries adopt cleaner
technologies, but have more machines. Finding the relative size of these two factors is an empirical issue, and it is addressed in the next section below.

How do intertemporal factors affect optimal emissions? In the absence of international capital markets, the level of future expected income is important since countries cannot simply smooth income over time through borrowing or lending. As a country gets poorer tomorrow, it reacts by increasing investment to better smooth consumption over time. The optimal reaction in terms of emission choice is however ambiguous: on the one hand, reducing emissions allows it to further reallocate welfare from today and into the future; but on the other, lower environmental standards are called for due to increased poverty. The effect of future wealth (and thus of external debt) on total emissions is again undetermined at a conceptual level. Whether more indebted counties emit more or less than less indebted ones on a per capita basis remains a question to be explored empirically.

Growth does not necessarily lead to more emissions. Economic growth leads—given technology—to more machines, but to the use of cleaner machines. Higher current income leads to an increased valuation of future consumption and of environmental quality. As a result, as societies grow richer, they value the future negative effects of environmental degradation more. This leads to increased social willingness to reduce emissions of carbon dioxide. In general, this can be achieved in two ways: by choosing more emission-efficient technologies, thereby sacrificing consumption, investment, and thus future growth, and by discovering new technologies that reduce the cost of abatement. These new technologies are more likely to be developed if researchers can expect to receive the present value of the rents accruing to their invention. However, in the absence of an international agreement on intellectual property rights, it is quite possible that the new technologies will correspond much more to the needs of the North than to those of the South.\(^6\)

How does the abatement technology's relative price affect optimal behavior? As the price of clean technologies falls, the quality of the capital stock is optimally increased. The effect on investment is however undetermined: on the one hand, the capital stock becomes less emissions intensive which calls for an increase in the quantity of machines; but on the other hand, welfare tomorrow can also be increased with improved environmental quality. Therefore, on a net basis, it is not possible to evaluate the impact of changes in technology prices on emissions.

Without international coordination, each country determines its own investment/technology choice given the actions of the other countries. But when countries' welfare is affected by the stock of total accumulated emissions, the extent of emissions by the rest of the world can have some restraining effect on local emissions. If the rest of the world emits more, the country optimally picks a cleaner technology to compensate partially for its own welfare loss. And since production becomes more expensive, investment is less productive and it is also optimally reduced. Thus, overall, its own emissions unambiguously fall.

Since each country's emissions depend on the emissions of the other country, gaming considerations become relevant in the determination of equilibrium levels of emission by each player. A Nash equilibrium is then defined as a situation where each player has no incentive to change its behavior given the behavior of its opponent. There are two sources of inefficiencies associated with the Nash equilibrium. First, the absence of coordination creates incentives for all countries to over-emit, the so-called "tragedy of the commons," because the global bad associated with emissions is undervalued by individual emitters. Second, emissions and capital do not produce the same amount of marginal output in different countries. In particular, the marginal productivity of capital is higher in the South but the marginal "productivity" of emissions is higher in the North.

\(^6\) Diwan and Rodrik (1989).
Empirical Investigation

The time path of carbon emissions as a proportion of population, output and capital stock is depicted in Figures 15-1, 15-2 and 15-3. Figure 15-1 shows how per capita emissions in the North peaked in the mid-1970s and began to fall thereafter, probably because of high energy prices and increased environmental legislation during that period. Emissions per capita have been on a declining trend in the 1980s in the North and have since stabilized and started to increase. In contrast, emissions per capita in the South, which are a small proportion of those in the North, are on a slightly increasing trend. The divergent paths of the North and the South is even more apparent in Figure 15-2 where emissions as a share of GDP are presented. Again, the turning point for the North is in the mid-1970s; the South continues on an upward path of emissions as a share of GDP which exceeds that of the North after 1977. The overall emission intensity of the capital stock is on a declining trend for both the North and the South (Figure 15-3), but the capital stock in the South continues to be dirtier than that in the North.

The Data

The framework for country choices about investment and technology described in the previous section has been explored econometrically by estimating the relationship between (1) emission per capita; (2) capital stock per capita; and (3) emission per unit of capital stock, and the following dependent variables: per capita income, debt per capita, and a time trend. The regressions use a panel data for 109 countries for the period 1960-87. For the industrialized countries and a smaller subset of 68 developing countries, capital stock data was available.

The problems associated with capital stock data are familiar, so three different measures were used: a capital stock measure that uses the conventional perpetual inventory method starting in 1945 and using a 5 percent depreciation rate; a measure that adjusts the perpetual inventory figures for capacity use based on the "peak to peak" method; and an estimate using instrumental variables to derive a measure of the capacity use adjusted capital stocks. Because the resulting estimates were not substantially different, only the regressions using the perpetual inventory method are reported here. Consistent data on external debt, which is important for evaluating wealth, were available for the 107 countries that participate in the World Bank Debtor Reporting System (this excludes many of the high income countries). The results are presented in Table 15-3. Regressions 1, 2, 3 and 4 do not include data for some of the high income countries while regressions 1a, 2a, 3a and 4a include the high income countries but their external debt has been set to zero. In the regressions that follow, all variables are in natural logarithms.

Regression Results

Equations 1 and 1a show that both higher per capita income and higher debt result in higher emissions per capita in the sample. The per capita income squared term in regression 1a, which includes the high

---

7 The estimates were also repeated for a cross-section for 1987 and the results were fairly robust for the most critical equations. Equations 1, 1a, and 2a were significant for all variables, the remainder all had the right signs, but not all variables were significant.

8 We are grateful to the World Bank's World Development Report 1991 for making this data available to us. Documentation of the capital stock data used in this analysis is available in the World Development Report 1991 Technical Annex.
Figure 15-1: Per Capita Emissions in North and South
Figure 15-2: Emission as Share of Output

![Graph showing emissions as share of output from 1960 to 1985, with two categories: North and South.](graph.png)
Figure 15-3: Emission as Share of Capital Stock
Table 15-3: Effects of Income, Debt and Technology on Investment and CO₂ Emissions 1960-87

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.41</td>
<td>-14.92</td>
<td>-25.46</td>
<td>-36.94</td>
<td>16.89</td>
<td>-9.37</td>
<td>18.46</td>
<td>36.26</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(-3.05)</td>
<td>(-5.46)</td>
<td>(-9.71)</td>
<td>(2.88)</td>
<td>(-2.95)</td>
<td>(1.83)</td>
<td>(4.59)</td>
</tr>
<tr>
<td>Per Capita Income</td>
<td>1.29</td>
<td>2.04</td>
<td>0.39</td>
<td>1.12</td>
<td>0.04</td>
<td>0.94</td>
<td>0.85</td>
<td>0.54</td>
</tr>
<tr>
<td></td>
<td>(5.21)</td>
<td>(16.73)</td>
<td>(2.31)</td>
<td>(10.29)</td>
<td>(0.24)</td>
<td>(11.09)</td>
<td>(2.36)</td>
<td>(2.11)</td>
</tr>
<tr>
<td>Per Capita Income Squared</td>
<td>-0.01</td>
<td>-0.06</td>
<td>0.05</td>
<td>0.00</td>
<td>0.00</td>
<td>-0.06</td>
<td>-0.05</td>
<td>-0.03</td>
</tr>
<tr>
<td></td>
<td>(-0.32)</td>
<td>(-6.49)</td>
<td>(3.87)</td>
<td>(0.55)</td>
<td>(0.13)</td>
<td>(-9.99)</td>
<td>(-1.67)</td>
<td>(-1.65)</td>
</tr>
<tr>
<td>Per Capita Debt</td>
<td>0.10</td>
<td>0.02</td>
<td>0.15</td>
<td>0.01</td>
<td>0.09</td>
<td>-0.00</td>
<td>-0.11</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(4.31)</td>
<td>(6.75)</td>
<td>(11.44)</td>
<td>(3.13)</td>
<td>(5.77)</td>
<td>(-1.13)</td>
<td>(-3.74)</td>
<td>(2.65)</td>
</tr>
<tr>
<td>Time Trend</td>
<td>-0.01</td>
<td>0.00</td>
<td>0.04</td>
<td>0.19</td>
<td>-0.01</td>
<td>0.00</td>
<td>-0.01</td>
<td>-0.02</td>
</tr>
<tr>
<td></td>
<td>(-1.30)</td>
<td>(0.43)</td>
<td>(6.01)</td>
<td>(9.91)</td>
<td>(-3.35)</td>
<td>(1.41)</td>
<td>(2.41)</td>
<td>(4.59)</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>1670</td>
<td>2496</td>
<td>1083</td>
<td>1401</td>
<td>1466</td>
<td>2164</td>
<td>1083</td>
<td>1223</td>
</tr>
<tr>
<td>Adjusted R squared</td>
<td>0.73</td>
<td>0.85</td>
<td>0.91</td>
<td>0.94</td>
<td>0.09</td>
<td>0.08</td>
<td>0.06</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Notes:
1. Consistent data of debt stocks were restricted to the 107 countries in the World Bank's Debtor Reporting System (DRS). Equations 1, 2, 3 and 4 do not include data for some high income countries because they do not report their debt to DRS. Equations 1a, 2a, 3a and 4a set debt equal to zero for these nonreporting high income countries.
2. All variables are in natural logs.
3. Numbers in paranthesis are t-Statistics.
4. The turning points for equations 4 and 4a are: $13078$ and $5570$ respectively.
income countries in the sample, is significantly negative--implying that at very high income levels, emissions per capita begin to decline. The turning point is at a per capita income level of over $80 million. This is not as implausible as it sounds -- Figure 15-4 indicates that carbon emissions per capita are rising exponentially with higher incomes and there is no sign of reaching a peak. Figure 15-4 is based on a cross section of 149 countries in 1985 where an index of per capita carbon emissions was regressed on the log of per capita income. It suggests that carbon emissions will continue to increase with rising incomes, despite improvements in the quality of capital. Therefore, there will be nothing automatic about bringing down global emissions with higher incomes. This is not surprising--where the local costs are perceived to be small, coordinated action will be required to change the path of emissions.

Equations 2, 2a, 4 and 4a decompose the total effect into a quantity and a quality effect, as suggested by the conceptual discussion. Equations 2 and 2a explore the relationships between capital stock per capita and per capita income and debt. The results show that as countries get richer and/or more indebted, their capital stock (per capita) increases. There is also a strong upward trend in capital stock per capita. In order to better understand the process of capital formation, equations 3 and 3a look at the determinants of investment (per capita). We find that (per capita) investment increases with income (per capita) and with debt (per capita) in the developing countries. Equation 3 indicates that there is a declining trend in developing country investment and equation 3a shows that at high income levels, investment rates begin to decline. The final equations 4 and 4a investigate the determinants of the "quality" of productive assets in place. The results indicate that as a developing country’s per capita income rises, emissions per unit of capital stock increase. This reflects the increasing industrialization and urbanization associated with the development process. However, when per capita income is squared, the sign becomes negative, implying a U shaped relationship between the emissions quality of assets and income. The squared term is significant at the 10 percent level. Thus as poor countries get richer, they emit more, but as they get very rich, they emit less. Our results suggest that the turning point occurs at a per capita income levels of $5,570 per annum. This relationship can also be seen in Figure 15-2 where emissions as a share of the capital stock decline for the richer countries in the sample. It is interesting to note that our turning point of $5,570 for carbon emissions is very close to the turning point of about $5,000 estimated for sulfur oxides by Grossman and Krueger. Indebtedness, or negative wealth, is found to reduce emissions as a share of the capital stock for poorer countries in equation 4. The time trend in the equations is a possible proxy for the availability of new, cleaner technologies. The time variable was significantly negative in equations 4 and 4a, implying that the availability of new technology serves to reduce emissions per unit of capital stock.

These econometric results are summarized in Table 15-4. The rich North is concerned about ways to carry its wealth into the future, both by investing in physical capital, and by conserving natural resources and the environment. The poor South is more interested in borrowing against future earnings to boost its productive capacity. For the liquidity constrained South, these output gains can be achieved by borrowing from nature. This difference in behavior does not derive from tastes that are fundamentally different. Instead, the optimal consumption baskets differ: because it is poor and thus more impatient, the consumption basket of the South is concentrated on current consumption rather than on future environmental quality. The table gives an indication of the potential channels for altering the pattern of emissions. But before analyzing the implications for international agreements, it is important to consider the international policy regime in which such agreements would be designed.

---

9 The turning point for equation 4 is $13,078. This higher turning point is the result of fewer observations for the high income countries in the regression. Because equation 4a includes a more complete range of income levels, we believe that the turning point calculation from that equation is more accurate.

Figure 15-4: Average Carbon Emissions Per Capita at Different Income Levels
Table 15-4: Impact of Income, Debt and Technology on Investment and Emissions

<table>
<thead>
<tr>
<th></th>
<th>Income</th>
<th>High Income</th>
<th>Debt</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital stock/population</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Emissions/population</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Emissions/capital stock</td>
<td>+</td>
<td>-</td>
<td>?</td>
<td>-</td>
</tr>
</tbody>
</table>
Effects of Capital Mobility and Emissions Trading

What are the consequences of different policy regimes for emissions choices made by the North and the South? Essentially, there are two critical decisions that countries make - investment levels and technology - that determine emissions. Thus there are two critical international markets that will affect the outcome - the capital market and a possible market in emissions rights.

This section discusses the important role those markets play in the determination of investment and technological choices in the North and in the South. The discussion on the effect of capital mobility is conducted in the context of simple examples that illustrate potential effects of capital flow on local and global outcomes. The numerical examples that follow are based on stylized facts and are intended to illustrate possible outcomes under plausible assumptions about parameter values. Population is taken to be 1.5 billion in the North, and 4.5 billion in the South. Capital stocks are taken to be $20,000 and $5,000 respectively. We assume that the production function is \( f(K) = 10K^{0.8} \) where \( f(K) \) describes the present value of production with a (steady state) capital stock of \( K \).

**Base Case with No Trade**

In a world without capital mobility, emissions by the South are restrained by low capital stocks, but are exacerbated by the use of poor technologies. The following table describe a plausible equilibrium in which the North spends 4 percent of GNP on abatement costs (in response to an emission tax of $0.5 per ton of emission). Interest rates are higher in the South reflecting differences in time preferences and in the scarcity and thus the marginal rate of return to capital. Investment and the equilibrium interest rate are computed using a model where domestic firms maximize profits. In essence, the model assumes that emissions can be reduced using a costly abatement technology. When emissions are taxed, such abatement activity is encouraged. Optimality then requires that the marginal cost of investment be set equal to its marginal benefit.

It is easy to check that in the example below, the cost of capital, of emission abatement, and of emission are consistent with the level of investment. For the North, the marginal cost is given by $1.04 since $0.04 of abatement expense must be incurred for each unit of capital invested. The marginal benefit of investment is given by the present value of the marginal productivity of capital minus the present value of the tax paid on emissions. In our example, this amounts to \( \frac{f'(20,000) - (0.08)(.5)}{(1.023)} = 1.04 \). For the South, the marginal cost of investment is given by $1, since no emission abatement takes place. The marginal benefit is given by the present value of the marginal product of investment, \( \frac{f'(5000)}{(1.45)} = 1 \).

With no capital mobility, total world emissions equal 4,874 billion tons and world output equals $80,699 billion. Emissions in the South are restrained by liquidity constraints, despite the high potential rate of return. Since poor countries have to borrow from nature because they cannot borrow from capital markets, does alleviating capital market constraints reduce the global warming problem?

**Capital Mobility**

What are the implications for global warming of opening up a previously closed capital market? Initially, the cost of capital is high in the South due to its scarcity, but lower in the North. Assume now that capital movements are not restrained in the sense that financial contracts are perfectly enforceable. The South borrows to smooth consumption through time. But it also borrows to take advantage of its existing profitable

---

Equilibrium with No Capital Mobility

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ emission tax ($ per ton)</td>
<td>0.5</td>
<td>0</td>
</tr>
<tr>
<td>Capital per capita (dollars)</td>
<td>20,000</td>
<td>5,000</td>
</tr>
<tr>
<td>Emission (tons per $1 of capital)</td>
<td>0.08</td>
<td>0.11</td>
</tr>
<tr>
<td>Abatement expense ($ per $1 of capital)</td>
<td>0.04</td>
<td>0</td>
</tr>
<tr>
<td>Population (billion)</td>
<td>1.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Domestic interest rates (percent)</td>
<td>2.3</td>
<td>45.6</td>
</tr>
<tr>
<td>PV of output per capita (dollars)</td>
<td>26,491</td>
<td>9,103</td>
</tr>
<tr>
<td>Emission per capita (tons)</td>
<td>1,600</td>
<td>500</td>
</tr>
</tbody>
</table>

Total emission: 4,874 billion tons.
World Output: $80,699 billion.

investment opportunities at the lower international cost of capital. Overall, it is likely that the South now emits more because of its ability to invest more through international borrowing (although its increased income will also result in higher quality machines). The North emits less because of the wealth effect—its earns higher returns on its capital. It is possible that in this new equilibrium with capital flows, global emissions increase relative to a world of autarky. The new equilibrium would result in higher world emissions when the North’s reduction in emissions is swamped by higher emissions by the South.

Using the same simulation framework above, allow for capital movement. (Note that the average capital stock per capita in the world is about $8,750). Initially, we assume that the South has no emission standards. A large inflow of capital is then needed to equalize the net rates of return on capital in the South and the North. For example, we can now have the following situation:

Equilibrium with Capital Mobility (but no standards in the South)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emission tax ($ per ton)</td>
<td>0.5</td>
<td>0</td>
</tr>
<tr>
<td>Emission (tons per $1 of capital)</td>
<td>0.08</td>
<td>0.11</td>
</tr>
<tr>
<td>Abatement expense ($ per $1 of capital)</td>
<td>0.04</td>
<td>0</td>
</tr>
<tr>
<td>Population (billion)</td>
<td>1.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Capital flows ($ per capita)</td>
<td>-13,500</td>
<td>4,500</td>
</tr>
<tr>
<td>World interest rate (percent)</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>Income per capita (dollars)</td>
<td>28,060</td>
<td>9,630</td>
</tr>
<tr>
<td>Emission per capita (tons)</td>
<td>520</td>
<td>950</td>
</tr>
</tbody>
</table>

Total emission: 5,482 billion tons.
World Output: $84,622 billion.
Optimality again requires that the marginal cost of investment be set equal to its marginal benefit. For the North, the unitary marginal cost is still given by $1.04 with $0.04 of abatement expense. The marginal benefit of investment is now given by the present value of the marginal productivity of capital minus the present value of the tax paid on emissions, now amounting to \( \frac{f'(20,000-13,500) - (0.08)(.5)}{1.28} = 1.04 \). For the South, the marginal cost of investment is $1 with no emission abatement taking place. The marginal benefit is then given by the present value of the marginal product of investment, \( \frac{f'(5,000 + 4,500)}{1.28} = 1 \).

Income increases in both regions as a result of capital mobility; but total emissions also increase. Conceptually, both the North and the South can be worse off than in the initial equilibrium with no capital flows. But it is likely that the South gains since it cares more about income than emissions (it would certainly gain for example if it does not care at all about environmental quality given its income level. On the other hand, it is quite possible that the North becomes worse off. The North’s income increases (6 percent) because of the higher return it earns on investments in the South but that may not compensate for the disutility due to the increase in emissions (12.5 percent).

**Strategic Interaction**

In the previous example, the possible welfare deterioration in the North results from the disparity at home between private interest and public good. When capital can move freely between regions, atomistic Northern capitalists gain by lending to capital-poor Southern producers. This however creates an externality as global emissions increase and Northern welfare can deteriorate. This welfare loss can be reduced by public policy that internalizes this externality, and in particular, by controlling the extent of total capital movement to the South.

For example, the North could achieve as high an income level with much less total emissions by lowering its own standards and closing its capital market to the South. Consider that at an emission tax of $0.02 per ton, firms in the North choose abatement costs of 1 percent of capital and emission standards of 0.09 tons per unit of capital. Then, per capita income in the North would be $27,319, and total emissions would be 5,175 billion tons. This may well be better than the results of the simple capital mobility case--income is slightly lower, and emissions are smaller.

Because the North might gain by closing its capital market and reducing its standards, the South may agree to increase its own standards in exchange for free capital mobility. This explains the desire of environmentally aware citizens of the North to impose environmental conditionality on loans to the South.\(^{12}\) But if the North’s perception is that the global environment is negatively affected by capital mobility, policies to restrict capital movement (or trade) will become more popular. In such circumstances, the South may gain by imposing higher standards at home in exchange for open capital markets. Those standards will then have to be low enough so as not to dominate the gains from trade in capital, but high enough to satisfy the environmental objectives of the North. This issue has already emerged in the negotiations between the United States and Mexico over the free trade agreement. Concern about capital moving to pollution havens in Mexico, particularly just across the border, has resulted in increased pressure on the Mexican government to raise local environmental standards.

A final simulation shows how the trading of capital mobility from the North in exchange for slightly higher environmental standards from the South may result in a Pareto improvement. Assume now that the South raises a tax of $.01 per ton, and that as a result, firms now spend 0.5 percent on pollution abatement and emissions per unit of capital equals 0.10. The new equilibrium is characterized by:

\(^{12}\) See for example Strand (1990) for a discussion of conditionality along those lines.
<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emission tax ($ per ton)</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Emission (tons per $1 of capital)</td>
<td>0.08</td>
<td>0.10</td>
</tr>
<tr>
<td>Abatement expense ($ per $1 of capital)</td>
<td>0.04</td>
<td>0.005</td>
</tr>
<tr>
<td>Population (billion)</td>
<td>1.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Capital flow (dollars, per capita)</td>
<td>-13,000</td>
<td>4,333</td>
</tr>
<tr>
<td>World interest rate (percent)</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>Income per capita (dollars)</td>
<td>27,948</td>
<td>9,419</td>
</tr>
</tbody>
</table>

Total emission: 5,039 billion tons.
World Output: $84,302 billion.

Once more, we check the consistency of this scenario. In the North, the marginal cost is still given by $1.04 with $0.04 of abatement expense. The marginal benefit of investment is now given by \(f'(20,000-13,000) - (0.08)(.S)/1.27 = 1.04\). For the South, the marginal cost of investment is now given by $1.005, since some emission abatement takes place and the marginal benefit is also equal to \(f'(5,000 + 4,333) - (10)(.10)/1.27 = 1.005\).

In this new equilibrium, the South is better off than in the no capital mobility case (1), but worse off than in the (politically unfeasible) case with capital mobility but no emission standards (2). The North may also be better off because, while its income is slightly lower than in the pure capital mobility case, global emissions are lower.

**Emissions Trading**

The creation of a world market for emission rights aims at both reducing total emissions and generating Pareto improvements by distributing emission rights more efficiently. Clearly, reducing emissions below present levels can be redistributive. A distribution based on population will favor the South, while one that is based on production will advantage the North. We will focus on the efficiency consequences of emissions trading, rather than the equity issues associated with the initial distribution of rights. The exact allocation of emission rights between the North and the South does not affect the nature of our conclusions as long as the South remains poorer than the North. Consider then that emission rights have been distributed to the North and the South in some fashion by some agency with enforcement powers, and that such rights sell at a market price per unit of emission.

