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International Commodity Markets

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Primary Commodity Prices and Macroeconomic Variables

A Long-run Relationship

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and
Panos Varangis

There is a long-run quantifiable relationship betv'een real interest rates and real commodity prices, but not between real commodity prices and either consumer prices or the money supply. Commodity prices in nominal terms strongly affect consumer prices but not the reverse — and some groups of commodity prices can be reliable indicators of movements in consumer prices. Changes in the money supply affect commodity prices — but not the reverse, and the relat:onship is not quantifiable.

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In recent years, fluctuations in such macroeconomic variables as interest rates and exchange rates appear to have significantly affected primary commodity prices.

Could primary commodity price indices be used as an indicator of inflation? What was the impact on commodity prices of announcements about the money supply, inflation, and economic activity?

Palaskas and Varangis studied the relationship between commodity prices and various macroeconomic variables.

They focused particularly on interest rates because of the important role they play in the portfolio adjustment model, in which investors move between commodities, bonds, and money as interest rates change.

Their tests did not rule out the hypothesis that there is a measurable, long-run equilibrium between real interest rates and real commodity prices. Changes in real interest rates significantly affect prices on metals, minerals, nonfuel commodities, and agricultural raw materials — as represented by the World Bank's commodity price indices.

Their tests rejected the hypothesis of a long-run relationship between real commodity prices and either consumer prices or the money supply (as represented by U.S. M2 plus dollar holdings in foreign central banks).

Causality tests show that commodity prices in nominal terms (except for metals and minerals) strongly affect consumer prices (as represented by the weighted consumer price index of the G-7 countries), but consumer prices do not affect commodity prices. And some groups of commodity prices can be reliable indicators of movements in consumer prices.

Causality tests also show that changes in the money supply cause changes in commodity prices, but commodity prices do not affect the money supply. Nor is it possible to quantify the relationship between money supply and commodity prices.

Palaskas and Varangis use co-integration techniques, error-correction modeling, and causality tests to analyze the relationships between macroeconomic variables and commodity prices.

Using an error correction model to specify and estimate the relationship between real interest rates and real commodity prices provides equations using other macroeconomic variables which have good forecasting abilities on commodity prices, such as industrial production, exchange rates, and the price of oil.

This paper is a product of the International Commodity Markets Division, International Economics Department. Copies are available free from the World Bank, 1818 H Street NW, Washington DC 20433. Please contact Dawn Gustafson, room S7-044, extension 33714 (54 pages with graphs and tables).

Primary Commodity Prices and Macroeconomic Variables: A Long-Run Relationship

by
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Panos Varangis

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I. INTRODUCTION

1. The effects of macro-economic variables, more specifically the effects of monetary variables and exchange rates, on agricultural commodity prices, exports and inventories have been analyzed in Chambers and Just (1982), Batten and Belongia (1986), Gilbert (1989), and Gilbert and Palaskas (1989). Recent structural models of commodity price behavior defined by Frankel (1986) and Boughton and Branson (1988, henceforth BB) have emphasized the important role in the price formation process of expectations concerning macro-economic disturbances. The prices of most primary commodities are determined in flexible "auction" markets, actually financial markets that trade contracts. This permits commodity prices to react immediately to "news" about changes in macro-economic disturbances, whereas manufactured goods prices do not. 1/ Frankel and Hardouvelis (1985) and Barnhart (1989) have undertaken empirical work to investigate how commodity markets react in the short run to expectations concerning macro-economic disturbances. Frankel has formalized the effects of monetary disturbances on commodity prices by extending the Dornbusch (1974) overshooting model of exchange rates. He argued that unanticipated, permanent shocks in the money supply cause short-run changes in interest rates and consequently in real commodity prices because prices of other goods are sticky. However, if changes in the real interest rates cause real commodity prices to overshoot in the short-run, they can still have a fixed or stationary relationship over the long