Without capital mobility, the effect of the introduction of an emissions rights market may result in a shift in production away from the South and toward the North. Since emissions can now be bought and sold at a unit price, all countries will optimally equalize their rate of emission by choosing technology so that the price of a unit of emission is equalized with the marginal abatement cost. The South would upgrade to cleaner technology while the North would downgrade its emission technology. But investment in the South would still be lower than that in the North with emissions trading. This is because the liquidity constraint remains binding in the South as long as it remains poorer than the North and cannot obtain access to capital markets.

How do investment levels compare with the situation in which there is no trading in emission rights? For this comparison to be relevant, assume that emission rights have been allocated on the basis of emission...
produced in the initial autarkic equilibrium. In the North, both the income and substitution effects call for higher investment: at the new emission rights price, investment is now "cheaper", because it does not increase overall emissions. In the South, the two effects—wealth and substitution—work in opposite directions. The wealth effect results from the new gains from trade in emission rights. Those gains are optimally allocated between increases in consumption and in investment. The substitution effect on investment is ambiguous, but it is quite possible that investment falls. In effect, the liquidation of what used to be a nonmarketable asset—a clean environment—allows the South to sell its environmental rights upfront rather than use them inefficiently, which it had to do initially because of the absence of other alternatives. It is thus quite possible that the tradability of rights (in the absence of a capital market) results in a shift in investment and thus of production away from the South and towards the North.

**Perfect Trade in Both Capital and Emission Rights**

When the capital market is also operative, investment levels are equalized between the North and the South. The South borrows to smooth consumption, increase its capital stock, and possibly to buy emission rights, until the marginal returns on capital and on emission rights are equalized in the two regions. In the resulting equilibrium, output increases in the South and decreases by less in the North so overall world output rises relative to the autarkic situation (and also relative to the situation with trade only in emission rights). When a capital market is open and efficient, opening an emission rights market benefits the two blocks and emission rights will tend to follow capital and flow towards the region that has a smaller initial share of total emission rights relative to its equilibrium share of total capital.

**Discussion**

In sum, what are the main differences in welfare terms of developing trade in capital and emission rights? The answer differs depending on whether it is the capital market or an emission rights market that is opened. When the capital market is opened, there is a possibility that the North loses because capital flows obey individual rationality, which results in capital flowing to the South where returns are high and environmental standards are lax, while at the same time capital flows create an aggregate externality. This calls for policy action to internalize this externality and can be achieved by restricting capital flows, which harms the South as well as private agents in the North. On the other hand, when an emission market is opened, trade cannot lead to losses—either in the North or in the South—because total emissions are fixed, and thus, the externality discussed above is not present. In welfare terms, both the North and the South are better off with emission trading, but the South’s welfare improvement stems from rents that result from sales of emission rights.

A more complex picture emerges if one considers the dynamic gains that can accrue in a growing economy. Then, the level of economic activity—as opposed to the level of revenue—also matter. The intuitively unappealing aspect of a "rentier" South stems from political economy concerns and from the loss of those dynamic gains that accrue with learning-by-doing. In such a context, individually rational decisions relating to capital flows create an aggregate externality, and the country that attracts capital gains while the region that exports capital loses on this front. Given the importance of externalities associated with investment, the South could then have a preference for an open capital market (since this attracts resources to the South), and the

---

13 Again, the comparison is with a case where the emission rights are equal to the emissions produced in the autarkic equilibrium.

North could prefer an open emission rights market (which attracts resources to the North). Opening both markets could also benefit the South at the expense of the North, because capital would then flow to it, together with the emission rights. Given the difficulties in enforcing property rights at the international level, the choice of a market in which public policy would attempt to enforce contracts can thus have profound distributional consequences. Clearly, these considerations must be explored further before international decisions about the establishment of an international market for emission rights are seriously contemplated.

Designing Policies for International Externalities

The difficulties associated with the opening of a market for emission rights illustrates the additional problems involved in coordinated action for global environmental problems when countries are differentiated. If a world planner coordinated international emissions by setting an environmental quality code to be respected by all producers, she would set looser rules when the interest of the South has a higher weight in her world welfare function. Ultimately, the only resolution to this conflict of interest is for all countries to become undifferentiated, i.e. for incomes to converge in the North and the South.

At another level, any international agreement gives rise to substantial free-riding incentives and a functioning system of emission rights requires an enforcement mechanism. The best mechanisms are self-enforcing and consistent over time. We conclude by contrasting the economic incentives generated by four types of possible North-South agreements on the environment: (i) cash for nature, (ii) debt for nature, (iii) technology for nature, and (iv) sanctions for nature. These are evaluated in terms of efficiency and enforceability in light of the framework presented above. In the first three cases, the idea is to attempt to utilize emissions more efficiently. Since the South emits more than the North per unit of output produced, and since the North values a clean environmental more, Pareto improving allocations (a relative concept in the absence of capital mobility) can exist whereby the North transfers resources to the South in exchange for a reduction in Southern emissions.

Cash Transfers

Once the South receives a compensating transfer, it has ex post incentives to increase--and not reduce--investment. At the same time, the South would want to choose cleaner technologies so as to smooth further the consumption gains through time. Our empirical results suggest, however, that the South would end up emitting more (per capita) under those circumstance, because the income effect is more powerful than the technological substitution effect. Thus, current transfers would worsen incentives and commitments are likely to be unenforceable, especially over the long run.

Debt for Nature

On the other hand, our empirical results suggest that debt reduction can be a time consistent tool to generate incentives for less emissions by the South. Indeed, as debt is decreased (i.e. future wealth is increased), incentives work in the correct direction. When the South becomes richer in the future, it would prefer to reduce investment and pick better technologies. As a result, total emissions by the South would decrease. Thus, the desirability of using debt as a transfer mechanism to achieve emission reductions is its

\[^{15}\] An exception to this is when substantial wealth redistribution is achieved through the initial allocation of emission rights. It is possible that the South would be able to gain in the initial distribution, since it can argue that the North has already emitted more than its "fair share", and thus, that the South must now be compensated for the loss of its share of the environment's assimilative capacity. Such a redistribution would depend on whether permits were allocated on a per capita or on an output basis.
time consistency. Linking debt forgiveness to expenditure on conservation, as is common in debt-for-nature swaps can thus be a Pareto improving transaction if from the South’s point of view, the implied additional environmental costs are low relative to the value of debt forgiven, and from the North’s point of view the gain on the environmental front is large relative to the value of debt relief. But in the absence of a commitment mechanism, the primary disadvantages of using debt as a compensating transfer from the point of view of the North are that it is a costly and indirect tool which leaves the South with a windfall. But compensation based on current transfers is relatively worse. Another problem is that the level and distribution of debts across countries may not coincide with the optimal distribution of emission reductions.

Technology Transfers

A third possibility is for the North to subsidize clean technologies in the South, either directly, or indirectly through investment in research and development. While the South may prefer other arrangements ex ante, its ex post interest is to use cleaner technologies if those were made available at a cost no higher than that of the technology of choice in the absence of subsidies. If only clean technologies are subsidized, the North may gain, especially when the marginal cost of those technologies is low. It may also be in the North’s interest to target subsidies on sectors that cause global emissions rather than local emissions, since local emissions are self-restraining. From the point of view of the North, such agreements represent the cheapest way to influence the South because no surplus needs to be paid so as to create "wealth" driven incentives. Such an approach is also readily enforceable and time consistent because the South’s choice of a clean technology would reflect profitability and self-interest.

Sanctions for Nature

The use of sanctions to enforce international agreements results in welfare losses in the South and/or enforceability problems over time. Sanctions might take the form of restrictions on trade or capital flows or involve the introduction of environmental conditionality associated with aid flows or borrowing. If the South complied, investment would be more costly because of the increased costs of clean technologies. If the South did not comply, investment would be reduced by restricted access to international capital markets. While a noncomplying South would choose dirty technology, total emissions from the South would probably fall because of the reduction in investment. But even cost-effective clean technologies that are embodied in imported capital would not be adopted in the South if trade sanctions were imposed. Welfare would also be lower in the South. Enforceability would also depend on the strength of the coalition in the North and the willingness to invoke a "credible threat."

Concluding Remarks

Seven important lessons for structuring international agreements emerge from our analysis.

1. Rising incomes have resulted in a worsening of emissions because the increase in the quantity of capital has overshadowed the improvement in the quality of capital.

---

16 Strand (1990) discusses how debt concessions can be used by donors to alter a developing countries' decisions about resource extraction. His results however stem from a model that posits that an LDC has a given stock of natural resources that it must deplete to earn income. Thus, transfers from the North can reduce an LDC's optimal depletion rate. In contrast, LDC income comes from investment in our framework, so transfers exacerbate environmental degradation because investment and emissions rise.

2. Technological advances would have to occur at a rapid rate to offset rising populations and incomes.

3. The North has the bulk of the world's capital stock and income, and it is responsible for the majority of carbon emissions. Coordinated action within the North is the most promising avenue for a rapid reduction in global emissions.

4. Although the South uses dirtier technologies, agreements that increase the South's current income in exchange for lower emissions will be difficult to enforce over time since the South will want to invest some portion of its higher income.

5. Policies that reduce investment by the South, such as debt forgiveness or capital market restrictions, will result in lower emissions. But such policies are obviously unacceptable in the long run -- an impoverished South with no investment may result in less global warming, but will cause a host of other global problems.

6. Emissions trading can contribute to more efficient use of the earth's assimilative capacity, but without well-functioning capital markets, can lead to a "rentier" South living off its export of emission rights.

7. Technological transfers provide the most attractive mechanism for a North-South agreement on both efficiency and enforcement grounds. Subsidizing clean technologies may be the cheapest way for the North to encourage emissions reductions in the South. The South would reduce emissions out of its own self-interest. Such emissions reductions would improve the quality of the South's capital stock and allow for increases in the quantity--allowing more investment and growth.
**Discussant's Comments**

**Ravi Kanbur**

This is a nice paper that highlights some key issues in the interactions between the market for capital and the market for polluting emissions. The argument proceeds on a theoretical level, backed up by the presentation of some interesting stylized facts and regressions. I will concentrate on the general theoretical pedigree of their line of argument, and suggest some areas for further research.

Standard first-best theory tells us that if all markets but one are working in the manner of classical competitive markets, then making that remaining market work like a competitive market will lead to a potential Pareto improvement. By this is meant that there exists a set of (lump sum) compensations that will make all parties better off after the single nonfunctioning market has been "fixed." The same holds true if two markets are not functioning and both markets are fixed, and so on. Standard second-best theory tells us that if two markets are not functioning in the manner of classical competitive markets, then fixing one of them may not necessarily lead to a potential Pareto improvement—quite the opposite, in fact.

Diwan and Shafik’s analysis is an excellent illustration of these general principles. They start out with the situation where neither the international market for capital nor the international markets for emissions is functioning. As they note, this leads to two, interdependent, sources of inefficiency. They work out the consequences of establishing each market in turn, and the consequences of establishing both markets together. With the structure they put on their model, they are able to derive some sharp, insightful results on the impact on investment, choice of abatement technology and on emissions. For example, greater capital mobility on its own will lead to a migration of capital from the North to the poor but environmentally lax South. The overall increase in emissions may well make the North worse off, and although the South is likely to be made better off (because it values income more than the environment), it is not clear that there will be a potential Pareto improvement. Opening the capital market and creating a market for emission rights does lead to a potential Pareto improvement, but not necessarily to an actual Pareto improvement—even in this case, compensation may be necessary.

Diwan and Shafik have developed a convenient parametrisation to investigate numerically the implications of varying degrees of disparity between North and South for the consequences of different policy regimes, and an interesting area for further research is to identify those policy reforms that lead to actual Pareto improvements, as opposed to potential Pareto improvements. The idea here is quite simply that when one or the other party is set to lose as the result of a policy reform, side payments are needed. Moreover, the more heterogeneous the parties, the more likely it is that a greater volume of side payments are needed. It is then a question of whether there exist institutional arrangements that can effect these side payments. The developing world is littered with attempted agreements, like those on customs unions, that ran aground on the sands of cross payments. At the very micro level, one sees the same principle in operation in the failure of local common property resource management mechanisms (Kanbur, 1992). I would urge that Diwan and Shafik utilize their framework to investigate this issue further. They could, for example, calculate the total volume of side payments needed for alternative policy reforms to lead to an actual Pareto improvement, for a range of parametrisations of wealth inequality between North and South. This would give an indication of which reforms are likely to be on the starting block.
International Policy Coordination and Environmental Quality

Raed Safadi and Patrick Low

Introduction

Growing demands for environmental quality raise thorny problems for policy makers. Some of the most difficult choices to be made concern the interaction among sovereign states to address environmental degradation. Where environmental problems involve transfrontier spillovers (such as acid rain and river pollution) or the global commons (depletion of the ozone layer and the greenhouse effect), options open to governments range from unilateral action to cooperation through international agreements or treaties.

Unilaterally defined environment policies designed to address international pollution spillovers, especially on the part of large countries, are likely to entail the application (or at least the threat) of action against other countries perceived to be a source of environmental degradation. Whether such measures are characterized as retaliatory, punitive or offsetting, if they are unilaterally defined from an exclusively national perspective, they will be suboptimal. What this suggests is that international cooperation, in one form or another, is necessary for good environmental policy.

This paper contrasts two forms of international cooperation -- binding international agreements and implicitly cooperative arrangements. The former entail fully negotiated commitments; the latter are characterized by policies that are determined at the national level, but which are responsive to the international ramifications of environmental spillovers. As environmental issues have moved up the political agenda in many countries, support has grown for the idea that the only way to address problems of environmental degradation involving multi-country spillovers is through binding agreements on polluting emissions, production methods, or particular patterns of resource use. However, little empirical work has been undertaken on the costs and benefits of binding international agreements aimed at improving environmental quality. Yet there is growing clamor for such agreements, driven in no small part by public demand for governments to "do something."

The paper focuses on a game-theoretic model of implicit cooperation, where through continued interactions between them, and in the face of a credible trade policy threat, governments unilaterally adopt policies which take into account environmental impacts in other countries. In other words, governments are

---

1 There is growing literature on such agreements, particularly in relation to the global commons. See for example Grubb (1989) and Nitze (1990).

2 For critical treatments of an uncritical predilection for international agreements, see Lal (1989), Hahn and Richards (1989), and Robertson (1990). In the field of monetary policy, there has been a fair amount of work generally showing that the gains from explicit cooperation are small. See: Canzoneri and Minford (1986, 1987), Hughes-Hallett (1986a, 1986b, 1986c), Oudiz and Sachs (1984) and Currie, Levine and Vidalis (1987).
assumed to adopt pollution abatement and control (or resource conservation) policies that accept a shared responsibility for global environmental degradation. Internal pressures of one sort or another may induce governments to behave in this way, but the key incentive modelled here for such behavior is the presence of a foreign retaliatory threat if a party is considered not to be "pulling its weight."

The retaliatory threat used in this model is a pollution tariff, which is unlike the kind of enforcement mechanism that might be encountered under a binding international agreement. In practical terms, the attraction of trade measures for such purposes is that effective action can be taken against an offending party without that party having to cooperate in his own punishment (as would be the case, for example, with fines).

It is important to note, however, for the purposes of our model, and more generally in respect of environment policy, that a pollution tariff is only a second-best policy, since it is imposed in the interest of the importing country and does not take account of global welfare. Although in principle a tariff can play a somewhat similar role in addressing transfrontier externalities as that played by a Pigouvian tax within a country, they are not perfect substitutes. Take, for example, a polluting country that levies an emission tax to close the wedge between social and private costs, while another affected country imposes a tariff equal to its marginal damage. The resulting tax and tariff combination will generally not yield the resource allocation that would have resulted if the polluting country had imposed an internationally optimal Pigouvian tax on its emissions, or in other words, a tax equal to marginal damage in all countries taken together.

Our model does not prove that implicit cooperation is superior to binding agreements. Rather, it shows that under specified assumptions, arrangements other than fully negotiated agreements or treaties may be equally effective in addressing environmental problems at the international level. This result establishes the case for thinking carefully about the design and content of international cooperative arrangements. It should not be assumed that the only way to address cross-border environmental externalities is for governments to sit around a table and pledge to limit emissions to specified amounts or to adopt particular resource use policies.

Whether or not binding agreements turn out to be the preferred approach depends on a series of factors that cannot be adequately addressed here. It is clear, however, that there are certain costs associated with formulating and implementing binding agreements. Moreover, they may divert attention from domestic initiatives to improve the environment and can promote "lowest common denominator" outcomes in terms of substantive commitments. On the other hand, without binding agreements, it is questionable whether governments will be adequately responsive to the international consequences of their actions (or lack of them). Implicit cooperation may turn out to be unstable, in which case the triggering of punitive action produces an unequivocally inferior outcome compared to a properly functioning binding agreement.

Throughout the discussion, it is worth bearing in mind that the options posed in this paper -- binding agreements and implicit cooperation -- are different points on a spectrum of forms of international interaction. The difference between the them is not as stark, for example, as that between autarky and free trade. Binding

---

3 This is a common approach in the literature. See, for example, Baumol and Oates (1975).

4 It is noteworthy that few if any existing international agreements, including the Convention on International Trade in Endangered Species, the Montreal Protocol on Substances that Deplete the Ozone Layer, and the Convention on the Transboundary Movement of Hazardous Waste, provide for retaliation. Rather, where agreements do contain trade policy provisions, these are to give effect to commitments and not to punish noncompliance. Retaliatory trade policy provisions, however, are likely to become features of such agreements in the future.
international agreements can be more or less specific and detailed, and implicit cooperation can take many forms, ranging from casual exchanges of information to highly structured coordination. Another point to stress is that wherever one comes down in terms of the degree of explicit policy commitment required for the conduct of good environmental policy internationally, any arrangements must necessarily be self-enforcing. Cooperation cannot be forced upon sovereign governments.

The next section of this paper presents the model (the model is specified formally in an appendix). Then we discuss some of the factors that would go into determining whether a binding agreement is to be preferred to a less explicit form of cooperation. Finally we present our conclusions.

The Model

To make the analysis tractable, we restrict our attention to two countries which we call the "home" country and the "foreign" country (we will have more to say about the consequences of this restriction later). Both countries are engaged in international trade in two commodities (x and y). The production of good x in both countries generates pollution, some of which remains in the country and the rest spills over to a common environment G. It is assumed that the only policy instruments available to each country are taxes (domestic taxes and import pollution tariffs). It is further assumed that welfare in the "home" country and the "foreign" country can be respectively represented by

\[ W = W(C_x, C_y, G) \]
\[ W^* = W^*(C'_x, C'_y, G) \]

where C refers to the consumption of the subscripted goods. W and W* are increasing in their first two arguments but decreasing in their third. The maximum welfare that each country can attain is constrained by its balance of payments condition.

We begin by assuming that the two countries are to play the game only once, and that no binding agreement exists between them. It is natural to begin by considering the Nash noncooperative equilibrium. The Nash noncooperative equilibrium indicates how each country should set its own tariff to maximize its own welfare (subject to the balance of payments constraint), while taking as given the tariff level of the other country and the state of the environment. This maximization gives rise to conventional reaction functions for the two countries (in the tariff space), and their intersection marks the Nash noncooperative solution. What characterizes the Nash outcome is that both countries end up charging a positive tariff (see equations (16) and (17) in the appendix), and in this sense, the outcome of this one-shot game is inefficient. This is an instance of the familiar Prisoners' Dilemma, where both countries would be better off if they agree to internalize their externalities.

The Pareto efficient combination of tariff policies is obtained by setting the relative price of good x in the home country equal to that in the foreign country. This traces a continuum of efficient equilibria, with free trade being one of them (see equation (19) in the appendix). However, in the absence of a binding agreement, the efficient equilibria lack credibility since these solutions do not lie on the countries' reaction

---

5 The home reaction function is defined by \( \frac{\partial W}{\partial t_h} = 0 \), and that of the foreign country is given by \( \frac{\partial W^*}{\partial t_f} = 0 \). Both are negatively sloped, and it is assumed that they have a unique intersection which is the Nash equilibrium of the noncooperative tariff game. See Mayer (1981) for a discussion on reaction functions in the tariff space.
functions. Therefore, the portrayal of the interaction between two countries as a one-shot game offers a strong justification for binding international agreements. And, if one is to believe that international environmental agreements are subject to the Prisoners' Dilemma syndrome, then binding agreements require incentive systems in the form of side payments to potential defectors. This, as Müller (1990) notes, requires the reversal of policy from the polluter-pays principle (PPP) to the victim-pays principle (VPP). Sweden's technical assistance program to reduce acid emissions from Poland is such an example, as are the currently negotiated technology transfers to China and India with respect to chlorofluorocarbon (CFCs) emission reductions under the Montreal Protocol.

However, in the real world, games are repeated. Repeated games allow countries to take advantage of quid pro quo strategies. They foster the possibility of players learning to cooperate, in the knowledge that they will be accountable in a subsequent period for their behavior in the current period. So, we extend the one-shot game to a multi-period setting in which quid pro quo strategies take the form of an intertemporal trigger mechanism that punishes deviant behavior in a previous period. It is the presence of the trigger mechanism (credible threat), taking the form in this case of a punitive pollution tariff, that allows an efficient outcome to be achieved in a noncooperative game.6

Game theorists have shown that trigger mechanisms allow players to achieve the same efficient outcome that would result from cooperation in a wide class of repeated games.7 Trigger strategy equilibria explain how rational, self-interested agents who interact repeatedly can achieve Pareto-efficient outcomes even though binding agreements are not possible. Trigger strategy equilibria may be considered as self-enforcing agreements in which the enforcement mechanism is a threat made by all players that, in the event the agreement is violated, they will change their actions to those corresponding to a single period noncooperative equilibrium (the Nash outcome), with payoffs that are worse for every player than the cooperative payoffs.8 Thus the trigger mechanism can eliminate the need for binding agreements.

In what follows, we shall introduce two games -- a deterministic and a stochastic one. In the stochastic game, there is uncertainty in the current period about the level of pollution that will be experienced in the next period, whereas in the deterministic one the outcome is known in all future periods. If we accept that in practice countries will attempt to avoid incurring the punishment implicit in the trigger mechanism, then the outcome of the nondeterministic game will not be entirely stochastic or random in each period. Outcomes will still have some uncertainty attached to them (because mutually explicit commitments to given targets are absent), but with reduced likelihood of triggering punishment. The closer this pattern of outcomes resembles a deterministic game, the nearer is the equivalence of outcomes between an implicit arrangement and a binding agreement.9 Thus, while trigger mechanisms achieve more efficient outcomes than a repeated play of one-shot Nash outcomes, there is still a need for binding commitments in "bad" periods. In this sense, trigger mechanisms are not a perfect substitute for cooperation.

---

6 For a textbook exposition of trigger mechanisms, see Friedman (1990).

7 Trigger mechanisms would also work in finitely repeated games provided that (1) the one-shot game has multiple solutions, or (2) policymakers are uncertain about opponents' preferences or strategies. Aside from the trigger mechanism, a reputational approach could also be used. See Kreps, et al. (1987) for a discussion of this approach.

8 Ibid. p. 126.

9 A fully deterministic game and a binding agreement amount to the same thing. This will be shown below.
Let the game described above be repeated, again and again. The timing of events is as follows: at the beginning of each period both the home and the foreign countries learn the realization of \( G \). They then simultaneously choose the levels of their tariffs, and these choices determine the outcome for that period. The strategic choices of the home and the foreign countries become common knowledge, and this one-period game is repeated after a new \( G \) is realized. In any given period, the policymakers in each country know that the game will be repeated by them or their successors. If, in this sense, policymakers live forever, we have an infinitely repeated game.

In period \( t \), the home and the foreign countries maximize \( V_t \) and \( V^*_t \), the discounted sums of current and expected future welfare:

\[
V_t = W_t + E_t \sum_{i=1}^{\infty} \delta^i W_{t+i} \\
V^*_t = W^*_t + E_t \sum_{i=1}^{\infty} \delta^i W^*_{t+i}
\]

where \( \delta \) is the discount rate. Both countries have already observed \( G \), and can therefore calculate current welfare; future welfare depends upon \( G_s \) (and tariffs) that have yet to be realized. In what follows, we first assume that the structure of the game does not shift from period to period (i.e., \( G \) is known in every period, or in other words, the game is deterministic). As just discussed, this is not a particularly helpful assumption from our perspective, because the result is much like a binding agreement.

Suppose that the home country exports good \( x \) and imports good \( y \). Good \( x \) is subject to a tariff instituted by the foreign country (\( t^\dagger \)), while good \( y \) faces a tariff equal to \( t^\gamma \) in the home country. Denote a cooperative tariff level by a superscript \( E \), and a "cheating" tariff level by a superscript \( C \). Then if, for instance, the home country decided to cheat in some period (by playing \( t^c \)), then its welfare in that period will be \( W^C \) which is larger than \( W^E \). So the temptation for the home country to cheat in any given period is:

\[
\text{Temptation} = W^C(t^c, t^E, G_t) - W^E(t^E, t^E, G_t)
\]

If, however, the home country decides to stick to the agreement (by playing \( t^\dagger \) instead of \( t^c \)), its welfare in the next period will be \( W^E \) which is larger than \( W^N \). So deterrence (or the reward for playing \( t^\dagger \)) is given by:

\[
\text{Deterrence} = \delta \{ W^E(t^E, t^E, G) - W^N(t^E, t^N, G) \}
\]

where \( \delta \) is the discount factor (the deterrence is discounted by the factor of \( \delta \) since it accrues in the next period). Thus, deterrence will outweigh temptation if
If this inequality holds, the story ends here. We have a trigger mechanism that gives both countries an incentive to play the efficient tariffs every period.10

However, in our present context, the countries' intertemporal strategies will be complicated by the fact that the temptation to defect from the efficient solution fluctuates from period to period.11 In other words, the temptation to cheat is stochastic since a new $G$ is realized in each period. If the level of environmental degradation $G$ is unbounded, then so is temptation. Trigger mechanisms are intended to deter cheating, with deterrence measured by the value of obtaining the efficient outcome $E$ rather than a bad outcome, say $N$, over all future periods. Since future values of $G$ are not known, deterrence must be defined in terms of expected values. These expected values are bounded; so in periods in which a large $G$ is drawn, temptation will outweigh deterrence, and the Friedman trigger mechanism will fail.

The trigger mechanism will not support the efficient outcome in any period in which the level of $G$ is "too large." Even if no country had cheated, the efficient equilibrium can be played in period $t$ only if

$$G_t \leq h$$

where $h$ is a certain high level of pollution (see appendix).12 Once we recognize that the efficient outcome may not be attained, we need to define cooperation less ambitiously; namely, the efficient tariffs are implemented so long as the level of $G$ is not too large; otherwise, in periods of extreme values of $G$, the one-
shot Nash tariff levels are implemented. Thus punishment is defined in the usual way, i.e., as Nash reversion. With this modified version of cooperation, the trigger mechanism just introduced is then the standard one: "cooperate as long as my opponent does likewise; otherwise punish."

More formally, consider the following strategies for repeated games. Strategy $S_1$ is to play $t^y (t^x)$ each period. $S_1$ is a Nash strategy for the repeated game; if one country adopts it the other country can do no better than adopt it as well. In the Nash equilibria that results, $t^y, t^x$ will be the outcome in every period. However, the trigger mechanism introduced above suggests that a better equilibrium also exists. Define strategy $S_2$ as follows: (i) in period 1, observe $G$, and play $t^y (t^x)$ if inequality (4) holds, otherwise play $t^y (t^x)$; and (ii) in periods $t = 2, 3, \ldots$, play $t^y (t^x)$ if the other country has cheated in the past; if not, play $t^y (t^x)$ if inequality (4) holds and $t^y (t^x)$ if it does not. This strategy recognizes that the trigger mechanism does not provide the right incentives when $G$, is large; it simply says to revert to $t^y, t^x$ in those periods.

For a suitable value of $h$, $S_2$ is a Nash strategy of the repeated game. Suppose that the foreign country has adopted $S_2$, and ask whether the home country can do any better than adopt $S_2$ in response. If the home country does not adopt $S_2$, then $t^y t^x$ will be the outcome when $G \leq h$ and $N$ will be the outcome otherwise. The only alternative worth considering is to cheat when $G \leq h$. But if $h$ is chosen as the value of $G$ with the property that temptation and deterrence are equal, and if $G \leq h$, the gain from cheating is less than the discounted expected future gain from cooperation. Thus the home country will adopt strategy $S_2$. By symmetry, if the home country adopts $S_2$, then the foreign country can do no better than adopt $S_2$ in response. $S_2$ is therefore a Nash strategy for the repeated game.

**Implicit Cooperation versus Binding Commitments**

In this section we discuss some of the considerations that would influence the choice by governments of the kind of cooperative arrangements to be settled upon internationally for dealing with environmental externalities. The discussion builds on key features of the model developed in the previous section, and on certain observations about the nature of binding international agreements.

**The Number of Countries Involved**

Our model is based on the interaction between two countries, and although this analytically convenient device could be dropped without invalidating the basic thrust of the results, the fact remains that the stability of any kind of international cooperative endeavor is likely to be influenced by the number of parties involved. The more parties there are to a negotiation or an arrangement, the higher become the transaction costs. It is unclear, *prima facie*, whether the difficulties associated with large numbers are more severe under implicit or binding arrangements.

It is easy to see how implicit arrangements relying on cooperation among many countries might be destabilized by disagreements between a few, and how binding arrangements might lessen such difficulties by establishing mechanisms for dealing with disputes. But binding commitments are likely to be difficult to achieve at all if the participation of a large number of countries is required. Barrett (1990b), for example, argues that the binding agreement underlying the Montreal Protocol on CFCs was only possible because relatively few countries were involved, and because the costs of substituting CFCs in several major uses was

---

13 This is nowhere more clearly illustrated than in the trade negotiating rounds of the GATT, where the ever growing number of parties involved in negotiations has created significant coordination and decision-making problems.
not great. These conditions clearly would not apply in the case of binding agreements dealing with the greenhouse gases problem.

**Small and Large Countries**

An important limitation of our model is the requirement that all players possess a credible threat. According to our assumptions, the basis for implicit cooperation does not exist if action is required from small and large countries to address an environmental externality. Small countries will have no means of ensuring that the behavior of large countries is consonant with their share of responsibility for internalizing the externality. On the other hand, it is unclear how much more successful small countries would expect to be in this regard under a binding agreement. Explicit precommitment at the international level may help in imposing discipline on one country in the absence of a credible threat from another. A binding agreement could, of course, contain provisions for joint retaliation in the event that a large country ignores its obligations to a small one. But there does not seem to be any existing example of an international agreement under which such a commitment has been accepted.

An important point to consider is how far the cooperation of small countries is actually required in order for action to be taken against pollution externalities. If a country makes a negligible or modest contribution to global environmental problems, should its commitment (binding or implicit) be regarded as essential to effective international action? There will always be an issue at the margin as to how a small country should be defined, and there is the point that many small countries can be important in the aggregate. Nevertheless, there are likely to exist small countries whose actions are unimportant in this context. To the extent that action by small countries is not required in order to deal with international pollution externalities, the structural limitation of our model of implicit cooperation relating to the trigger mechanism becomes less important.

**The Role of Uncertainty**

The presence of uncertainty is a crucial element in the determination of appropriate policies to address international pollution externalities. It has already been seen from the model that if the outcome in each period is random, a binding agreement is superior to implicit cooperation, with its attendant risk of reversion to the Nash equilibrium if pollution $G$ exceeds a certain level $h$. We have also argued that the presence of the trigger mechanism would provide an incentive for countries unilaterally to adopt policies that would lead to bounded expected values of $G$. The empirical issues relevant to the choice between explicit and implicit cooperation are how successful countries will be in avoiding pollution level $h$ when they act individually, and how much iteration is required through repeated interactions before such a stable equilibrium is attained.

Other important sources of uncertainty concern the very nature of the pollution or resource depletion problem and the effects of remedial action. These are perennial issues in debates about the dissipation of the ozone layer and the accumulation of greenhouse gases. Similarly, the actual level of pollution emissions for which individual countries are responsible may be a source of contention. In addition, there is the well-known problem of revealed information -- countries may be tempted to conceal their true environmental preferences in the hope of being able to free-ride on the policies of others. The relevant question is whether arrangements among countries that fall short of binding agreements can adequately address these kinds of uncertainty.

---

14 The relative contribution of various countries to global pollution problems remains uncertain. In general, however, it is clear that a few countries account for by far the greater part of environmental degradation. For a discussion of countries' emissions of fossil fuel carbon, see Flavin (1990a), Whalley and Wigle (1991) and Whalley (1991).
However, the establishment of mechanisms for frequent and full exchanges of information among governments may prove an effective alternative to binding agreements. Consideration of this mechanism is especially warranted since, as is shown in the model, there exist many welfare-improving equilibria, and through the exchange of information, countries could focus on a particular one.

The presence of uncertainty is likely to make it more difficult for governments to draw up binding agreements, since each source of uncertainty represents a potential area of disagreement. There may well be circumstances in which environmental quality would be better served by focusing on domestic policies alongside the development of adequate international information exchanges, rather than pursuing the more elusive course of negotiating a fully fledged international agreement.

**Costs of Binding International Agreements**

There are some costs associated with binding agreements that may be obviated under implicit cooperative agreements. First, binding agreements are likely to take significant time to negotiate, particularly in the face of uncertainty as to what is at issue. Domestic action on the environmental front might be postponed, or perhaps not even defined, while governments concentrate on extracting commitments from each other. This is a process that could take years. Secondly, once binding agreements are drawn up, there are costs associated with their implementation, including in relation to verification of compliance.

Another issue to consider is whether international negotiations modify the objectives of governments, or lead to outcomes that are more modest, in terms of addressing environmental degradation, than those that would be achieved through a domestically oriented policy formulation process. There may be a tendency for lowest common denominator outcomes to predominate, where the negotiating party least willing to adopt policies to address environmental degradation is the one that determines the level of commitment accepted by all parties. Similarly, by focusing on international negotiations, and on what other countries should do, governments deflect attention away from their own action (or inaction). In this vein, one might speculate whether the declared interest of the European Community in seeking international commitments on an oil-based carbon tax exerts any influence over its position on the domestic use of coal. Coal is considerably more polluting than oil.

Finally, a potential cost of binding international agreements to consider is the influence that they may have on the content of environmental policy in terms of efficiency. One source of inefficiency is reliance on measures of direct control. It is generally easier to express international commitments in terms of explicit quantitative limits than to develop more sophisticated instruments for pollution abatement and control, such as those that operate through the price system and embody incentives for efficient abatement. The Montreal Protocol, for example, is based on quantitative targets, although in this case the objective of the complete elimination of CFC production makes the choice between quantity and price-based approaches somewhat academic. Much existing domestic environmental policy relies on direct controls, and efforts to

---

15 See Whalley (1991) and Winters (1991) on estimates of carbon taxes necessary to address the greenhouse effect.

16 Implicit arrangements are also likely to carry verification costs.

17 For an analysis in these terms on the Montreal Protocol on Substances that Deplete the Ozone Layer, see Bohm (1990).

18 See Eskeland and Jimenez (1991) for a survey of available policy instruments for pollution control.
develop more efficient policy approaches will tend to be short-circuited if international commitments come to dominate domestic environmental policy.

A second source of inefficiency would be an imperative to seek uniform commitments from all parties to an agreement. This kind of enforced harmonization, both in terms of the policy approach adopted and the substance of the commitment, could carry significant costs. Harmonization along these lines ignores variations among countries in pollution absorptive capacities and differences in cost-benefit structures of pollution abatement and control policies. The need for harmonization is not intrinsic to binding international commitments, but the difficulties of negotiating differentiated commitments will make it tempting to pursue a uniform approach.

Conclusions

This paper has developed a model of implicit cooperation that could serve as an alternative to binding international agreements to address international environmental externalities. The formal model does not establish that implicit cooperation is superior to a binding agreement, but identifies the circumstances in which these two approaches may be equally efficient among countries of comparable size that are able to wield credible retaliatory threats against each other. The choice between the two approaches depends on a number of circumstantial factors, which are also briefly discussed. These factors include conditions determining the stability of equilibria under the two scenarios and certain deadweight costs associated with international negotiations.

In general, it is argued that implicit cooperation may prove more effective than binding agreements where reasonably well defined environmental policy objectives can be established among a few countries, and where countries are willing to cooperate through the exchange of information. This conclusion is based on the transactions costs and likely behavioral responses associated with the negotiation of binding international commitments.

Just as explicit and well defined environmental objectives shared by a few key players make implicit cooperation an attractive approach, the absence of these conditions adds to the difficulty of successfully negotiating binding international agreements. An emphasis on implicit cooperation, driven by a primarily domestic focus on environmental policy will be preferable, in these circumstances, to an agreement among governments to talk and talk. This suggests that in all cases, governments should consider the alternative of emphasizing implicit cooperation based on domestic policy initiatives (albeit backed by credible retaliatory threats) prior to launching negotiations on binding international agreements. The optimistic message offered by this analysis is that there is scope for constructive action to address international environmental externalities even if governments prove unable or unwilling to make explicit, binding international commitments with respect to environmental quality.
Appendix

The model presented here is an extension of that of Vandendorpe (1972), Markusen (1975) and Thursby and Jensen (1983). Vandendorpe (1972) developed optimal tax structures in a model with traded and non-traded goods without any externalities. Markusen (1975) calculated optimal tax structures in the presence of externalities but did not consider any strategic interactions. Finally, the model borrows from the works of Thursby and Jensen (1983a) and (1983b) the idea of the existence of a consistent conjectural variation in the strategic tariff equilibria.

The world economy is made up of two countries, the home country and the foreign country. Variables with asterisks are foreign country variables. The two countries are assumed to be producing and trading two goods \((x, y)\) and \((x^*, y^*)\), and pollution is a function of the domestic and foreign production of good \(x\). We ignore the waste being released into the environment by the consumption sector. We further assume that pollution does not affect the production functions and there is no possibility of substitution among inputs or outputs such that the amount of pollution resulting from a given level of production can be varied. The basic model is described by the following set of equations:

\[
\begin{align*}
W^i &= W^i(C^i_x, C^i_y, G) \\
G &= G(x, x^*) \text{ and } dG = G_1 dx + G_2 dx^* \\
F'(x^i, y^i) &= 0 \text{ or } y^i = T(x^i) \\
p^i &= \frac{F^i_x}{F^i_y} = -T^i_x \text{ and } dp^i = -T^i_x dx^i \\
&\quad \text{or } dx^i = (-T^i_x)^{-1} dp^i = R^i dp^i \\
q^i &= (1 + \theta^i)p^i \\
x^i + E^i_x = C^i_x \\
y^i + E^i_y = C^i_y
\end{align*}
\]
(7) \[ E_y + q \tau_y E_x = 0 \]

(8) \[ \tau_x E_y^* + q^* E_x^* = 0 \]

(9) \[
E_x + E_x^* = 0 \\
E_y + E_y^* = 0
\]

(10) \[ \tau_x = 1 + \tau_x \quad \tau_y = 1 + \tau_y \]

(11) \[ \pi = \frac{q^*}{\tau_x} = q \tau_y \]

where

\( G \) denotes pollution
\( C_i \) denotes consumption of good \( j \) in country \( i \), \( i = \text{home, foreign} \), \( j = x, y \).
\( x^i, y^i \) denote production of good \( x \) and good \( y \) in country \( i \)
\( E_i \) denotes excess demand for good \( i \) in country \( i \)
\( p^i \) denotes the relative producer price of good \( x \) in country \( i \)
\( q^i \) denotes the relative consumer price of good \( x \) in country \( i \)
\( \theta \) denotes production tax on good \( x \) in country \( i \)
\( \pi \) denotes the world relative price of good \( x \)

Equation (1) defines the welfare functions in the home and foreign countries to be functions of the respective consumptions of the two goods and pollution. The functions \( W \) are assumed to be continuous, twice differentiable, and quasi-concave. Welfare is assumed to be increasing in consumption and decreasing in pollution. Equation (2) defines pollution to be additive where \( G_i \) represents the partial derivative of \( G \) with respect to its \( i \)th argument. The special case of \( G_2 \) refers to the case where the externality is purely in the home country. Equations (3) define the production possibility curves which are assumed to be concave, while (4) specify the usual marginal product conditions for optimality. Equation (5) describes the relationship between the relative producer price of \( x \) in the two countries. Equations (6) define excess demand as the difference between consumption and production. For the import good \( E > 0 \), while for the export good \( E < 0 \).\(^1\)

Equations (7) and (8) describe the balance of trade equilibrium for the two countries, while equations (9) specify market clearing in world markets for the two goods. Assuming zero transport costs, equation (10)

\(^1\) Under our assumption \( E_y > 0 \), and \( E_x^* > 0 \).
specifies the relationship between the relative prices of the two goods in the two countries and the tariff being levied. It is clear from equations (7), (8) and (9) that the goods markets are not both independent; by Walras' law equilibrium in one implies equilibrium in the other, so that one equation, say the first one in equation (9) can be dropped.

**Derivation of Pigouvian Taxes**

The presence of an externality creates a divergence between the domestic rate of substitution in consumption (RSC) and the domestic rate of transformation in production (RTP). Under these circumstances Bhagwati and Ramaswami (1963) demonstrated that the Paretian first-best policy is to intervene with a tax at the point at which the distortion occurs. Thus a Pareto optimal state in the home country is defined where:

\[
\frac{\partial W}{\partial C_y} + \frac{\partial W^*}{\partial C_y} = p
\]

or \( q + q_0 G_1 = p, \quad q_0 < 0 \)

Similarly, in the foreign country:

\[
\frac{\partial W^*}{\partial C_y^*} + \frac{\partial W^*}{\partial C_y^*} = p^*
\]

or \( q^* + q_0^* G_2 = p^*, \quad q_0^* < 0 \)

where \( q_0 (q_0^*) \) is the social marginal rate of substitution between pollution and good \( y \) in the home (foreign) country, and where we have made use of the competitive equilibrium condition \( W_i/W_y = q^i (i= \text{home, foreign}) \).

Using equation (5), the optimal production tax in the home and foreign countries is given by:

\[
\theta = -\frac{q_0 G_1}{p} > 0 \quad \text{and} \quad \theta^* = -\frac{q_0^* G_2}{p^*} > 0
\]

**The Nash Tariffs**

In this Section we characterize the set of Nash equilibria when countries choose tariffs as punishment. These equilibria will serve as credible punishments (i.e., they are subgame perfect) in the dynamic game considered in Section C, the threat of which can support tacit cooperation in a repeated setting.
Consider first the home country. Substituting equations (4) (6) and (13) in its welfare function (equation 1) and totally differentiating it yields the first order condition for an optimum:

\[
\frac{dW}{dW/dC_y} = q dE_x + dE_y + q_0 G_2 R^* d\pi^* = 0
\]  

(15)

Next, using the differential of the home and foreign balance of payments (equations 7 and 8) and using equations (9) and (10) and the relation between domestic prices and the world prices (equation 11), and grouping terms yields the optimal tariff formula:

\[
t_N = Y_t x - \gamma - \frac{\gamma^*}{\hat{E}_x^*} - \frac{t_N}{e - 1} \text{ where } e = -\frac{\hat{E}_x^*}{\hat{F}_x^*}
\]  

(16)

where a hat over a variable denotes percentage change, and where \( e^* \) is the elasticity of the foreign country's demand for imports along its offer curve. This equation, except for the last two terms, is identical to the one derived by Jensen and Thursby. An analogous derivation for the foreign country yields:

\[
t_F = Y_t y - \gamma - \frac{\gamma^*}{\hat{E}_x^*} - \frac{t_F}{e - 1} \text{ where } e = -\frac{\hat{E}_x^*}{\hat{F}_x^*}
\]  

(17)

where \( e \) is the elasticity of the home country's demand for imports along its offer curve.

Equations (16) and (17) define respectively the home and foreign country's Nash reaction functions in the \((t_x, t_y)\) space. The Nash reaction function tells a country how it should set its tariff to maximize its welfare given the tariff of the other country and the size of the spillover. The intersection of these two reaction functions give the Nash equilibrium of the noncooperative tariff game. \( \hat{t}_x/\hat{F}_x \) is interpreted as the home country's conjecture about how the foreign country will react to a change in its terms of trade induced by a change in \( t_x \). Likewise \( \hat{t}_y/\hat{F}_y \) refers to the foreign country conjecture on how the home country will react to a change in its terms of trade induced by a change in \( t_y \). In what follows, we will assume, as in Jensen and Thursby, that these "conjectural variations" are constant with \( C \) and \( C^* \) denoting that of the home and foreign country respectively. Note that setting \( C = C^* = 0 \) in equations (16) and (17) respectively (that is no retaliation is anticipated) yields the traditional Cournot optimum tariff.

Now consider the case where the home country contemplates raising its tariff. It expects \( \hat{t}_x/\hat{F}_x > 0 \) if the foreign country does not retaliate. However, the foreign country will have to increase its tariff \( t_y \) in order to offset the worsening of its terms of trade (\( \hat{F}_y > 0 \)) caused by the increase in the home country tariff rate. Therefore, if the home country believes that the foreign country is maximizing its utility, then the home country should conjecture \( C = \hat{t}_x/\hat{F}_x > 0 \) where the change in \( \pi \) is induced by the change in \( t_x \). Likewise, if the foreign country expects \( \hat{t}_y/\hat{F}_y < 0 \) in the absence of retaliation but believes that the home country will

\[\text{Similar games with non-zero conjectural variations have been studied by Cornes and Sandler (1984, 1985).}\]
increase \( t \) in an attempt to offset the worsening of its terms of trade, then the foreign country should conjecture \( C^* = \bar{r}/\bar{x} < 0 \). Thus, given our assumption of constant conjectural variations, these must satisfy \( C \geq 0 \geq C^* \).

The first term in either equation (16) or (17) is the well-known optimal tariff for the two goods case in the absence of externalities. The last two terms in either of these equations result from the environmental spillover that each country imparts on the other. Both these terms are positive (\( \epsilon \) and \( e' \) are both greater than one and \( C \geq 0 \geq C^* \)). These two terms will vanish if the spillovers are zero (this is equivalent to setting \( \gamma^* \) in equation 16 and \( \gamma \) in equation 17 to zero). Note that if the victimized country faces a foreign offer curve which is infinitely elastic, then its optimal tariff is equal to zero.

*The Efficient Solution*

We begin by transforming the welfare functions given in equation (1) from the commodity space into the tariff space. This is because we are interested in the relation between economic welfare and tariff rates, thus

\[
W = W(t, t', G) \quad W^* = W^*(t, t'; G)
\]

the functions \( W \) and \( W^* \) are twice differentiable and quasi-concave with the first derivative with respect to own tariff being positive and otherwise negative. Equations (18) give the home (foreign) country's maximum attainable utility given the home and the foreign country's tariff rates \( (t, t') \) for every \( G \).

The Pareto efficient combinations of tariff policies requires that the relative price of \( x \) to be the same in the two countries. Equating \( q \) and \( q^* \) in equation (11) yields:

\[
\frac{r_x^*}{r_x} = 1 \quad \text{or} \quad (1 + t_x^*)(1 + t_x) = 1
\]

Equation (19) reveals that free trade (i.e., \( t_x = t_y = 0 \)) is on the Pareto efficient loci. Notice that equation (19) gives rise to a continuum of efficient policies where one country or the other subsidizes imports. Thus we have the traditional multiplicity of Pareto efficient equilibria.

*Trigger Strategies in Infinitely Repeated Externalities Game*

The timing of events is as described in the text. In period \( t \), the home and the foreign countries maximize \( \mathcal{V}_t \) and \( \mathcal{V}_t^* \), the discounted sums of current and expected future welfare:

---

3 See for example, Bhagwati and Srinivasan (1983) or Takayama (1974).

4 Recall that the optimal tariff of one country refers to a point on the elastic portion of the other country offer curve.

5 This transformation is possible only if trading equilibria are unique which we will assume.

6 One can transform \( \partial W/\partial t \) and \( \partial W^*/\partial t \) into the optimum tariff formulae that are specified in equations (16) and (17). This is the approach taken by Mayer (1981).

7 It is well-known that multi-period games generally have a multiplicity of Pareto-improving solutions. See for example Rogoff (1987) or Mayer (1981).
\[ V_t = W_t + E \sum_{i=1}^{\infty} \delta^i W_{t+i} \]
\[ V_t^* = W_t^* + E \sum_{i=1}^{\infty} \delta^i W_{t+i}^* \]

where \( \delta \) is the discount rate.

Both countries have already observed \( G_i \) and the tariff rates and can therefore calculate current welfare; future welfare depends upon \( G_i's \) (and tariffs) that have yet to be realized.

One might try to apply Friedman's trigger mechanism in this setting, but the countries' intertemporal strategies will be complicated by the fact that the temptation to defect from the efficient solution fluctuates from period to period.\(^8\) If the foreign country plays \( t^*_x \), the home country can gain:

\[ \text{Temptation} = W^E(t^*_x, t^*_y; G_t) - W^N(t^*_x, t^*_y; G_t) \]

by playing \( t^*_y \) instead of \( t^*_x \). The temptation to cheat is stochastic since a new \( G \) is realized in each period. If the support of \( G \) is unbounded, then so is temptation. Trigger mechanisms are intended to deter cheating, with deterrence measured by the value of obtaining the efficient outcome \( E \) rather than a bad outcome, say \( N \), over all future periods. Since future values of \( G \) are not known, deterrence must be defined in terms of expected values. These expected values are bounded; so in periods in which a large \( G \) is drawn, temptation will be greater than deterrence, and the Friedman trigger mechanism will fail.

The trigger mechanism will not support the efficient point \( E \) in any period in which the level of \( G \) is too big. Even if no country had cheated, \( E \) can be played in period \( t \) only if

\[ G_t \leq h \]

where \( h \) is determined as follows. If the home country does not cheat between periods \( t \) and \( t+i \), its expected welfare in \( t+i \) period is:

\[ E_t W_{t+i} = \int_0^h W(t^*_x, t^*_y, G) f(G) dG + \int_h^\infty W(t^*_x, t^*_y, G) f(G) dG \]

where \( f(.) \) is the probability density function of pollution. We can now calculate the deterrence against cheating that is embodied in the trigger mechanism. If the home country cheats, \( N \) will be played in all future periods; if it does not cheat, \( E \) will be played whenever \( G \leq h \). So, deterrence is the discounted sum:

\(^8\) A similar type of trigger mechanism has been developed in the macro literature by Canzoneri and Henderson (1988), and Safadi (1990).
\[ K = \left[ \frac{\delta}{1 - \delta} \right] \left\{ \int_{0}^{h} W^F f(G) dG + \int_{h}^{\infty} W^N f(G) dG - \int_{0}^{\infty} W^N f(G) dG \right\} \]

or

\[ K = \left[ \frac{\delta}{1 - \delta} \right] \int_{0}^{h} [W^F - W^N] f(G) dG \]

Since \( h \) is defined as the value of \( G \) with the property that the temptation to cheat against the efficient outcome equals the deterrence embodied in Nash reversion, we can write:

\[ W^C(t^C, t^E; G_i) - W^Z(t^C, t^E; G_i) = K \]

and the value of \( h \) is then determined by:

\[ W^C - W^Z = \left[ \frac{\delta}{1 - \delta} \right] \int_{0}^{h} [W^F - W^N] f(G) dG \]
Discussant's Comments

Patricia Annez

This paper provides us with a useful analysis of the process of international cooperation. Some will probably find the conclusion that formal agreements are not always necessary and potentially inferior to implicit cooperation controversial and disputable. But I think the more interesting points in the paper relate to how cooperation can work better and where it will run into difficulties, whether it is explicit or implicit.

One of the important messages of this paper is that countries can learn to cooperate whether or not this is formally recognized and codified in an agreement. It models a process where countries lose because they do not take into account that other countries can retaliate if the externalities are ignored. Learning from this painful experience, they can choose a mutually beneficial outcome—which involves adopting efficient policy interventions. In a sense, one could interpret the analysis as explaining how international agreements evolve, that is, how countries decide to collaborate rather than work at cross purposes. Implicitly, the paper also illustrates what cooperation for small countries can mean--they have no choice but to accept the priorities set by the large country. In the world portrayed by this model, equity concerns simply don't play much of a role. However, a small country, just as the "equal partner" modelled here, can still choose to implement the most efficient policy to address the environmental concern of the other country, and it is better off doing so. The important difference for the small country is that its views won't necessarily be taken into account.

It is interesting that this model shows that cooperation can emerge even if the two countries perceive or suffer from the problem differently. For example, if one country considers its damages from the polluting activity zero while the other country suffers (or perceives) high damages, cooperation will still result in a policy which takes into account both countries' views. Thus, cooperation in this framework does not require or necessarily bring about a consensus on environmental damage; it merely reflects the willingness of one party to punish the other based on its own priorities. One might also add that this has the implication that the presence of cooperation is not necessarily an indication that environmental priorities have been set correctly. The responsibility for this lies particularly heavily on the large countries that decide to set the agenda. If damages are assessed incorrectly, then all parties incur unnecessary costs even if they cooperate.

In the paper, fluctuations in pollution--referred to as uncertainty--play a major role in making a binding agreement an attractive option. Under implicit cooperation, if pollution is high enough in a given period, either party has an incentive to revert to noncooperative behavior because it perceives the other to be cheating on the agreement. The high pollution level might be due to lax policy enforcement or to a temporary failure of policy for reasons beyond the control of the policymakers--but the second country cannot tell. This "uncertainty" might be better described as incomplete information about the intentions of the counterpart. While the paper suggests that this problem could be overcome with a binding agreement, this problem of relating outcomes to the good intentions of one's partners could still persist. However, it is easier for formal arrangements to include means of verification and dispute settlement that would avoid the reversion to uncooperative behavior. Interestingly enough, relatively few international environmental agreements have included this feature.

If only implicit cooperation takes place, it would also be likely that the two countries would have difficulties interpreting the intention of the tariff wars--are they for controlling pollution or for improving the terms of trade? Thus, it seems that formal agreements might allow for exchanges of views that could sort these issues out more efficiently.
A puzzling implication of this paper concerns the "least common denominator" effect of formal agreements. The framework established here suggests that no large country needs to settle for less than a solution that reflects their concerns. Otherwise, they can simply refuse to cooperate and inflict punishment until the other party comes around. Yet this conclusion is not particularly appealing in light of experience. The paper argues that least common denominator solutions are less likely to come about in implicit cooperation but recourse to other factors than those modelled here is needed to explain that. The same is true for the proposition that formal agreements will come up with inefficient policies, such as across the board emissions reductions. Clearly, there are benefits from and constraints to formal agreements that cannot be taken up in this simple model. The useful lesson of this paper is that policymakers have more than one option for cooperation, each having its strengths and weaknesses in specific circumstances. It is worthwhile weighing the merits of all options -- unless of course the counterparts set their objectives as a specific form a cooperation rather than the efficient policy package.
Questions of environmental protection are being treated increasingly as international matters. Proposals for reducing pollution and environmental degradation are being pushed into the international arena and institutions with much wider responsibilities than the environment, such as the GATT and the OECD, are being captured for discussions of environmental issues. There are many motives for this, including over-zealous pursuit of single issues and evasion of difficult political questions. More worrying, however, is the failure to rationalize this trend and to analyze the effectiveness of these essentially economic institutions to deal with environmental problems.

Most environmental problems can be dealt with effectively at the national or regional level. Research and discussion at the OECD early in the 1970s established that the polluter-pays principle (PPP) was the most economically efficient and the most equitable approach to environmental policies. As long as damage to the environment and full resource costs are not incorporated into production costs there will be scope to improve the efficiency of resource allocation. Hence the objective is to internalize "externalities." Furthermore, PPP established the idea that polluting countries should bear the cost of controlling transfrontier pollution. The instruments to achieve PPP were not designated and governments have made their own choices to counter the causes of pollution, ranging from user fees and special taxes which internalize externalities, to assignment of property rights which create markets in pollution permits, and finally, to command and control methods (regulations). A recent OECD survey of instruments used in environmental policies showed that OECD countries' governments have preferred "command and control" measures. This selection has created competitive distortions and increased interest in international aspects of environmental policies.

The international dimension of environment policies has two components. First, international agreements are sought to manage degradation of the global commons and at the regional level to manage transfrontier pollution problems. Second, governments and industrialists argue for "harmonization" of national policies to allow "fair" competition, including environmental policies. These two kinds of international objectives are usually accepted uncritically and both receive wide support from environmental lobbies. The prospect of international cooperation of any kind gives a warm feeling!

In the case of global commons, the demand for an international agreement is largely a question of preventing free-riders; governments are unprepared to act without similar actions being taken by others. To reduce greenhouse gas emissions (GHG), for example, action by an individual country, such as a tax on carbon dioxide emissions, raises energy costs to industry and makes that country's outputs less competitive.

1OECD (1975).


3OECD (1989a).
on world markets at existing exchange rates, while everyone benefits from the reduction in the rate of increase in GHG. Similarly, reduced access to forests for logging decreases exports (and may increase imports), which advantages logging and wood-product industries in other countries at existing exchange rates, while any contribution this makes to slowing climate change or protection of species benefits everyone. An international agreement on GHG emissions or forest conservation would be intended to share the burden in an equitable manner across all countries. The low probability of an international agreement being reached in the first place, never mind enforcing it, makes this a popular prevarication for governments. In many instances arguing for global treaties leads to the neglect of local environmental problems which, if acted on, could contribute to easing the so-called global issues. For example, abatement of air pollution in major cities would bring benefits to their inhabitants as well as reducing GHG build-up. This "joint-product" aspect of local pollution abatement policies is often neglected.

Transfrontier pollution was one of the first environment-pollution problems to receive attention in international relations, through river and water catchment pollution and "acid" rain. PPP methods are difficult to apply because "upstream" polluters and their governments have no incentive to tax or charge polluters, because it would raise domestic costs of production, while benefiting downstream users and consumers. In these circumstances, threats of sanctions have been tried, but they are difficult to apply without trade discrimination. The most efficient approach was found to be "victim-pays policies" (VPP), which involve the injured party bribing the upstream polluter to act. This modification to PPP still has the advantage of using economic instruments to seek efficient solutions.

Harmonization appears to be a benign approach to global or transfrontier problems. Harmonization may be defined as the coordination of policies and instruments to reduce international differences and to facilitate international competition. It is intended to increase global efficiency by reducing distortions in international economic relations. This paper will attempt to assess the value of international policy harmonization. It begins with a theoretical assessment of the role of harmonization in international economic relations and then reviews the results of practical harmonization in the GATT. Finally, it considers the place of harmonization in the environment debate.

Harmonization and Trade

Over the past 40 years the world economy has become progressively more integrated with the dismantling of many barriers to trade, especially tariffs, deregulation of capital markets, adoption of flexible exchange rates and revolutions in transport and communications. In the same period, proposals for harmonization or convergence of economic policies, have increased. This has now spread to include proposals to harmonize environmental policies and standards.

The most significant target of international harmonization has been trade policy, where under GATT auspices negotiated reductions in tariffs have contributed to rapid economic growth in the past 45 years. (More extensive reductions in trade barriers have occurred in regional free trade arrangements according to article XXIV of the GATT.) In general, however, liberalization of trade barriers does not require harmonization of other economic policies. Arguments that policies on the environment should be harmonized to avoid the creation of new trade restrictions demonstrate misunderstanding of the mechanisms that provide efficiency gains from international trade. Worse, in many instances these proposals are made jointly by environmentalists and industry lobbies which implies a hidden agenda of protection.


5OECD (1976) recommends harmonization of environmental policies 'where valid reasons for differences do not exist' to avoid disruption of trade and resource allocation.
Removing discrimination against foreign suppliers by dismantling trade barriers brings welfare benefits according to the principle of comparative advantage. As long as exchange rates adjust to maintain average balance on the external account, moderated perhaps by capital movements, re-allocation of production and consumption by reducing trade barriers between countries will increase economic efficiency. Differences among countries in the general level of taxes or social policies are incorporated into exchange rates. It is relative differences in the impact of policies on costs that determine comparative advantage and so trade patterns. The effects of tariff reductions (reciprocal or unilateral) on trade balances may result in changes in exchange rates. In the same way, a change in domestic economic policies may have repercussions on the exchange rate. Independence in domestic policies, however, does not have to be sacrificed in order to benefit from trade liberalization. Of course, coordination or unification of other policies may be desirable for other reasons, for example, in a customs union or common market. But efficiency gains from freer trade do not require harmonization of nontrade policies.

Writing in 1968, Johnson argued that demands for harmonization of economic policies arise from ignorance of the principle of comparative costs and the theory of international monetary adjustment. At that time most discussion about harmonization related to European economic integration and the ramifications of the Treaty of Rome and the Stockholm Convention for the countries of the European Community (EC) and of the European Free Trade Association (EFTA), respectively. Since that time harmonization has taken on global perspectives, prominent in the Tokyo and Uruguay GATT rounds and in coordinating activities of G7 governments in macroeconomic and exchange rate policies. Nevertheless, Johnson’s conclusions remain valid. Harmonization may be sought for particular motives, but it is not necessary in order to optimize returns from trade liberalization, although to maximize benefits from particular programs harmonization may be important. This applies, for example, to the EC which is pursuing deeper integration than simply removing impediments to trade among its members. Public choice, in terms of consumption through the budget (tax, transfer and expenditure policies) and "public goods" such as environmental protection, should not be denied simply on grounds of maintaining existing comparative advantage. As long as a community chooses particular social policies knowing what the costs might be in terms of economic efficiency, any distortions created have to be accepted. The alternative is to assert priority to harmonization of policy and economic efficiency over national sovereignty. "What appears to the theorist of economic integration as distortions of competition represent the outcome of the balancing in government decision-making of economic efficiency against socially desirable objectives..."

Since many trade barriers persist even among the OECD countries, and new bilateral trade restrictions are being implemented, it is evident that governments are reluctant to give up border measures to achieve the obvious efficiency benefits of liberal trade. This should arouse suspicions about proposals to harmonize environmental policies. With so many trade distortions still in existence it is doubtful whether harmonization of other policies will bring economic benefits. And why are supporters of such harmonization proposals apparently prepared to sacrifice national sovereignty over environmental policies?

---

6Paul Samuelson, "Comparative advantage is the one proposition in all the social sciences which is both true and nontrivial," quoted in Laird and Sampson (1987).

7Johnson, Wonnacott and Shibata (1968).

8Funabashi (1988).

9Johnson et al., 1969, p.8.
Despite Johnson's warnings about harmonization as a policy objective, governments and international organizations have pursued harmonization in many areas of international economic activity. Policy harmonization is recommended as the panacea for many problems and advocated by experts and governments. In practice, however, it is often an excuse for inaction at the national and international level, because reaching agreements is difficult and time consuming. It may also be used as a device to increase protection against foreign competition through formalized procedures. National governments can always use international negotiations and a pending agreement as a reason to delay action, on the grounds that any actions would be a unilateral concession to others or may have to be reversed to comply with an agreement when it is achieved. If an agreement to harmonize is reached, it must by definition involve adjustments to relevant domestic policies in most participating countries; if differences had not existed in the first place, harmonization would not have been necessary. Differences in social preferences, policy structures and physical endowments can be difficult to allow for in harmonization. So further internationalization implies less national independence in the design of economic policies, as well as costs in terms of amending existing policies. Harmonization is not costless and it cannot be assumed that all countries will participate.

The same loss of independence would apply to harmonization of environmental policies. Much of the enthusiasm for policy harmonization -- and international agreements on managing the global commons -- seems to be based on anticipation among environmental groups that the highest standards of conservation and pollution abatement will be adopted by all, without much regard to the effects on economic efficiency or welfare, or differences in social preferences, income levels and natural resource endowments.

**Harmonization and the GATT**

Harmonization of trade policy is a natural place to begin because the GATT represented the first attempt at global harmonization of economic policies. GATT provides a framework of rules and principles for negotiating reductions in trade barriers to promote competition and specialization through trade. The early success with tariff and quota dismantling and the removal of discrimination, brought the expected efficiency gains from trade expansion. Harmonization towards GATT principles of nondiscrimination, reciprocal tariff reductions and transparency, with tariffs as the acceptable form of trade intervention, brought immediate returns in the 1950s and 1960s. New distortions in international competition were revealed, however, as nontariff measures (including aspects of government policies other than commercial policies) affected international competition. New procedures had to be found to reduce the trade distorting effects of these new impediments to trade.

In the closing stages of the Kennedy Round (1962-64) an antidumping code was agreed, intended to establish uniformity in national procedures for assessing one alleged form of "unfair" competition (dumping). Article VI of the General Agreement permits contracting parties to apply antidumping duties to offset the margin of dumping, if it can be shown to cause or threaten material injury to competing domestic industries. The antidumping code was revised in the Tokyo Round and several other codes were negotiated in attempts to obtain uniformity of treatment for other nontariff impediments to trade, including codes on customs valuation, import licensing, subsidies, government procurement and technical standards; an attempt to negotiate a "safeguards" code (article XIX) failed, largely because of EC attachment to discriminatory measures, such as voluntary export restraints.

---

10 The Brandt Report (1980); various OECD Ministerial Council communiqués.

11 Jackson (1989).

Several new codes are being negotiated in the Uruguay Round, and existing codes are being revised or extended. But these attempts to harmonize trade policies and other government policies since the Kennedy Round have raised new difficulties in GATT negotiations. The quantitative convenience of tariff concessions has been lost; a concession made in one code has to be weighed against success in an unrelated policy, and that makes reciprocity difficult to judge. Cross-sectoral and cross-issue trade-offs have become inevitable, so achieving a balance for each country across the contents of several codes is difficult. This leads to a "lowest common denominator" approach which weakens the codes. Some codes simply accept all existing practices. Hence, adoption of interpretive codes in the search for uniformity in the use of nontariff barriers has qualified the GATT principle of reciprocity, created discrimination by restricting the rules of some codes to signatories only, legitimized discrimination using GATT escape clauses, and reduced transparency because of the complexity and variety of the new codes. The three founding principles of GATT have been weakened in the process of dealing with nontariff harmonization; use of "contingent" protection has increased with the evolution of codes.

The damage to GATT from attempts to extend harmonization beyond tariffs to other impediments to trade gives cause for concern. The new codes have increased legalism in trade matters, though the General Agreement was never designed as a legal document. Lawyers now scrutinize the codes for gaps and justification for new forms of discriminatory protection, when the original articles in Part II of the General Agreement were intended as escape clauses, not guiding principles. Much of the liberalization achieved by reciprocal tariff-cutting procedures appears to have been negated by resort to escape clauses, exceptions and "managed" trade in important sectors (textiles and clothing, steel, motor vehicles, etc.).

Harmonization of policies to remove nontariff distortions seems to have increased the use of these new forms of protection. It is worth asking whether the competitive distortions caused indirectly by government policies have warranted the pursuit of harmonization? Johnson argued that harmonization of microeconomic policies should be limited to those cases in which government policies would prevent free trade from achieving its full desired effect or would need to be altered if it were desired to obtain the full benefits intended from free trade over a larger area of the economy. Identifying such policies is difficult, especially since there is a fine line between genuine distortions and those deliberately created for reasons of social policy. Nevertheless, the tendency to believe that all policy differences create distortions and require "harmonization" is not in accordance with Johnson's analysis.

The GATT Standards Code

The technical standards code agreed in the Tokyo Round represented an attempt to harmonize national policies in order to remove competitive distortions, and this code is being revised in the Uruguay Round. An ad referendum text was available in Brussels in December 1990 when negotiations were suspended, and some further amendments have been adopted subsequently by the negotiating group. The contents of this code have


14Jackson, 1989, Ch. 8.

15Grey (1986).

16Johnson et al., 1968, p. 16.
particular relevance to environmental issues because OECD and other governments have revealed a preference for regulations and standards in dealing with pollution problems. ¹⁷

Implicit discrimination against imports often occurs in the application of product standards, although most standards are intended to protect consumers, workers or the environment. Many examples exist of standards that incidentally impede trade (e.g. metric and imperial measurements, left-hand and right-hand drive vehicles, etc), but it is also alleged that some industries seek standards specifically to disadvantage foreign competitors in their market; for example, pharmaceuticals, cosmetics and food. In conjunction with standards, it is possible to impose inspection procedures that give protection to domestic producers and delay customs clearances. Because of the degree of protection that product standards can provide, irrespective of the intention, they have become significant nontariff barriers.

Differences in national technical standards increase production costs for all suppliers, as well as distort production in favor of domestic producers. Foreign producers have to adapt their products, which raises unit costs, and they have to increase their stocks. The more differences in national standards that exist, the more these costs will be raised. As long as technical standards apply to products from all sources, meeting GATT requirements for national treatment according to article III, such differences in standards are permitted. So if an unusual standard is adopted and foreign suppliers decide to withdraw from that market, the standard is equivalent to a prohibition on imports. To be rational, the costs of such protection should be weighed against the domestic benefits from the standard, in terms of health, environment, safety, etc, but like other forms of protection, this is seldom done.

Deciding which standards are genuine and which are purposely protectionist is no easy matter, but the effectiveness of protection of domestic industry using technical standards has made this area of nontariff protection a target for harmonization in GATT negotiations. Two kinds of harmonization are possible: total harmonization meaning all products in a category must satisfy standards in a harmonization agreement in order to be sold in countries that are party to it; optional harmonization allows national standards to exist but requires specific standards to be met in international trade. If a standards agreement adopts the strictest pre-existing standards, the optional route allows some flexibility to countries with lower standards for their internal markets, which means less cost-demanding specifications. Optional harmonization could be relevant to environment standards where community preferences, resource endowments and income levels result in international differences.

It had been widely accepted before the Tokyo Round began that technical barriers to trade were not adequately dealt with in the GATT articles. A draft code for preventing technical barriers to trade had been prepared before the official negotiations began.¹⁸ The declared aim was to remove unnecessary barriers to trade in agricultural and industrial goods. The subjectivity implied identified the problems in implementing such an agreement. What is an unnecessary product standard? The GATT does not establish standards and all the standards code could do was to complement the activities of international organizations concerned with technical standards (ISO, IEC, WIPO, etc.), and to recommend adoption of international standards wherever possible. An associated aim was to clarify product certification and testing procedures, and labelling requirements, so that traders understand requirements and information is available to allow transparency and equal access (i.e., national treatment). Developing countries were to be assisted in their endeavors to comply with the provisions of the code. The code claimed that it established "rules of a legally binding character

¹⁷OECD (1989a).

¹⁸GATT (1979).
between governments which will enable them to complain and obtain redress." A committee on technical barriers to trade was established to settle disputes and to formulate dispute procedures.

One of the unresolved difficulties left after the Tokyo Round code related to the differences in administration between centralized and federal forms of government. In federal systems many regulations are administered by state and local authorities (and industry organizations), and centralized countries feared that the balance of obligations would be affected by such decentralization. The Tokyo Round solution was a "best efforts" commitment by federal states, backed up with a complaints procedure and an apparently self-defeating right to suspend obligations under the code if the complainant was not satisfied. The code is subject to a five-year review, with a view to adjusting rights and obligations in the agreement where necessary to ensure mutual economic advantage and balance of rights and obligations.

In the Uruguay Round some important revisions have been made to the standards code. The "balance of obligations" dispute has remained on the agenda and has yet to be resolved. (It has doubtless received more attention in the negotiations than the fundamental question of what the obligations mean!) A number of vague concepts in the original code have been clarified in the light of experience. For example, the new draft code calls for "available scientific and technical information" in deciding "unnecessary obstacles" and introduces criteria for judging the need for specific standards. It requires also that technical regulations should be based on product requirements in terms of performance rather than design or description. The agreement also lays down a code of good practice for the preparation, adoption and application of standards. Developing countries continue to be granted special and differential treatment.

At several points in the Uruguay Round draft standards code, the environment is mentioned with health and safety as a valid reason for technical standards. This is an innovation because the environment is not specifically referred to in the General Agreement itself, although article XX is regarded as providing some exemptions for environmental protection. This revision would appear to provide scope for environmental regulations to be used to restrict trade. This was already done in the Montreal Protocol which included measures to control trade with nonparties on products produced with controlled substances.

In the December 1990 draft code, processes and production methods were included in the definition of technical regulations. This has special relevance to environmental policies where some governments have set down regulations to control the method of production and material inputs that may be used, in an effort to reduce pollution and toxic wastes. If importing countries are allowed to prescribe the production methods used for acceptable imports, the scope for discrimination and protection will be widened.

Regulating a process or production method is a more difficult proposition than applying standards to products, which is the conventional GATT approach. Environmental damage may not be physically present in the product which is imported. In this case, trying to impose a standard on its production method amounts to extraterritorial application of the importing country's laws (e.g., restricting products that cause water pollution in the producing country). In economic terms, there is a production externality that should be internalized by the producer, not subject to a trade policy measure in the importing (consuming) country.

---


20GATT (1990b).

21The General Agreement article XX's: general exceptions allow the use of trade measures to protect human, animal or plant life or health, national treasures and to conserve natural resources.
According to the GATT interpretation of national sovereignty, the importing country is not entitled to restrict imports unless it applies to products (articles I and III).

The danger evident in the Brussels draft has been recognized in the negotiating group on technical barriers to trade and some revisions have been proposed. The draft terms and definitions for the Agreement on Technical Barriers to Trade now covers "products and related processes and production methods." This relates to products according to GATT conventions, and limits processes and production methods to a secondary role dependent on product standards. It remains to be seen whether this form of wording will satisfy the environmental lobbies in any final package agreed for the Uruguay Round.

The main objective of the standards code is to reinforce nondiscrimination and national treatment obligations of the General Agreement. Otherwise it specifies some procedures to encourage countries to work towards harmonized product standards, including attention to foreign suppliers' interests. It is also provides for greater transparency of standards, which will help to reduce uncertainty. In general, this code has been well received, with 36 contracting parties signing the Tokyo Round code, and the Uruguay Round negotiations have also received widespread support.

Costs and Benefits of the Standards of Harmonization

Harmonization of standards is intended to remove important distortions from trade relations, but it does involve costs by compromising community preferences and independence of national actions. Agreement on desirable standards will involve disparate interests in any one country - producers, consumers, protectionists, environmental groups, etc. The need for harmonization means that national differences exist that need to be reconciled, and political considerations will be important. The more dissimilar the countries seeking harmonization, the more intrusive and economically costly the process of reaching agreement will be.

Applying the standards code to production methods and processes would bear directly on the sources of comparative advantage that lie at the root of free trade. The traditional model of comparative advantage determined by factor endowments has been extended to technology-based cost advantages, locational advantages, government policy-induced advantages ("strategic" trade theory), etc. Differences in pollution absorption and income/environment trade-offs are equally relevant to comparative costs.

If developed countries declare a particular production process as unacceptable because of pollution or undesirable social effects, they would prohibit imports using that process. But the circumstances in other countries could be different and the restriction unwarranted. After all, noxious emissions may be dangerous in an urban setting, but located in remote areas with ample water and appropriate prevailing winds the same emissions might be acceptable. Many industrial processes in developing countries are "old-fashioned" or use obsolete equipment, but because of low labor costs or locational advantages such plants can export competitively. Should these enterprises be denied access to markets because they do not meet other countries standards in production? Higher levels of pollution are likely to be tolerated in developing countries as a trade-off for faster economic growth. What price should be placed on cleaner air in countries with widespread poverty?

This kind of protectionism follows the same arguments as the familiar demand in developed countries for minimum wage levels and workers' rights in developing countries. Argued in terms of "fair" competition and raising workers' living standards in developing countries, these proposals make no allowance

---

for supplies of unemployed labor in these countries and the fact that raising wages would reduce the number of jobs available. Only the fortunate few retaining jobs would benefit from higher labor standards. Similarly, harmonization of production methods and processes would remove competition from developed countries' markets and reduce export opportunities for developing countries.

The extent of the difficulties inherent in harmonization of standards, even among similar countries, is evident in EC efforts to achieve a single European market by 1992. The completion of the internal market depends on removing impediments to the freer movement of goods, services, persons and capital. Even in the area where EC harmonization has been greatest - removal of trade barriers and creation of a unified external commercial policy - there are serious difficulties, with discriminatory VERs and restrictions by individual EC states against third countries. Achieving a unified trade policy against outsiders is proving difficult.

Harmonization of technical standards has high priority in the EC 1992 program. After many years of unsuccessful negotiations seeking unified standards, which required unanimous approval by EC governments, the Commission relinquished this difficult quest for total harmonization at a high level in favor of "mutual recognition" in noncontroversial areas. If there is disagreement about "mutual recognition," however, EC standards will still have to be sought in difficult areas relating to health, safety, etc. "Mutual recognition" means that goods lawfully manufactured and sold in one EC country must be allowed free entry into other EC countries. This amounts to minimal harmonization and could lead to tensions between member countries with strict existing standards and those with lower standards, the former being placed at a competitive disadvantage in trade. The effects of this mutual recognition of technical standards agreed in 1988 remains to be tested. It is not clear whether non-EC suppliers still have to meet national standards in each EC market, which would amount to discrimination, or whether access through one market will allow general circulation of these products throughout the EC. As environmental and other standards become more important in trade, this EC regional harmonization could influence new global standards harmonization.

Environment and the Standards Code

The proposed extensions to the standards code in the Uruguay Round hold particular relevance to discussions of environment issues in the GATT context. As noted earlier, the OECD countries have demonstrated a preference for regulations in dealing with problems of pollution and environmental degradation. In most cases this involves the use of product standards, process standards and pollution standards. These regulations tend to raise costs to domestic producers, or even curtail their outputs. This would give comparative advantage and new opportunities to foreign competitors not burdened with such stringent environmental standards, unless the standards are supported by frontier measures to protect domestic industry. The natural response is to restrict access for imports, and in the case of standards to apply the same standards to foreign producers. Such "extra-territorial" measures are difficult to make effective at the product level. Equal treatment of products says nothing about the methods of production and possible externalities. By extending the standards code to production methods and processes, new opportunities are created to protect domestic producers and national regulations, and to change comparative costs among countries at unchanged exchange rates.

---


The popularity of "command and control" systems and the drive for international harmonization of standards represent a threat to countries with high absorptive capacities for pollution or low social priorities attaching to environmental quality. If certain production methods or processes can prohibit access to overseas markets, the comparative advantage of developing countries in some activities will be usurped. Their social choices based on an income/pollution trade-off, or the physical characteristics that allow less stringent environmental standards, based on population density, resource availability, climate, etc., are unacceptable to other countries and their national sovereignty sacrificed to "those who know better." The excuse is often related to global pollution, without any attempt at evaluation. Using market measures and internalizing environmental costs provides scope for trade-offs, and allows for parameter differences such as those mentioned above.25

The logic of standards harmonization is to prevent standards being used to impede trade or to promote inefficient trade. Environmental standards (e.g. pollution limits) as well as economic instruments (e.g. taxes and charges) will raise production costs, but suppliers of the same product in other countries may not face similar internalizing costs, which means they have a competitive edge in that product. According to the GATT, a border levy to offset such a cost disadvantage must be applied without discrimination, unless it is regarded as "unfair" competition and made subject to antidumping or countervailing duties (articles VI and XVI). New measures against "unfair" competition through lax environmental standards are being proposed.26 This would avoid disadvantaging exporters in other countries with similar environmental policies compared with exporters from countries less concerned about the environment. Applying standards to production processes is another way to overcome these disadvantages, but only at the expense of lower cost producers where social choices may be different.

The popularity of regulations in environmental policies is a surprise for economists because many market-based instruments are available that could achieve the same pollution objectives (according to the PPP philosophy), with fewer distortions or economic inefficiencies. The preference for regulations seems to derive from basic mistrust of markets which all interventionists show, and the desire of governments to demonstrate their commitment to the environment. In addition, many established industries welcome controls even though their costs may be raised. They anticipate that new entrants are unlikely to get pollution rights etc. and regulations are often effective barriers to trade. In other words, industrial protectionists are appeased by reduced competition. Problems arise because regulations create new forms of trade interventions and the solutions seem to rest with international policy harmonization, which means more intervention.

The use of economic instruments, such as subsidies, charges, taxes or pollution permits, may also have trade implications which affect cost-competitiveness of firms and sectors. But industries are constantly adjusting to cost changes and the results are economically more efficient than direct interventions (see Low and Safadi 1991, Table 1). Changes in relative costs among industries brought about by these economic instruments reflect community choices (such as less air or water pollution or improving waste disposal) and they need not require policy harmonization in the same way that differences in standards do. This accords with Johnson's view of harmonization examined earlier. Each country is free to choose its environmental objectives according to social preferences and the country's physical characteristics. Any changes in social policies will require adjustments to production and consumption, but international monetary adjustment (exchange rate flexibility) will ensure that external balance is maintained in the medium term. International harmonization


26If differential duties are applied on environmental grounds, what is to stop similar border actions against countries with cheap energy policies or any other policy differences that affect comparative costs? This is the kind of harmonization logic that Johnson rejected.
Another consequence of increasing international economic interdependence has been convergence of policies, which refers to the gradual alignment of national economic processes in the major countries. Ostry attributes this process to the strengthening role of global corporations, which can adapt to a distorted but stable system but are worried by uncertainty and unpredictability, and governments focusing on "strategic" sectors to maintain national competitiveness. International macroeconomic policy coordination since the breakdown of Bretton Woods is cited as an example of convergence, especially since the Tokyo Summit in 1986. The EC 1992 process is another example mentioned. But convergence gives way to proposals for international harmonization in important areas of trade competition, where Ostry expects convergence to be "instituted in a reformed and strengthened GATT." Given the failure of earlier GATT Rounds to provide lasting solutions to divergent policies on contingent protection, this is more ambitious than it might appear. In other areas of trade and industry policy, Ostry believes an OECD consensus should be sought to draw up a set of policy guidelines, a timetable for reform and a monitoring system. The conflicts between Japan, on the one hand, and the EC and the United States on the other, make it unlikely that this triad could reach real agreement on policy harmonization. Like many analyses from North America, the Ostry study ignores the interests of the rest of the world in the convergence process.

The OECD claims there has been some convergence of environmental policies among its member countries, but the gap is growing between the environmental approaches and standards of the OECD and those of developing countries. On the whole, developing countries lack the administrative machinery and the resources to implement environmental policies. Some developed countries fear that international harmonization of environmental norms will weaken their environmental standards, while developing countries fear that harmonization may reduce further access for their exports to OECD markets. As noted above, harmonization of standards can be very disruptive economically, and may leave all participants unsatisfied; least-common-denominator approaches upset countries with strict standards, while higher standards impose costs on the poorer countries. If the OECD countries proceed with discriminatory environmental standards to impose its wishes on the rest of the world, serious economic costs would result.

Harmonization of environmental standards according to the GATT code on technical standards or other international agreements will be difficult because of wide disparities in national standards and the considerable economic costs that will result from harmonization, whether at high or low standards. Regulations in any area of activity fail to take account of economic trade-offs, and therefore impose unavoidable economic costs. An efficient outcome, once environmental objectives are established, is to equate the marginal cost of achieving that target with the benefit of improved environmental quality. The use of regulations rather than pricing instruments reduces the adjustment capacity of an economy.

\[\text{Ostry (1990).} \]
\[\text{Loc.cit., p. 7.} \]
\[\text{Loc.cit., p. 89.} \]
\[\text{OECD Working Paper 91.4.} \]
Trade and the Environment

One of the surprising features of the ongoing environment debate is the strong emphasis given to trade issues. Environmental policies and instruments are regarded with concern because they may introduce nontariff barriers that affect trade opportunities. Trade policies are regarded as enforcement instruments by environmentalists (e.g., bans on tropical timber imports and trade restraints in the Montreal Protocol). Yet agricultural protection in OECD countries has added to pollution problems by encouraging overproduction and use of chemical pesticides and fertilizers. Trade liberalization is regarded as inimical to environmental objectives because it increases economic growth and the exploitation of natural resources. Yet all the evidence points to concern for the environment increasing with rising living standards which provide the resources to tackle pollution and environmental problems.

These contradictions occur because of the confusion of ends and means. Trade is a means of promoting efficient resource allocation and economic growth, and raising living standards by exploiting the division of labor (comparative advantage). The environment is an end. Environment policies are intended to achieve prescribed objectives of pollution abatement and environment conservation. Many kinds of instruments are available to achieve these objectives, and some are more expensive than others in terms of economic growth foregone. Some instruments may affect trade but that is incidental, as long as the objectives are achieved in the most efficient manner possible. The PPP recognized that, and using price-based instruments allows economic trade-offs. By failing to internalize external costs (e.g. river or air pollution), some exports may be underpriced which makes them competitive on world markets and possibly disadvantages producers in other countries that are less polluting or are subject to PPP instruments. It may also prevent other domestic firms from competing on world markets because of additional costs imposed on them by the uncompensated pollution.

Economic theory has established that trade policies are inefficient instruments for correcting domestic economic distortions. They are second-best instruments. The most efficient measures act directly on the source of the distortion. This applies to environmental problems. Trade liberalization, for example, will improve economic efficiency and raise incomes. If it increases output of pollution-creating industries that is best tackled directly through tax or subsidy policies, not through restoring protection which affects both production and consumption, and is welfare reducing. By raising incomes, trade liberalization provides additional resources that can be applied to environmental objectives. Even for global environmental problems trade policies are a second-best instrument. Build up of GHG will be more efficiently handled through emissions taxes than through trade restrictions or prohibiting energy-intensive production processes.

The attraction of trade policy to environmental lobbies is difficult to explain. Nontariff protection has been enhanced by preferences for direct interventions, such as environmental standards and regulations. There is probably also an element of mercantilism, blaming foreigners and hoping to pass on the burden by reducing imports is a popular reaction promoted by import-competing domestic industries and rent seekers. The OECD and GATT are both investigating trade and environment questions, and recent international agreements (Montreal Protocol and Basel Agreement) give emphasis to international trade issues. Proposals for managing global environment issues contain new restrictions on trade. Economic instruments that would act to internalize externalities and produce economically efficient solutions are neglected in favor of regulations, probably because economic measures are not understood.

---

31 Studies of the effects of environmental policies on production and trade patterns have shown little impact, see Dean (1991).

32 Bhagwati and Srinivasan (1983).
Why Harmonization?

Harmonization of economic policies has been accepted uncritically as beneficial to international relations. It is not, however, a costless process and it does require sacrificing national independence. There is no general argument in favor of international policy harmonization; each proposal should be considered in the light of existing distortions. In economic terms Johnson showed that benefits from trade liberalization are not dependent on harmonizing general social policies (taxation systems and social policies). With many efficiency gains still to be obtained from reducing trade barriers, adopting policy harmonization to deal with environmental problems appears perverse. Social policies, representing community choices, may well effect comparative costs. But environmental policies aimed at internalizing externalities will improve economic efficiency. As long as governments’ decisions are taken in full knowledge of the costs, that is an exercise in national sovereignty. Economic efficiency is not the only objective. But achieving specified goals should always be sought in the most efficient manner.

Environmental policies involve important social choices. If environmental policies affect comparative costs in the economy, they will affect trade, production and incomes. But overall economic balance can be maintained through international monetary adjustments. Economic efficiency becomes important in choosing the instruments for achieving environmental aims. This is where many governments fail, by adopting the most obvious instruments based on regulations, rather than using pricing instruments. By opting for pollution standards and regulations, governments have given new emphasis to the question of harmonization. Differences in standards are more obvious than economic measures that are absorbed into prices, and differences in standards quickly produce complaints of unfair trade -- an increasingly common and acceptable plea for protection in many countries.

So, adoption of regulations and standards to deal with environmental problems has promoted negotiations for international policy harmonization. The examination of the GATT standards code and the difficulties experienced with it indicates the problems ahead in harmonizing environmental standards, as well as taking account of environmental concerns in harmonizing technical standards.

Ostry argues that emphasis on competitiveness in national economic policies has raised the profile of microeconomic policies in international economic relations. This encourages industries to complain about unfair foreign competition where they receive immediate relief using various GATT escape clauses - antidumping duties, countervailing duties, etc., or employing "grey area" measures. This concept of contingent protection carries over into environmental issues. Any measures taken to reduce pollution or environmental degradation by internalizing external costs is regarded not as improved efficiency in resource use but as undermining an industry’s competitive position, which requires more protection against foreign suppliers not similarly charged. The concept of economic adjustment is rejected. One basis for this claim of unfair competition appears to be that many environmental problems are global problems, and everyone must bear equal costs for reducing them. In reality, most environmental degradation is a local problem and even global issues can be modified by local actions. The focus on microeconomic policies should not lead to neglect of macroeconomic policies and the role of the international monetary mechanism in maintaining broad external equilibrium.

The promotion of economic instruments for achieving domestic environmental objectives would reduce the need for harmonization of standards and regulations by incorporating more costs into production accounting. Policy harmonization should also be examined carefully. It is a difficult process and seldom reaches the high standards sought because of the need to take account of different social choices and potentials. The loss of policy independence that follows from policy harmonization is neglected by single-minded environmentalists, but this and the economic costs may be significant.

---

Ostry, 1990, p. 11 and Ch. 4.
Discussant's Comments

Nemat Shafik

David Robertson's paper is an interesting survey of economic thinking about harmonization of standards and also provides a discussion of why governments have preferred "command and control" over market-based incentives in environmental policy. The paper concludes with the classical economists' view that harmonization is a bad thing while efficiency, comparative advantage and the gains from trade are a good thing. After reading the paper I was struck by the fact that economists and environmentalists could have such different views on so seemingly an uncontroversial issue. So I made a list of why environmentalists like harmonization and why economists hate it.

Why Environmentalists Like Harmonization:

♦ Fairness. Producers should compete on a level playing field and this should include environmental costs.

♦ Direct control. Harmonization allows direct control of environmental outcomes in different countries.

♦ Preferences. Harmony in environmental standards allows the imposition of external preferences without the disharmony of gunboat diplomacy.

♦ Political economy. Environmental groups are realistic about where their political power is greater. Even if harmonization is an eighth-best instrument, it is far easier to influence trade policy at home than to try to change environmental policies in developing countries (even if that could be a first-best instrument). This is not an unrealistic assessment of the political reality if one looks at how unsuccessful donors have been at influencing energy pricing in developing countries. Environmental groups in the United States know first hand how much easier it is to get protectionist policies put into place than it is to raise taxes on energy.

Why Economists Hate Harmonization:

♦ Fairness. Imposing standards is unfair since conditions differ across countries and they should be free to exploit their comparative advantage. Local environmental preferences should prevail over those of foreigners.

♦ Efficiency. Harmonization of standards is not efficient and should take economic factors into consideration, such as the enormous gains from trade.

♦ Environmental costs are small. Studies have shown that environmental regulations play an insignificant role in industry location decisions. This is because environmental costs are far outweighed by wage differentials across countries in determining comparative advantage.

Is there any common ground between these seemingly divergent positions? It seems to me that there is, if one accepts the distinction between local and international environmental problems. This common ground might be:
It is hard to be against local decisionmaking about local environmental problems. If local people want a factory to provide jobs in their neighborhood, they should decide since they will be breathing the local air. It is critical, however, that local people are informed about the costs of environmental degradation—in terms of human health, productivity or amenity values. Rather than lobby for protectionism at home, environmental groups should be informing people abroad about the local consequences of pollution.

Since environmental compliance costs in most economic activities are only 1-5 percent of investment costs, it is difficult to believe that they are a crucial factor in industries migrating to pollution havens. Most investments are not made with those margins in mind, so the argument that it is an unfair trading practice to have lower environmental standards is not very convincing based on the evidence.

There may be an argument for harmonization where there are international externalities, such as with climate change or ozone depletion. The Montreal Protocol to phase out the use of CFCs is a good example. The key to convincing developing countries to accept the standards being proposed was the availability of low-cost alternative technologies and financing to cover the incremental costs of compliance.
GATT and Environment:
Basic Issues and Some Developing Country Concerns

Piritta Sorsa

Introduction

GATT has been accused of being hostile to the environment by environmental groups\textsuperscript{1} on account of restricting the use of trade instruments for environmental purposes and promoting trade liberalization. Vocal political support for a wider use of trade instruments as environmental policies has come from antitrade labor and consumer lobbies.\textsuperscript{2} Trade officials, while recognizing the importance of protecting the environment, are concerned to maintain the integrity of the international trading system and want to clarify the issues. Developing countries have followed the debate from the sidelines with some suspicion. They fear that environmental standards will become new trade barriers against their exports or that trade sanctions will be used to make them pay for correcting environmental damage which in many cases results from past underpriced, overconsumption of common resources by developed countries.

Much of the confusion about the role of GATT in the environmental field is related to the appropriateness or otherwise of trade instruments as environmental policies or as tools for their enforcement. But because trade as such is not the source of most environmental damage,\textsuperscript{3} trade policies are not first-best in achieving environmental goals. Furthermore, international environmental problems are better solved by negotiation than through punishment with trade sanctions. Cooperative solutions are more stable than coercion.\textsuperscript{4} It follows that by setting limits to the use of trade instruments, GATT is not hostile to the environment.\textsuperscript{5} On the contrary, by promoting the use of more appropriate environmental policies that address the source of the problem directly, GATT is very much "for the environment." Furthermore, a well-functioning international trading system can make an additional contribution to environmental goals--trade promotes growth, which helps to allocate resources for environmental protection.

\textsuperscript{1}Shrybman (1990), Arden-Clarke (1991).

\textsuperscript{2}For example, in the United States-Mexico Free Trade talks main opposition to the agreement has come from labor and environmental groups for environmental reasons.

\textsuperscript{3}Environmental problems arise from various types of market (prices not reflecting environmental costs) and government failure (subsidies to polluting activities) or lack of clear property rights.

\textsuperscript{4}For a discussion see, for example, Low and Safadi (1991).

\textsuperscript{5}GATT forbids the use of quantitative restrictions (article XI) except in a number of exceptional cases such as balance of payments support, etc. on a temporary basis. Bound tariffs cannot be raised without compensation.
Although most efficient environmental policies are not in conflict with the GATT, there is some uncertainty about the interpretation of certain rules. The rules have seldom been tested on environmental issues and their drafters in the 1940s could hardly foresee the present dimensions of environmental problems. The resulting uncertainty can disrupt trade, lead to protectionist abuses and affect environment-related investments. Higher environmental costs in the 1990s may become an excuse for demands for protection against competing imports. Differences in environmental policies across countries may be politically appealing as a basis for unfair trade action. Clarification of the relationship of GATT to environmental policies is therefore much needed, both to prevent unnecessary disruption of trade on environmental grounds and to promote environmental goals with the most appropriate policies.

The present discussion on the links between environment, trade and the GATT rules embodies many elements of a new North-South divide. While most agree on the importance of protecting the environment, its priority among policy goals tends to correlate positively with incomes. Developing countries can be important actual or potential sources of global environmental damage, but may be too poor to afford the benefits of a cleaner environment or wider bio-diversity. Taxing the use of global commons raises difficult equity issues for cost sharing. If the present problems are mainly caused by past action by developed countries, why should the developing countries pay for it? Their export earnings may be threatened by the unilateral imposition of sanctions by developed countries under pressure from environmental lobbies wishing to "export their values" or unilaterally determine standards. The increasing incidence of higher and differing environmental standards in developed countries increases costs for developing country exporters and complicates market access. Their environmental carrying capacities can attract industries facing higher environmental costs in developed and environmentally "saturated" countries.

Developing countries have a major interest in the maintenance of multilateral disciplines and the clarification of GATT rules in relation to environment. GATT rules can protect them from new forms of protectionism under the guise of environmental policy, reinforce the respect of sovereignty in trade relations and shift emphasis from the use of trade sanctions to negotiations and creation of incentives in promoting the adoption of environmental policies worldwide. The rule-based multilateral system protects the interests of small countries against power-based unilateral policing by large countries.

The interaction of GATT rules and environmental policies is discussed in more detail below. It is important to distinguish between purely domestic or local and international environmental problems with cross-country spillovers, due to the different scope of the issues involved. The main uncertainties in the GATT context are linked to the right of countries to restrict imports on account of differences in environmental policies, the use of unilateral trade sanctions to solve problems relating to international sources of pollution, and the overall relationship of international environmental agreements to the GATT.

GATT and Domestic Environmental Policies

The main issues in relation to domestic environmental problems and the GATT are whether the rules allow countries to restrict trade for differences in environmental policies across countries, and whether environmental standards are used as disguised forms of protection. Both issues have important implications for the competitiveness of developing country exports, and they also influence the terms of market access. Countries have different values and problems and different ways of solving them, and this makes sovereignty

---

International problems are often divided into global and transnational ones. The distinction is related to the number of players involved: global problems affect most mankind (global warming or depletion of the ozone layer), whereas transnational ones are limited to a few countries (acid rain or river pollution).
considerations important. Within GATT, respect for sovereignty limits external interference in purely domestic policies. GATT is also concerned with the application of domestic policies with trade effects -- not why policies are applied.

At the outset, it is important to distinguish between product-related and process- or production-related (PPMs) related environmental problems and policies. Product-related policies address consumption externalities. Both imports and domestic goods can be the source of environmental damage and subject to similar policies. Production-related policies address production externalities. The source of damage is limited to domestic production. Costs of policies affecting the production of goods are part of comparative advantage, and therefore should be borne by domestic producers with no ramifications on imports. Countries have different domestic policy objectives and the costs of these policies affect competitiveness and costs of production.

Should countries with higher profit taxes levy compensatory duties on imports from countries with lower rates? Should imports in nuclear free countries be restricted from nuclear using ones, because the ensuing energy costs structures are different? Should Europe impose an extra tax on imports from the United States because U.S. producers bear lower energy taxes? Should Sweden restrict imports from countries with less extensive welfare systems? All these policies have a cost and, therefore, have an impact on competitiveness of their producers. But taxing or restricting imports on these grounds would run against specialization in trade through comparative advantage.

The costs of production-related environmental policies addressing local problems are part of costs of production, i.e., determinants of comparative advantage between countries. Subjecting imports to domestic methods of production would undermine specialization through trade. In practice, however, the above distinction can be difficult. In some cases PPMs do affect the product as such (e.g., in food or pharmaceuticals industries). This raises practical difficulties for the interpretation of GATT rules as well as the making of domestic policies.

In principle, GATT rules concern product-related policies within a country's own borders. The way goods are produced is outside its scope. The most relevant GATT rules for domestic environmental policies are: (i) basic rules on border adjustment (articles I,III); (ii) public policy exceptions (article XX:b,g); (iii) the Standards Code; and (iv) the rules on dumping and subsidies.

Basic Rules

Most environmental policies are not in conflict with basic GATT rules. Policies that affect products can be extended to imports under GATT provided they meet certain criteria. National treatment (article III) requires that imports are not treated less favorably than domestic goods (nondiscrimination between domestic and imported goods). The unconditional Most-Favored-Nation (MFN) principle (article I) requires that policies are applied in a nondiscriminatory way to all sources of imports. Thus, for example, imported and domestic toys can be subjected to similar safety requirements, or limits on contents of toxic materials. Tradable permits should be GATT compatible, if imports and domestic goods are treated in a similar way.

The nature of some environmental policies can be such that they favor domestic goods -- or provide disguised protection to domestic industries. If the application of a domestic tax or regulation intentionally or unintentionally has the effect of restricting trade, it may not qualify for national treatment. It will be

7"All taxes, laws, regulations and requirements that affect their sale, offering for sale, purchase, transportation, distribution or use."
considered as a quantitative restriction (QR), which is contrary to basic GATT rules (article XI). In certain cases seemingly protective or unreasonable policies can still be justified within the GATT, if they are related to public policy goals and meet certain criteria (see for discussion later on the Standards Code and article XX). The protection implicit in many environment-related policies can be difficult to prove, and is often a matter of judgment. Past GATT disputes have dealt with few cases, and have solved problems case by case.  

Product-related environmental standards and labelling are likely to multiply in the years to come. Whether the measures restrict trade or are legitimate environmental standards is difficult to judge. In many cases, exporters from developed and developing countries will have no choice but to adjust to the higher standards.

Border adjustment of taxes was clarified by a GATT Working Party in 1970. It established a basic rule that "taxes levied on products (indirect taxes) were eligible for border adjustment," but direct taxes were to be borne by the producer. The adjustment also applied to indirect taxes on inputs, if these were physically incorporated in the product. The distinction was based on practical convenience and certain shifting assumptions, but also reflected the product-production distinction of the basic rules. Indirect taxes (sales, turnover, value-added, per unit input or output charges) are assumed to be shifted to the consumer, whereas direct taxes (income tax, social security charges, profit taxes) would be "borne by the producer."  

Applied to environmental problems, the taxation rules can create a bias in favor of indirect taxes aimed at production externalities. A tax on a product whose production pollutes would be less efficient than a tax on the polluting process, because it does not address the source of the problem directly. The use of product-related environmental taxes to address production externalities would reduce the impact of environmental costs on competitiveness, as indirect taxes can be rebated on exports and levied on competing imports. The use of indirect taxes would also allow governments to make imports pay for domestic environmental cleanups. A further impact of the measure could be double taxation of environmental costs for some imports. For example, having paid a direct environmental tax at home, an exporter may have to pay another indirect tax for the same externality in the importing country. Some of the above problems could be avoided by the application of the polluter-pays principle, which the OECD countries have adhered to in principle.  

---

In intra-European trade an Italian requirement that all pasta be made from a certain hard wheat grown mainly in southern Italy, or a German requirement that beer is to contain only certain additives were considered NTBs by the European Commission. Neither could justify scientific evidence that the regulations were required to protect health or other public policy goals and were therefore rejected. In another case a Danish requirement that all soft drinks must be sold in returnable bottles was first rejected by the European Commission as an NTB for giving unfair locational advantage to domestic bottlers. The decision was later upheld on environmental grounds by the European Court.  


In practice, whether producers really bear direct taxes depends on conditions of competition, e.g., with market power the tax element can be passed on to the consumers.

In principle the basic rules apply equally to taxes and regulations. Some asymmetry may arise, however, from the taxation rules, for example, an indirect tax may be rebated at the border, but the costs of compliance with a similar regulation cannot.

The above problems were apparent in the so-called the Superfund case in the GATT. An indirect tax by the United States levied on imports to finance toxic waste cleanups was found GATT compatible. The EC argued against this on the grounds of the polluter-pays principle, which the Panel rejected as irrelevant for the GATT taxation rules.
There has been some controversy whether article III applies to production methods. Difficulties in defining pure PPMs or those that affect the product raise problems for the application of the rules. GATT provides no definition for PPMs. In the recent tuna/dolphin case, the United States argued that domestic production regulations were covered by article III. The Panel stated that "article III covers only those measures that are applied to the product as such." Regulations governing the taking of dolphins incidental to the taking of tuna could not, therefore, affect tuna as a product.

There are also two elements in the text of the General Agreement that support the view that PPMs are not covered by the basic articles. These are the concepts of like product and unconditional MFN. The purpose of the like product concept is to prevent protectionist measures being taken on the basis of artificial differentiation of products. Hormone grown beef is not different from grain grown beef (unless it can be shown to affect the product). The meat cannot be made different for customs treatment on the basis of production method. GATT offers no definition for like products. In practice, a case-by-case approach has been considered most appropriate.

The concept of unconditional MFN also circumscribes discrimination at the border based on differing production methods. Customs treatment of a product cannot be made conditional on environmental or other conditions in the exporting country. The intention of the drafters of the GATT in respect of the MFN principle was to preserve the comparative advantage enjoyed by the lowest cost producers, without regard to value judgments in the importing country about the desirability of policies that permit low costs. In the past, labor groups have demanded import protection against products from developing countries with differing labor standards, but without success.

The PPM issue is very important in the respect of sovereignty among countries and to the search for effective policies with environmental problems. With local environmental problems, as the method of production does not directly affect the welfare in the importing country, any interference on how goods are produced could interfere with the sovereign right of countries to decide on their domestic policies and choices of objectives. The attainment of environmental goals could also be undermined by forced solutions. If policies do not create incentives for protecting the environment, the environmental goal is not reached.

The problem in many poorer countries is not lack of high environmental standards, but their poor enforcement. For example, the former Communist Eastern European countries in many cases had very high environmental standards, but no incentives to apply them in practice. Most developing countries do not have resources to monitor or enforce environmental standards, the more so, if the standards are imposed from outside. As many environmental problems are location specific, other countries standards are likely to be too high or too costly with related cost implications. Incentives for environmental protection are unlikely to be created by forced solutions from outside. The end result with forced PPMs could be a profitable market for compliance "certificates", but no impact on protecting the environment.

Exceptions - Article XX (b,g)

Article XX allows GATT signatories to deviate from their basic obligations for public policy goals, but under strict criteria. GATT thus recognizes that trade measures may be needed in certain cases as second-best alternatives, if less distortionary policies are not available or are proven not to work. The relevant text is at times vague and has seldom been tested in disputes. Originally, it was drafted for health quarantine

---

13 Most relevant for environmental issues are sub-paragraphs (b) and (g). Article XX(b) covers measures "necessary" to protect "human, animal or plant life or health". It was originally drafted for health quarantine purposes. Article XX(g) covers measures that "relate to" the conservation of exhaustible natural resources,
purposes. The recent tuna/dolphin case helped to clarify some of the issues, as it ruled against extraterritorial application of article XX. The report has not yet been adopted, and is likely to provoke much controversy in the GATT Council.

The main issue of uncertainty in respect of the interface between environmental policies and article XX is extraterritoriality -- that is, whether imports can be restricted for differences in environmental policies across countries. In addition, environment is not specifically mentioned among the public policy goals, and the text does not mention what GATT inconsistent measures could be allowed. It is thus unclear whether subsidies or restrictions on other products would be covered.

Domestic environmental policies justified under article XX would have to meet three criteria: (i) fit the defined scope; (ii) be necessary or the least trade restricting alternative available or "related to" the conservation of exhaustible natural resources; and iii) be applied in a nondiscriminatory way.

Scope. GATT rules are not concerned with the objectives of policies. The appropriateness of protecting the environment within one's borders is a matter of national judgment. But with article XX: b and g a decision has to be made on whether the invoked policies are within the public policy area. For example, in the Thai/U.S. Cigarette Case, the Panel did not take issue with the question whether a reduction of smoking is desirable, but stated that smoking does damage health according to an expert report by WHO. With environmental policies, application of the article can raise difficult definitional problems. Panels may have to decide whether certain species are exhaustible or whether certain environmental problems are harmful to human, animal, plant life or health. How would one decide whether killing a certain species not in serious danger of extinction is a problem of biodiversity or part of activities like hunting or fishing? For example, in the context of the recent tuna/dolphin dispute, there were claims that the dolphin populations concerned would not be in danger of extinction. Due to the delicate nature of many environmental problems, much caution is needed in the application of the article. Extraterritorial application of the article to environmental problems would cause many disputes about values. A country is free to decide on the desirability of protecting dolphins and how, but applying its values and policies to another country raises difficult definitional problems. For example, a bear may be a nuisance to local sheep farmers but a value to the public at large. GATT rules give great freedom for countries to decide on local environmental problems within their borders, but limit the imposition of these decisions on other countries.

Scope may also be an issue in regard to some legitimate environmental policies, as environment is not specifically listed in the text (contrary to many similar national laws). Protection of "human, animal, plant life or health" or "conservation of exhaustible natural resources" may cover many environmental issues, but not all. Some legitimate environmental policies may be left outside the scope of GATT.

Necessary or relating to. The "necessary" requirement in article XX:b means that GATT rules require countries to exhaust all less trade-distorting policy options available, before resorting to trade

if taken together with restrictions on domestic production and consumption. The headnote to the article requires the measures to be applied without "arbitrary or unjustifiable discrimination" between countries where the "same conditions prevail", and so that they do not constitute "disguised restrictions on international trade".

For example, the three species affected by Mexican fishing practices are not in the CITES list of endangered species.

The issues range from chemical pollution to biodiversity. Many problems are subject to difficult measurement problems, value judgements and uncertainty.
measures. Thus, GATT promotes the search for the most efficient policies by encouraging countries to use first-best policies that attack the true source of the problem. The burden of proof lies with the country invoking the article. In the Thai cigarette case, the Panel regarded information campaigns etc. more appropriate for the stated health target than trade restrictions. In the dolphin case, the Panel stated that the United States could have used less trade-distorting policies to protect dolphins -- international cooperation was mentioned as one possibility. The environmental value of the U.S. tuna policy (limiting the dolphin kill rate of tuna fishing fleets to some tens of thousands per year) has also been questioned. For example, Greenpeace has questioned the appropriateness of the U.S. measure or standard for true protection of dolphins: "such provision permits the continuance of the deliberate encirclement of dolphins to catch tuna and hinders international efforts to solve this environmental problem. The United States has not maintained policies that encourage sound tuna fishing practices." Recently the United States, along with other countries allowing driftnet fishing (Japan, China, Korea, Italy, Faro Islands), was condemned by the International Court of Animal Rights in Geneva for allowing the massacre of dolphins to continue. The unilateral trade action of the United States would have led to spreading its "bad environmental policy" by force worldwide.

Less trade-distorting and GATT compatible ways to influence environmental policies in other countries are, for example, product labelling, awareness building, side payments or aid. Labelling should have no problems with GATT rules if applied in a nondiscriminatory way. Awareness building can be very effective in changing behavior through the market in countries with high environmental awareness. The recent influence of environmental groups in increasing environmental awareness in many developed countries has been impressive. In poorer countries environmental quality can still be such a luxury that the only lasting way to change behavior and create incentives for environmental protection is side payments or compensation. Compensation is also already working in practice. Much development aid is geared to environmental problems, and debt for nature swaps have transferred resources for environmental protection. In Europe, the Nordic countries and the EC have transferred substantial sums for cleaning up environmental damage in Eastern Europe. Even within many European countries there are many successful compensation schemes in existence. For example, if a protected animal like a bear kills a sheep in a farmer's yard, he gets compensation from his government. Without the payment, he would probably kill the bear with sympathy from neighboring sheep farmers. A law forbidding the killing might have little force in practice and be difficult to enforce in distant forest areas.

Article XX has been used to justify trade restrictions, for example, to control imports of nuclear waste, or to deny market access for goods likely to carry contagious disease. Such measures have not been challenged in the GATT -- curing a disease at the source, for example, would take too long to be effective.

The "necessary" concept may force GATT Panels to give judgment on the ranking of environmental policies, which can be difficult even among environment experts. For example, it might be difficult to judge whether a requirement for producers to take back old cars for recycling is the least trade distorting alternative available to reduce waste. The present approach in relation to the "least trade distorting available" criterion is case by case. Attempts to develop more precise criteria for the wide range of public policy issues involved could run into serious definitional difficulties and cause more problems than would be solved.

The application of the "relating to" concept in article XX:g is somewhat more straightforward. Restrictions to trade have to be accompanied by similar restrictions on domestic production or consumption. True conservation efforts are undermined unless all sources of demand are restricted. Restricting exports or imports only would be discriminatory. Compared with the necessary criteria the "relating to" concept seems to be somewhat less strict, because its user only has to prove nondiscrimination with a domestic policy but not "least trade distorting available." Past Panels have checked whether domestic production, consumption
and trade are treated equally. For example, the present ban by Indonesia on exports of logs only is unlikely to be GATT compatible, whereas the total ban on all logging in Thailand would pass the test.\textsuperscript{16}

Nondiscrimination or disguised protection. Certain seemingly discriminatory measures under article III or I may fit the exceptions, because of the additional flexibility allowed for public policy goals. For example, discrimination embodied in some recycling policies might be compatible with article XX. But in the recent United States/Mexico dolphin case the U.S. policy may not have passed the nondiscrimination test either. In counting the yearly dolphin kill rate for U.S. and foreign fleets, the U.S. fishermen knew their rate before the season whereas the foreigners knew theirs only after the season.

The wording of the article has given rise to differing interpretations as to its applicability to processing methods (PPMs). This is because the text does not specifically mention where the object of the policy measure should be located. Some have interpreted this as allowing countries to worry about environmental protection outside their own borders -- including how goods are produced in other countries. The recent tuna/dolphin Panel ruled against this by stating that trade could not be restricted on the basis of differences in environmental regulation of producers across countries.

GATT members have interpreted the article widely. Measures covering PPMs are either planned or already in force in many countries. The EC has plans to restrict imports of furs with effect from 1995 if animals are caught with leg-hold traps. Some European countries are planning to make imports of tropical timber conditional on sustainable forest management in exporting countries. The United States has a number of laws allowing trade to be restricted unless exporting countries follow similar conservation policies to those of the United States (turtles, shrimp, tuna/dolphins). The recent Panel ruling would suggest that all these measures would be incompatible with the GATT.

In practice, restricting trade on grounds of differences in environmental standards can amount to the imposition of values by importers upon exporters. In the tropical timber case the EC and United States are attempting unilaterally to tell developing countries how their forests should be managed. This also raises difficult equity issues. If Europe cut down its trees in the past with no concern for sustainability, why should developing countries now be restricted, under threat of sanction, from managing their resources as they see fit? After all, the present global threat to sustainability may have been caused by past overconsumption of common resources. Furthermore, as many environmental problems in developing countries are linked to complex problems of poverty, trade restrictions would not solve the core of the problem. Environmental degradation could even increase, if the countries are deprived of their export revenues.

Cooperation and mutual assistance are much more likely to produce lasting results for the environment than coercive practices, especially in countries with different income levels. Unless policies manage to create incentives for environmental protection the achievement of many goals is likely to fail. For example, if Europe restricted trade from Eastern Europe on the grounds that unsafe nuclear plants are used to produce electricity, this is unlikely to improve the situation. The perceived risk of the plant may differ and many Eastern European countries have no alternatives or immediate funds to make the improvements, or they lack the technical expertise. Closing of nuclear plants in Bulgaria, for example, would quickly deprive the country of its main energy source making it even more difficult to find resources for improving safety. This is why the EC has offered financial and technical help in solving the problem.

\textsuperscript{16}Indonesia could, of course, achieve a similar effect by taxing the export of logs and be in line with the GATT.
Extraterritorial application of article XX would also favor large countries over small ones. Production methods in advanced industrial countries are unlikely to suit the conditions of countries with lower income levels and different environmental conditions. Exports of developing countries would be hurt, and environmental protection made unnecessarily costly.

The tuna/dolphin ruling has already been criticized by environmental groups as anti-environment. In reality, the ruling only limits the use of a bad environmental policy and encourages the parties concerned to solve the underlying environmental problem with more appropriate policies. A favorable ruling would have given a blank check for countries to impose their own standards and values on others. A more constructive way for the United States and Mexico to solve their dispute would be to cooperate in an international treaty protecting the dolphins.

Standards Code

The Standards Code was negotiated in the Tokyo Round to clarify the application of standards in the trade field, and to prevent their abuse as nontariff barriers (NTBs). In spirit, it has many similarities with article XX, and it also suffers from similar definitional problems. The text gives no clear indication whether PPMs are covered. Environment is explicitly mentioned among the public policy goals, which makes its theoretical scope wider than that of article XX. The Code is a freestanding agreement applying only to its signatories (who number about 40). It gives guidelines for the application of standards in trade, but provides no authority to enforce them. This would have to be made with articles III or XX of the General Agreement. The Code has never been formally challenged in disputes.

To minimize the use of standards as NTBs, the Code promotes a number of principles. The use of harmonized international standards is given priority. Standards should be the least trade distorting measures available. The use of scientific evidence is recommended in the dispute procedures. Transparency is enhanced by a notification requirement, and prior to their adoption proposed standards are circulated for comments to other signatories. The Uruguay Round has discussed some revisions to the Code. These include more precise rules for risk assessment, more specific mention of scientific evidence and a proportionality principle for applied policies.

The Code raises some other problems in relation to efficiency and protectionism. International harmonization of standards in some cases may run counter to allocational efficiency and comparative advantage. Harmonization of product standards, however, can also reduce the costs of compliance with standards and reduce their potential for use as NTBs.

An example of problems with the application of the Code (or articles III and XX of GATT) are Swedish and Swiss regulations forbidding chickens from being raised in cages (a PPM), with the same measures to be applied to imports. Chickens are unlikely to qualify as an exhaustible natural resource, but are part of animal life. Does living in cages affect chickens as a product? Is the "standard" necessary for the health of chickens? Could such a measure be justified by scientific evidence? If the PPM does not affect chicken as a product, why should Sweden and Switzerland worry about chicken welfare in other countries? All this merely highlights some of the difficulties facing environmental policy makers, and calls for caution in the use of trade instruments.

Subsidies and Dumping

Eco-dumping is one of the recent buzzwords of environmental groups. The argument is that imported goods should be subjected to duties unless the exporter has applied certain environmental policies. Implicitly,
the statements seem to assume that the costs of environmental policies should be the same across countries, ignoring differences in absorptive capacities, in the willingness to tolerate pollution, and in the costs of abating pollution. Alternatively, they assume that investigators in the importing country would know the optimal level of pollution in the exporting country for each source of damage, the exact amount of the unpaid environmental cost in each product, and its source in the exporting country. Any such scheme would run into formidable problems at the practical level. Furthermore, as environmental standards are set by governments, it would be difficult to accuse enterprises of not complying with a policy that does not exist.

Various environmental assessment techniques, or cradle to grave approaches, used to measure environmental costs and recommended by environmental groups can, at most, give some guideline on the environmental cost of products. Due to the complexity of many environmental problems even most sophisticated methods leave room for judgment and measurement errors. Therefore, they would be more useful as a tool of information to influence consumer behavior than as a trade restriction. Furthermore, as environmental costs are a relatively small part of total costs, a tariff of 3-5 percent at the border in many cases is unlikely to solve the environmental problems in the exporting countries. The likely result would be additional protection for domestic producers.

As for subsidies, the GATT subsidy rules interact with environmental policies in two ways. GATT sets some limits to the use of subsidies to finance environmental policies. Lack of environmental measures has been regarded as a form of implicit, countervailable subsidy by a number of environmental groups.

GATT rules set limits to the use of subsidies because of their potential impact on competitiveness. The existing rules are not very precise, either on what is allowed or what is a subsidy or injury. As a general rule, environmental or other subsidies of a general nature should be GATT compatible. A reasonable use of environmental subsidies to help pay for abatement or cleanups is therefore likely to be GATT compatible. The Uruguay Round has attempted to classify subsidies as allowable and nonallowable. Governmental contributions to one-time adaptation or to the costs of environmental equipment have been proposed as generally allowable subsidies. The GATT does not prohibit production subsidies, but seeks to prevent their use by countries to acquire more than an "equitable share" of international trade in a product. In practice, countries use many types of implicit or explicit subsidies. A limited use of subsidies might help to mitigate demands for protection on account of differences in environmental costs across countries.

Whether GATT rules on subsidies should allow countries to impose countervailing duties for differences in environmental standards across countries is subject to some debate. Apart from the requirement to establish proof of injury, the very existence of a subsidy could be difficult to prove. A true investigation of environmental costs would have to identify the sustainable level of environmental damage in the exporting country and how much producers deviate from that. It could also be argued that the "lack of subsidy" is


18Export subsidies on manufactured products are, in principle, prohibited. Production subsidies can be countervailed, if they cause injury to an industry in the importer's market.

19Subsidies may have some undesirable side effects: entry to the industry may be encouraged and polluters may pollute more to get more money.
generally available and therefore compatible with the GATT. All this is subject to formidable measurement problems and could open a Pandora's box as far as trade remedies are concerned.

GATT and International Environmental Policies - Conflict or Coexistence?

The relationship between international environmental treaties and the GATT has been subject to some debate. At one extreme, some have suggested that international environmental treaties should completely override GATT rules. Within GATT, the contracting parties could do this by waiving their GATT obligations for environment in general or for specific treaties on environment. Such a blank check could, however, lead to serious trade disruption. The ability of governments to resist these pressures is weakened without the support of the international trade rules. The benefit of such an arrangement for the environment would also be doubtful. Trade disruption would reduce growth and true environmental problems would remain due to the second-best nature of trade policies. Many international treaties on various aspects of global environmental problems exist, and most of them have been negotiated without the use of trade measures.

A better solution for both trade and the environment would be an accommodation between the GATT and international treaties. GATT rules would discipline the use of bad environmental instruments (trade policies) in global treaties and lead to caution in their use as sanctions. Any potential conflicts between the two could be solved either through waivers on specific issues or through a clarification of some existing rules. But as at present GATT rules contain little that would run contrary to efficient national or international environmental policies, the conflicts are likely to be few in number.

International environmental policies interact with GATT to the extent they have trade effects. This can arise from: (i) common instruments in international treaties, from (ii) instruments used by countries individually to reach a commonly agreed target, or from (iii) sanctions used to enforce common action within or outside a treaty. If the measures are to be justified under article XX, the environmental problem would have to fit within its scope. Ozone depletion or toxic waste are unlikely to raise any issues. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) deals with endangered species. By signing a global convention, countries also seem to acknowledge the existence of a global common. An elephant may be a nuisance to local farmers but of great value to environmental groups or voters in developed countries. It can be made a global common by multilateral agreement. Measures taken under the CITES convention would have to be judged on a case-by-case basis under article XX. The Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal (not in force yet) raises an interesting question, since it includes metal scrap in its definition of hazardous material. While hazardous waste may pose a true health risk, it may be more questionable whether restricting trade in metal scrap would fit within the scope of article XX.

Efficiency questions arise in relation to the choice of instruments used, just as they do in the case of domestic policies. For example, the Montreal Protocol on Substances that Deplete the Ozone Layer sets targets to reduce the use of chlorofluorocarbons (CFCs), but countries are free to choose the policies they

---

20 A similar protective effect can, nevertheless, be achieved under the taxation rules. A producer facing production-related environmental charges only has to convince his regulator to impose an indirect tax to correct the externality. It is less efficient from the point of view of controlling pollution, but allows the producers to benefit from protection from competing imports.

21 Policies dealing with international environmental problems are subject to similar efficiency concerns as those dealing with national ones: policies should aim at the source of the problem to equalize marginal costs and benefits across locations. Cost sharing requires judgements about property rights, which with international sources can be subject to complex negotiations.
judge necessary. Problems with GATT may arise if trade in products produced with CFCs (a PPM) is
restricted. In treaties where common measures are defined for all signatories, these may come under GATT
scrutiny. For example, the GATT compatibility of the CITES ban on ivory trade would require that it is
accompanied by similar domestic measures, or that it is proven to be the least trade distorting measure
available. Recent research on ivory trade indicates that trade bans alone may be counterproductive for the
protection of elephants. Creation of local property rights and incentives to manage the resource as an asset
are more necessary for the maintenance of elephant populations. Trade bans alone are likely to create
incentives for smuggling. The short-run price decline from the present ban is likely to create new sources of
demand, which over time will establish new trade links with the producing countries thus raising the price for
poachers.

The use of trade sanctions to enforce international environmental protection has been a controversial
topic. In view of the global nature of some environmental problems, efficiency calls for widespread
participation by countries in reducing the sources of damage. Action by a few can be costly to them and do
little to reduce the global problem. Countries may be tempted to free-ride in order to get the global benefits
without incurring costs. Participation and compliance are induced by punishment or reward, and negotiation
and compensation are less distorting and more stable solutions than sanctions. Unless incentives are created
for the enforcement of environmental standards they are unlikely to be implemented in poor countries with
little resources for monitoring. The sharing of the burden will also raise difficult questions in respect of
property rights and equity, which are best solved by negotiation.

In theory, the use of trade measures to reduce international sources of environmental damage has been
justified as third-best. However, the unilateral use of sanctions can easily lead to the imposition of
unilaterally determined values across countries, but only bring marginal benefits in terms of addressing the
global externality. In the context of the international trading system, this is likely to do more harm than good.
Within a multilateral framework established to address global problems, the threat of sanctions may induce
participation in common action, or may be needed as a third-best last resort to curb free-riding or enhance
efficiency, once efforts to reach cooperative solutions have been exhausted.

International problems of enforcement raise two specific untested issues for the GATT rules: the use
of unilateral sanctions with transnational problems, and discrimination against nonsignatories in international
treaties. These are discussed in more detail below.

Unilateralism

Whether article XX would allow for the unilateral use of trade sanctions to deal with international
environmental problems is subject to some uncertainty. This is linked to similar problems of interpretation
as those relating to extraterritoriality and PPMs discussed earlier. The main difference is that a transnational
or global environmental problem is presumed to cause damage in the importing country as well. Smog or
chemical fumes across the border from production in the exporting country can cause direct damage to the
importer -- even if trade does not take place between the two.

The text in article XX is sufficiently unclear to allow for various interpretations. The direct damage
to "human, animal life or health" inside the importer's borders from polluting production in other countries
could be proven in this case. It could also be argued that availability of less trade distorting measures is

---

22Barbier et al. (1990).

23See, for example, Baumol (1971).
restricted by sovereignty. The recent Panel ruling on the United States-Mexico tuna/dolphin case did not directly address this issue, although it suggested that interpretations of article XX should be resisted. The spirit of GATT is against unilateralism.

The problem should be clarified in the GATT. Any unilateral use of sanctions, even in respect of international environmental problems, should be forbidden. First, the existence and extent of many international environmental problems is subject to difficult measurement problems, subjective value judgments or uncertain scientific evidence. As environmental values tend to diverge considerably with income levels, developing countries are especially vulnerable to unilateral punishment and feel hurt by interference with their sovereignty. The number of species in a tropical forest may have high value for environmental groups in developed countries, but rank low with local forest workers. Perceptions of property rights may be subject to differing views. Environmentalists may claim rights to tropical forests as global commons -- Malaysia, Brazil or Congo may see them more as part of their own natural resources and demand compensation for any interference. Coercion through trade sanctions would be confrontational and provoke a North-South clash. Cooperation in international agreements or other cooperative solutions would seem a more productive way to solve the common environmental problem and bring lasting results.

Second, the source of pollution and the underlying causal relationship can be difficult to establish, which makes the use of unilateral trade sanctions questionable. It would be difficult for the Nordic countries, for example, to establish how much acid rain comes from which neighboring country, or from the production of any specific good. This could lead to difficult measurement problems and requirements of proof.

Third, unilateral sanctions are unlikely to be effective in solving the cause of the environmental damage. The polluter can always direct exports to other countries. If a small country like Finland restricted imports from its eastern neighbors for cross-border air pollution, they could continue to export elsewhere with no reduction in pollution. Dutch restrictions on tropical timber would do little to mitigate global warming, but would cut revenues of developing countries and contribute to worsening of the underlying environmental problem. The causes of environmental degradation in many developing countries are extremely complex. Forests may be depleted through agricultural uses or through the use of wood as cooking fuel by the poor. Trade sanctions would do little to solve the problem. Imposing environmental standards on poor countries would do little for the environment, as lack of resources or other priorities can make their enforcement impossible. It would only create trade harassment and resentment. Instead of coercion, developed countries should seek collaboration with developing countries in solving these complex problems.

Fourth, any attempts at devising effects-based rules would encounter serious definitional difficulties and cause more problems than they would solve. The examples from other unfair trade rules, like antidumping and countervailing duties, are a good indicator.

Fifth, the effectiveness of sanctions would be related to the size of the country imposing them. Uncooperative solutions would lead to large countries imposing their values and standards on smaller ones which have little retaliatory power. In many cases production methods in developed countries are unlikely to suit the technological or financial conditions in developing countries.

**Discrimination in Global Treaties**

The use of trade sanctions against nonsignatories in international treaties on the environment raises several problems with the GATT, although the issue has not been tested in disputes. The ensuing discrimination is likely to be contrary to the unconditional MFN principle. To make them GATT compatible, there are three basic choices: (i) the text in article XX could be interpreted to allow for trade sanctions under
international treaties if they are judged necessary, (ii) GATT contracting parties could waive their GATT obligations case by case for any GATT inconsistent measure; or (iii) GATT could be amended to cater to the environmental concerns of its signatories.

According to the first option, discrimination could be accommodated by an interpretation of the headnote to article XX. The words in the headnote, "where the same conditions prevail," would allow countries that have undertaken certain specific obligations within an international treaty to discriminate against nonsignatories. This is further supported by the spirit of article XX(h), which allows exceptions for international commodity agreements under certain conditions. Thus, GATT could be interpreted to permit the use of trade sanctions in international treaties as a last resort measure, if all other options have been exhausted. The burden of proof for the need for trade sanctions would be with the signatories. The coexistence of GATT and international treaties would thereby allow trade sanctions under multilateral global treaties in accordance with strict criteria, and at the same time ensure a certain discipline in their use.

Discrimination against nonsignatories is envisaged in the Montreal Protocol. The drafters of the Montreal Protocol relied on the above interpretation, and acted in the belief that the proposed trade ban against third parties was GATT compatible. Whether it was necessary has been the subject of some debate among economists. Some have pointed out that as the treaty agrees to reduce the use of CFCs, and not the emissions directly resulting, efficiency losses from suboptimal instruments could outweigh those from free-riding,\textsuperscript{2} and that as most producers of CFCs have signed the agreement, no sanctions are necessary against nonsignatories. On the other hand, the threat of sanctions may have induced more countries to join than otherwise would have been the case. Production can also relocate to nonsignatories unless trade is curbed.

The second option, of a waiver under article XXV, would require a two-thirds majority of GATT members representing over one half of the GATT membership. Its exceptional nature could make countries exercise caution in using it. However, if used frequently (as each specific case could exempt GATT signatories from all of their GATT obligations), discipline on the use of trade measures would be reduced. This could increase the use of trade instruments not just as sanctions, but as instruments of international treaties on environment as well. Also, if the number of international treaties increases in the future, this could lead to an erosion in the special status of the waiver.

The third option, of negotiating an amendment to GATT for the environment, was implicitly suggested by the recent dolphin Panel. This would substantially reduce the discipline in GATT on the use of trade policies for environmental purposes. As the present rules contain very little against efficient environmental policies, major amendments to the rules would not seem unjustified.

Conclusions

Environment is likely to be one of the main trade issues of the 1990s. Environmental standards and costs of compliance are likely to increase in many countries. International environmental treaties will also impose additional costs on producers. Dynamic industries should have no problem in adjusting to new standards, but already troubled ones may find in environmental arguments another excuse to seek trade protection. Differences in environmental costs can trigger protectionist demands, especially if other countries are not seen to be making similar efforts. Developing countries would be hardest hit by such protectionism, as they can least afford the costs of local or international environmental protection. Moreover, differences in environmental costs will continue, reflecting different endowments and demands for environmental quality. To avoid environment-related trade disruption, some of the present GATT rules need to be clarified.

\textsuperscript{2}See, for example, Bohm (1990).
Developing countries have a major interest in clear, strong, multilateral rules that prevent the unilateral imposition of environmental values across countries, and reduce the potential for NTBs in the application of standards. GATT can promote respect for sovereignty in regard to national environmental issues, and the search for cooperative solutions in the international context.

Trade fora seem to be the wrong places to address environmental issues. This is because the source of the problems is not in trade, but rather in the need to internalize environmental costs in prices, to address bad policies, and to clarify property rights. Focus on trade is diverting attention from the real sources of the problems, and therefore from more appropriate solutions to many environmental problems. The analysis has shown that GATT poses little threat to the pursuit of most legitimate environmental policies. On the contrary, as trade measures seldom are efficient either as instruments or as tools of enforcement of environmental policies, GATT promotes good environmental policies.

GATT sets no restrictions on the pursuit of purely domestic environmental policies. Production-related measures are outside its scope. Product-related environmental policies can be extended to imports, if they are applied in a nondiscriminatory manner. Some environmental policies may come up against the national treatment requirement if they are biased in favor of domestic producers. Article XX allows more flexibility in the use of instruments for public policy goals, but encourages the use of first-best alternatives whenever feasible. Under strict interpretation, article XX prohibits the use of trade measures to correct differences in environmental costs (PPMs).

Some of the relevant rules are uncertain, especially those dealing with international environmental problems. The recent tuna/dolphin Panel suggests that the extraterritorial application of article XX would be against the GATT rules, but the legitimacy of unilateral sanctions under article XX to deal with transnational environmental problems is still open to interpretation. Also, the question whether discrimination is permitted against nonsignatories of international environmental treaties under article XX is subject to varying interpretations.

A closer look at the GATT rules also reveals some anomalies with respect to efficient environmental policies that may cause trade friction and affect the pursuit of legitimate environmental policies. The GATT border adjustment rules may promote the use of indirect taxes to reduce the impact of environmental costs on competitiveness, and allow for double taxation of imports. Some legitimate environmental measures may fall outside the scope of GATT, because environment is not specifically listed among the public policy goals in article XX. The subsidy rules set some limits on the financing of environmental policies, although a limited use of general subsidies may reduce demand for protection on environmental grounds.

The role of GATT as the guardian of the international trading system may thus be challenged by environmental considerations. But there seems little justification for a major amendment of the GATT on these grounds. The present problems can be solved by clarifying some of the rules, or by a selective use of waivers in exceptional cases. Certain issues warrant particular attention. First, the scope of article XX and the Standards Code should be clearly limited to product-related measures. This was already confirmed in the United States-Mexico tuna Panel, where the extraterritorial application of article XX was condemned. Second, the unilateral use of trade sanctions should not be allowed under the GATT to address international environmental problems. This requires a clarification in the scope and use of article XX. Countries should be encouraged to use either moral suasion or compensation when dealing with cross-border environmental problems. Less trade distorting ways of influencing environmental policies in other countries are product labelling, awareness building, moral suasion, and financial or technological transfers. Third, the relationship between international treaties on global environmental problems and the GATT needs to be clarified. They can coexist and reinforce each other. GATT rules should encourage the application of efficient global
environmental policies, and allow for a limited use of trade sanctions for enforcement and to induce participation only as a last resort. This could be achieved by a clarification of article XX, or by a waiver under article XXV.
Discussant's Comments

J. Michael Finger

Mrs. Sorsa's paper takes up three issues:

1. Developing (and other) countries' concerns that environmental standards will become new and arbitrary barriers against their exports.

2. The correspondence between GATT rules and environmental regulations.

3. The unilateralism that is creeping into international trade and into international environmental issues.

This comment will take up the same issues. On the first two, what I have to say is in agreement with what Mrs. Sorsa has to say, but my emphasis will be on a different dimension of the issue. On the third issue, unilateralism, my point and hers cannot be reconciled.

To open, I want to say a few kind words for the GATT. In my view of development history, the openness of major developed country markets to imports of manufactured goods has been the most important international factor in the many development successes that have been recorded since the Second World War. The GATT was the instrument for creating this openness, hence as an international development institution, I am inclined to rate it even above the World Bank -- the institution responsible for my own economic development. I am a great admirer of the GATT.

Being a great fan of the GATT, I am, by self-appointment, its defender. My toughest chore however is not to defend GATT from its enemies. They are usually ill-informed, brash, and can be put aside with minimal effort. My greatest challenge is to defend GATT from its friends. These friends are always sincere, and my challenge is to cut through this sincerity to the reality of the functioning institution that the GATT is. The GATT I know and love is not Sir Lancelot, the true and pure knight, in shining armor astride a noble white horse.

Have you seen the film, "Terminator 2"? I see GATT in the image of Arnold Schwartzzenegger in the last reel: a beat-up old machine, rusting metal showing through where the flesh has been torn away; a machine designed to kill, but cross-wired to be a protector. And there beside Arnold is GATT, a creaking assemblage of mercantilist parts rigged to defend free trade. Those whose interests are being protected mostly do not even know it, and the opposition has the newer technology on its side -- the newer, slicker model terminator; the newer, slicker paragraphs in the trade remedies laws.

The first matter I want to explain is the following: consistency of environmental regulations with GATT rules is irrelevant to any judgment as to whether either the environmental regulations or the GATT rules are a good thing. There are two reasons for this. The first is that the GATT rules are built on standards that are entirely arbitrary -- well-intentioned, but arbitrary.

---

25Internal factors were more important than international ones. That is why the adjective "international" is emphasized in that sentence.
GATT starts with its basic principles. By joining the GATT a country commits itself to:

- Apply trade restrictions in a nondiscriminatory manner.
- Participate in negotiations to reduce these restrictions.

In the GATT as a written document, this takes only a few pages, about the first three articles. The thrust of the other 25 or 30 articles is in the opposite direction. They are, functionally speaking, a list of permissions to impose trade restrictions of one sort or another -- but always within limits, and the specifications of these limits are what we call the GATT rules.

The GATT rules are limits to trade restrictions, but arbitrary limits. The sense of them is "Hey! I'll let you get away with this, but only so much of it!" There is no economic, commercial, or moral sense in stopping where the GATT rules say to stop. For example, serious injury versus material injury: a domestic industry suffering serious injury from import competition has to tough it out, but one suffering material injury has a right to governmental protection. But if the foreigner is unfair as well as injurious, then serious injury is enough. But if the serious injury is the cumulative effect of 40 or 50 foreigners rather than the single effect of one, then serious may not be enough. Extending this to environmental concerns, GATT panels would, as Mrs. Sorsa points out, sit down to distinguish between practices that exhaust the dolphin population versus those that only cause pain and death to dolphins. The first problem is a material one, the second one only serious, hence those dolphins have no claim for relief.

Environmental policy has a lot to learn from the GATT rules.

So much for the arbitrariness of GATT rules. The second reason why their correspondence or lack thereof with environmental regulations is irrelevant to judging whether either is good relates to GATT's power to enforce its rules. In sum, it has none, except for the power of persuasion, armed by appeal to an agreed international standard. The international standard itself, as I explained above, is arbitrary, and has no power in and of itself to persuade.

My second concern -- and here Mrs. Sorsa and I are clearly trying to do the same thing -- is to warn those who want to use trade instruments to advance environmental objectives. There have been other attempts to use trade instruments to advance nontrade objectives, and they have a sad history. (Indeed, those of us who want to use trade instruments to achieve good trade policy have a sad history. But I'll go on, anyway.)

What has happened to antidumping policy illustrates the risk. Antidumping as an excuse for trade restrictions was justified by the need to extend across international borders the policing that antitrust laws provide against monopolies at home. Today many observers of antidumping are convinced that it has become a tool of monopolies, not an antidote. Antidumping is how a monopoly extends across national borders the price rigging that it has already accomplished at home.

Thus a warning about the use of trade restrictions to achieve environmental objectives. Parallel attempts in the past have shown that the "rules" that hold the trade instruments focused on a justified cause are soon bent out of shape, captured, corrupted. They do not just fail to save dolphins, they end up killing songbirds as well.

My third concern is to put in a good word for unilateralism. Mrs. Sorsa's view, a more popular one than mine, I admit, is characterized by statements such as: the spirit of GATT is against unilateralism;

---

26 There is economic, commercial and moral sense in not doing any of this at all, but that is another story.
coercion through trade sanctions would be confrontational and provoke a North-South clash; environmental objectives are better achieved by negotiation and compensation than through punishment with trade sanctions.

Come now! Perhaps better achieved, but certainly not often achieved. Trade restrictions, we all know, have greater domestic costs than domestic benefits. Hence, in a "Coase theorem" world of effortless negotiation and compensation, the gainers from free trade would buy off the potential gainers from protection, and there would be:

- no trade restrictions
- no GATT
- no GATT - environment controversy
- no conferences such as this one
- no session on this conference for me to make a speech.

But here I am, and the fact of my presence (plus the logic of the previous paragraph) proves that Mrs. Sorsa’s premise is wrong.

There has always been a strong element of unilateralism in the GATT. When the intellectuals thought this unilateralism was a good thing they called it “United States hegemony.” Now, the intellectuals call it “the diminished giant syndrome.” To give the devil his due, there has been something of a switch from a unilateral carrot to a unilateral stick. My good word is for the unilateral stick, "section 301" in U.S. trade law. For anyone who has spent the last ten years on the planet Mars, "301" provides an avenue for a U.S. exporter to complain to the U.S. government about a foreign policy or practice that retards U.S. exports. If the U.S. government finds grounds to uphold the allegation, and the foreign government refuses to change the policy, the U.S. government must retaliate by restricting U.S. imports from the "guilty" country.

The good word is "results." Since "301" was created in 1974, 74 cases have been completed. In 11 of these the U.S. government found the petition to be groundless, leaving 63 which ended with a change of policy. In 48 out of 60 cases the policy change has been a liberalization; only 15 times has a case ended with the United States taking retaliatory action. And 36 of the 48 liberalizations were multilateral rather than bilateral, i.e., of benefit to any exporter, not targeted at U.S. exporters only.

No one likes these numbers. I have presented them several times, and each time people have stepped forward to argue the numbers are lies, or at best misrepresentations. In response, I admit that anyone who refuses to buy tuna out of concern for dolphins is certainly within his or her rights and, I do not doubt, is acting rationally. But, I continue, those that question my numbers go farther. They insist that tuna caught at the expense of dolphins' pain and death must therefore taste bad, and be unhealthy. I find this logic questionable. That there is one good reason not to buy tuna does not mean that every reason points in the same direction. There may be reasons to dislike "301" but its results are not among them.

---

27The information in this paragraph is from my tabulation of case outcomes reported by the United States Trade Representative. The sources are United States Trade Representative (1975) and (1991a,b).
Bibliography


Daly, Herman E. and John B. Cobb, Jr. 1989. For the Common Good: Redirecting the Economy Toward Community, the Environment, and a Sustainable Future. Boston: Beacon Press.


Game Theory with Applications to Economics. New York: Oxford University Press.

Comment on Horst Siebert, 'Environmental Policy and European Integration'. In Horst Siebert (ed.) Environmental Scarcity: The International Dimension. Tübingen: Mohr (Siebeck).


An Interim Report on the State of Forest Resources in the Developing Countries. Rome: FAO.


Game Theory With Applications to Economics. New York: Oxford University Press.


Goldenberg anuncia reducao do desflorestamento na Amazonia. Gazeta Mercantil (March 7).


The Tokyo Round of Multilateral Trade Negotiations, Report by the Director-General of GATT, Geneva (April) ch. VIII.


_________. 1976. Implications for the Trade and Investment of Developing Countries of US Environmental Controls. NY:UNCTAD.

_________. 1982. Environmental Policies and Their Trade Implications for Developing Countries, With Special Reference to Fish and Shellfish, Fruit and Vegetables. New York: UNCTAD.


Report to the Congress by the President. 1991. Response of the Administration to Issues Raised in Connection with the Negotiation of a North American Free Trade Agreement. (May).


Strand, J. 1990. Lending Terms, Debt Concessions, and Developing Countries' Resource Extraction. Working paper no. 5, Department of Economics, University of Oslo (March).


<table>
<thead>
<tr>
<th>Country</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARGENTINA</td>
<td>Carlos Hoch, SRL&lt;br&gt;Calle 28&lt;br&gt;Florida 141, 4th Floor-C&lt;br&gt;453/455&lt;br&gt;1333 Buenos Aires</td>
</tr>
<tr>
<td>AUSTRALIA, PAPUA NEW GUINEA, FIJI, SOLOMON ISLANDS, VANUATU, AND WESTERN SAMOA</td>
<td>D.A. Books &amp; Journals&lt;br&gt;430 Whitemore Road&lt;br&gt;Milkam 32&lt;br&gt;Victoria</td>
</tr>
<tr>
<td>AUSTRIA</td>
<td>Gerald and Co.&lt;br&gt;Virgin 31&lt;br&gt;A-1011 Wien</td>
</tr>
<tr>
<td>BAHRAIN</td>
<td>Bahrain Research and Consultancy Associates Ltd.&lt;br&gt;Internal Building No. 22&lt;br&gt;Diplomatic Area&lt;br&gt;P.O. Box 2790&lt;br&gt;Mansoua Town 317</td>
</tr>
<tr>
<td>BANGLADESH</td>
<td>Micro Enterprise Development Assistance Society (MEDA)&lt;br&gt;House 5, Road 16&lt;br&gt;Dhaka 1229&lt;br&gt;Branch office: 136, Nur Alam Road&lt;br&gt;Chittagong 4000&lt;br&gt;76, K.D.A. Avenue&lt;br&gt;Kolkata</td>
</tr>
<tr>
<td>BELGIUM</td>
<td>Jean De Laveuve&lt;br&gt;Av. du Rat 222&lt;br&gt;1080 Bruxelles</td>
</tr>
<tr>
<td>CANADA</td>
<td>La Dalmation&lt;br&gt;C.P. 8012, 1831 rue Amher&lt;br&gt;Montréal, Québec&lt;br&gt;H3 J 5J6</td>
</tr>
<tr>
<td>CHINA</td>
<td>China Financial &amp; Economic Publishing House&lt;br&gt;&amp; Da Fe St Ding Jia&lt;br&gt;Beijing</td>
</tr>
<tr>
<td>COLOMBIA</td>
<td>Bolivariana Ltd.&lt;br&gt;Apartado Aereo 34270&lt;br&gt;Bogota D.E.</td>
</tr>
<tr>
<td>COTE D’IVOIRE</td>
<td>Centre d’Edition et de Diffusion&lt;br&gt;Afrique (CEDA)&lt;br&gt;40 B.P. 561&lt;br&gt;Adjamé 04 Plateau&lt;br&gt;CYPUS</td>
</tr>
<tr>
<td>DENMARK</td>
<td>Sandelands Litteratur&lt;br&gt;Rummersals Allé 11&lt;br&gt;DK-1000 Frederiksberg C</td>
</tr>
<tr>
<td>DOMINIC REPUBLIC</td>
<td>Editors Fisher, C. per A&lt;br&gt;Rameau aux Aigles la Cambre 339&lt;br&gt;Apartado Postal 2190&lt;br&gt;Santo Domingo</td>
</tr>
<tr>
<td>EGYPT, ARAB REPUBLIC OF</td>
<td>At Alray&lt;br&gt;Al Galal Street&lt;br&gt;Cairo&lt;br&gt;The Middle East Observer&lt;br&gt;61, Seriel Street&lt;br&gt;Cairo</td>
</tr>
<tr>
<td>EL SALVADOR</td>
<td>Facilas&lt;br&gt;Avenida Manuel Enrique Arose 1230&lt;br&gt;Editions S.A., 1st. Two&lt;br&gt;San Salvador</td>
</tr>
<tr>
<td>FINLAND</td>
<td>Alkovenen Erikkos&lt;br&gt;P.O. Box 220&lt;br&gt;Helsinki 10&lt;br&gt;50370 VITI</td>
</tr>
<tr>
<td>FRANCE</td>
<td>World Book Publisher, 64, avenue d’Alma&lt;br&gt;75464 Paris</td>
</tr>
<tr>
<td>GERMANY</td>
<td>LIND Verlag&lt;br&gt;Poppelsdorfer Allerie 55&lt;br&gt;D-33202 Biele&lt;br&gt;Schokoriez 1</td>
</tr>
<tr>
<td>GREECE</td>
<td>KEA&lt;br&gt;Bryntoploton Street Planta Plastics&lt;br&gt;Athens-Issia 11455</td>
</tr>
<tr>
<td>GUATEMALA</td>
<td>Libreria Poncita Santa&lt;br&gt;S. calle 7-55&lt;br&gt;Zona 1&lt;br&gt;Guatemala City</td>
</tr>
<tr>
<td>HONG KONG, MACAO</td>
<td>Acon 2000 Ltd.&lt;br&gt;46-68 Wyndham Street&lt;br&gt;Wan Chai Centre&lt;br&gt;2nd Floor&lt;br&gt;Central Hong Kong</td>
</tr>
<tr>
<td>INDIA</td>
<td>Allied Publishers Private Ltd.&lt;br&gt;751 Moten Road&lt;br&gt;Mumbai - 400022&lt;br&gt;Branch office: 15 D, Hornet Marg&lt;br&gt;South Bombay - 400026&lt;br&gt;13/14 Aesl All Road&lt;br&gt;New Delhi - 110 002&lt;br&gt;17 Chittaranjen Avenue&lt;br&gt;Calcutta, Quebec&lt;br&gt;135 1516</td>
</tr>
<tr>
<td>IRELAND</td>
<td>Irish Academic Book&lt;br&gt;Model Building, 5&lt;br&gt;Newman Avenue&lt;br&gt;Galway - 090&lt;br&gt;3-8 5129 Kildough Road&lt;br&gt;Hydehall - 020 027&lt;br&gt;North Road&lt;br&gt;South Clare&lt;br&gt;Alembal - 360001&lt;br&gt;Pakira House&lt;br&gt;16-A, Agra Marg&lt;br&gt;Lucknow - 226 001</td>
</tr>
<tr>
<td>INDONESIA</td>
<td>Pt. Indra Limited&lt;br&gt;J. Suyanto Marg 37&lt;br&gt;P.O. Box 181&lt;br&gt;Jakarta Post</td>
</tr>
<tr>
<td>ISRAEL</td>
<td>Yamot Literature Ltd.&lt;br&gt;P.O. Box 56205&lt;br&gt;Tel Aviv 61650&lt;br&gt;Israel</td>
</tr>
<tr>
<td>ITALY</td>
<td>Libris Comunicatori&lt;br&gt;Sasparet S.P.A.&lt;br&gt;Via Dura Di Calabria, 1/1&lt;br&gt;Casale Ponzit 531&lt;br&gt;20125 Fauto&lt;br&gt;ISRAEL</td>
</tr>
<tr>
<td>JAPAN</td>
<td>EAEN Bank Services&lt;br&gt;2-F, Hagi-Michana, Bunkyo-ku 11-3&lt;br&gt;Tokyo</td>
</tr>
<tr>
<td>JORDAN</td>
<td>Alanneh Book Corporation&lt;br&gt;P.O. Box 101, Warran&lt;br&gt;Kuwait</td>
</tr>
<tr>
<td>KENYA</td>
<td>Africa Book Service (S.A.) Ltd.&lt;br&gt;P.O. Box 4245&lt;br+Nairobi&lt;br&gt;KOREA, REPUBLIC OF&lt;br&gt;Fan Eras Book Corporation&lt;br&gt;P.O. Box 107, Yonsei University&lt;br&gt;Seoul&lt;br&gt;SOUTH AFRICA, BOTSWANA&lt;br&gt;P.O. Box 3465&lt;br&gt;University Press&lt;br&gt;Southern Africa&lt;br&gt;P.O. Box 1141&lt;br&gt;Cape Town 8000</td>
</tr>
<tr>
<td>LIVESTOCK</td>
<td>Information Services&lt;br&gt;P.O. Box 7184&lt;br&gt;Riyadh&lt;br&gt;SAUDI ARABIA, QATAR&lt;br&gt;Jaar Bank Store&lt;br&gt;P.O. Box 3960&lt;br&gt;56471</td>
</tr>
<tr>
<td>LUXEMBOURG</td>
<td>Filipin I Sosial&lt;br&gt;Saud Aliah Ali Book&lt;br&gt;King Hall&lt;br&gt;Kingah Book&lt;br&gt;P.O. Box 3669&lt;br&gt;Dammam&lt;br&gt;33, Mohammad Hamad Avenue&lt;br&gt;P.O. Box 9978&lt;br&gt;Jaipur&lt;br&gt;SINGAPORE, TASMANIA, MYANMAR, RUSSIA&lt;br&gt;Information Publications&lt;br&gt;P.O. Box 2300&lt;br&gt;Riyadh&lt;br&gt;54, New Industrial Road&lt;br&gt;Bangane 19950</td>
</tr>
<tr>
<td>MEXICO</td>
<td>INFOTEC&lt;br&gt;Apartment Postal 22, 660&lt;br&gt;14400 Tijuana, Mexico D.F.</td>
</tr>
<tr>
<td>MOROCCO</td>
<td>Societe d’Etude Marketing Marocaine&lt;br&gt;11 rue Momenet, Bd. d’Arif&lt;br&gt;Casablanca</td>
</tr>
<tr>
<td>NETHERLANDS</td>
<td>De Libri#!/DeLibri&lt;br&gt;P.O. Box 220&lt;br&gt;7400 All Hasbergen</td>
</tr>
<tr>
<td>NEW ZEALAND</td>
<td>Hills Library and Information Service&lt;br&gt;Penina Bag&lt;br&gt;New Market&lt;br&gt;Auckland&lt;br&gt;COLOMBIA</td>
</tr>
<tr>
<td>NIGERIA</td>
<td>University Press Limited&lt;br&gt;Three Cevra Building Jericho&lt;br&gt;Private Mail Bag 5069&lt;br&gt;Badan</td>
</tr>
<tr>
<td>NORWAY</td>
<td>Narom Information Center&lt;br&gt;Bank Department&lt;br&gt;P.O. Box 6215&lt;br&gt;Fearsey&lt;br&gt;N0092 Oslo 8&lt;br&gt;OMAN</td>
</tr>
<tr>
<td>PAKISTAN</td>
<td>Mina Book Agency&lt;br&gt;65, Shakht-e-Chin-e-Amin&lt;br&gt;P.O. Box No. 729&lt;br&gt;Lahore 3&lt;br&gt;PHILIPPINES&lt;br&gt;International Book Center&lt;br&gt;Fifth Floor, Filipino Life Building&lt;br&gt;Ayala Avenue, Makati&lt;br&gt;Metro Manila</td>
</tr>
<tr>
<td>PORTUGAL</td>
<td>Livraria Portugal&lt;br&gt;Rua De Carni 7526&lt;br&gt;1200 Lisbon</td>
</tr>
<tr>
<td>RUSSIA</td>
<td>MIMAR Information Services&lt;br&gt;P.O. Box 3960&lt;br&gt;Riyadh 114</td>
</tr>
<tr>
<td>SRI LANKA, MALDIVES</td>
<td>Lake House Workshop&lt;br&gt;P.O. Box 272&lt;br&gt;7400 All Hasbergen</td>
</tr>
<tr>
<td>SWEDEN</td>
<td>For single order&lt;br&gt;Feyeon Fashongenre&lt;br&gt;Targntaggen, 12, 13256&lt;br&gt;S-103 27 Stockholm</td>
</tr>
<tr>
<td>SWITZERLAND</td>
<td>For single order&lt;br&gt;Livraria Feyer&lt;br&gt;Service de l’Aménagement&lt;br&gt;Case postale 661&lt;br&gt;CH 1121 Genève 11</td>
</tr>
<tr>
<td>TANZANIA</td>
<td>Oxford University Press&lt;br&gt;P.O. Box 220&lt;br&gt;Bujumbura 2</td>
</tr>
<tr>
<td>THAILAND</td>
<td>Central Department Store&lt;br&gt;206 Silom Road&lt;br&gt;Bangkok</td>
</tr>
<tr>
<td>TRINIDAD &amp; TOBAGO</td>
<td>Antigua, Barbados&lt;br&gt;Dominica, Grenada, Guyana, Jamaica, Montserrat, St. Kitts &amp; Nevis, St. Lucia&lt;br&gt;St. Vincent &amp; Grenadines&lt;br&gt;Syndetmaaa Unit&lt;br&gt;69 Water Street&lt;br&gt;Curacao&lt;br&gt;Trinidad, West Indies</td>
</tr>
<tr>
<td>UNITED ARAB EMIRATES</td>
<td>MIMAR Gulf Co.&lt;br&gt;P.O. Box 6027&lt;br&gt;Sharjah</td>
</tr>
<tr>
<td>UNITED KINGDOM</td>
<td>MIMAR Information Services&lt;br&gt;P.O. Box 5289&lt;br&gt;Alma, Hampshire CLD2 EP3</td>
</tr>
<tr>
<td>VENEZUELA</td>
<td>Libraria del Estado&lt;br&gt;A3212 037&lt;br&gt;Caracas 1020-A</td>
</tr>
<tr>
<td>FINLAND</td>
<td>Alkovenen Erikkos&lt;br&gt;P.O. Box 220&lt;br&gt;Helsinki 10&lt;br&gt;50370 VITI</td>
</tr>
<tr>
<td>FRANCE</td>
<td>World Book Publisher, 64, avenue d’Alma&lt;br&gt;75464 Paris</td>
</tr>
<tr>
<td>GERMANY</td>
<td>LIND Verlag&lt;br&gt;Poppelsdorfer Allerie 55&lt;br&gt;D-33202 Biele&lt;br&gt;Schokoriez 1</td>
</tr>
<tr>
<td>GREECE</td>
<td>KEA&lt;br&gt;Bryntoploton Street Planta Plastics&lt;br&gt;Athens-Issia 11455</td>
</tr>
<tr>
<td>GUATEMALA</td>
<td>Libreria Poncita Santa&lt;br&gt;S. calle 7-55&lt;br&gt;Zona 1&lt;br&gt;Guatemala City</td>
</tr>
<tr>
<td>HONG KONG, MACAO</td>
<td>Acon 2000 Ltd.&lt;br&gt;46-68 Wyndham Street&lt;br&gt;Wan Chai Centre&lt;br&gt;2nd Floor&lt;br&gt;Central Hong Kong</td>
</tr>
<tr>
<td>INDIA</td>
<td>Allied Publishers Private Ltd.&lt;br&gt;751 Moten Road&lt;br&gt;Mumbai - 400022&lt;br&gt;Branch office: 15 D, Hornet Marg&lt;br&gt;South Bombay - 400026&lt;br&gt;13/14 Aesl All Road&lt;br&gt;New Delhi - 110 002&lt;br&gt;17 Chittaranjen Avenue&lt;br&gt;Calcutta, Quebec&lt;br&gt;135 1516</td>
</tr>
<tr>
<td>IRELAND</td>
<td>Irish Academic Book&lt;br&gt;Model Building, 5&lt;br&gt;Newman Avenue&lt;br&gt;Galway - 090&lt;br&gt;3-8 5129 Kildough Road&lt;br&gt;Hydehall - 020 027&lt;br&gt;North Road&lt;br&gt;South Clare&lt;br&gt;Alembal - 360001&lt;br&gt;Pakira House&lt;br&gt;16-A, Agra Marg&lt;br&gt;Lucknow - 226 001</td>
</tr>
<tr>
<td>INDONESIA</td>
<td>Pt. Indra Limited&lt;br&gt;J. Suyanto Marg 37&lt;br&gt;P.O. Box 181&lt;br&gt;...</td>
</tr>
</tbody>
</table>
Recent World Bank Discussion Papers (continued)

No. 130  Patterns of Direct Foreign Investment in China. Zafar Shah Khan

No. 131  A New View of Economic Growth: Four Lectures. Maurice FG. Scott

No. 132  Adjusting Educational Policies: Conserving Resources While Raising School Quality. Bruce Fuller and Aklilu Habte, editors

No. 133  Letting Girls Learn: Promising Approaches in Primary and Secondary Education. Barbara Herz, K. Subbarao, Masooma Habib, and Laura Raney


No. 135  A Strategy for Fisheries Development. Eduardo Loayza, in collaboration with Lucian M. Sprague


No. 137  Deferred Cost Recovery for Higher Education: Student Loan Programs in Developing Countries. Douglas Albrecht and Adrian Ziderman

No. 138  Coal Pricing in China: Issues and Reform Strategy. Yves Albouy

No. 139  Portfolio Performance of Selected Social Security Institutes in Latin America. Carmelo Mesa-Lago

No. 140  Social Security and Prospects for Equity in Latin America. Carmelo Mesa-Lago


No. 142  Restructuring Socialist Industry: Poland’s Experience in 1990. Homi J. Kharas

No. 143  China: Industrial Policies for an Economy in Transition. Inderjit Singh

No. 144  Reforming Prices: The Experience of China, Hungary, and Poland. Anand Rajaram

No. 145  Developing Mongolia. Shahid Yusuf and Shahid Javed Burki


No. 147  The Effects of Economic Policies on African Agriculture: From Past Harm to Future Hope. William K. Jaeger

No. 148  The Sectoral Foundations of China’s Development. Shahid Javed Burki and Shahid Yusuf, editors

No. 149  The Consulting Profession in Developing Countries: A Strategy for Development. Syed S. Kirmani and Warren C. Baum

No. 150  Successful Rural Finance Institutions. Jacob Yaron

No. 151  Transport Development in Southern China. Clell G. Harral, editor, and Peter Cook and Edward Holland, principal contributors

No. 152  The Urban Environment and Population Relocation. Michael M. Cernea


No. 154  Earnings, Occupational Choice, and Mobility in Segmented Labor Markets of India. Shahidur R. Khandker

No. 155  Managing External Debt in Developing Countries: Proceedings of a Joint Seminar, Jeddah, May 1990. Thomas M. Klein, editor

No. 156  Developing Agricultural Extension for Women Farmers. Katrine A. Saito and Daphne Spurling

No. 157  Awakening the Market: Viet Nam’s Economic Transition. D. M. Leipziger

No. 158  Wage Policy during the Transition to a Market Economy: Poland 1990–91. Fabrizio Coricelli and Ana Revenga, editors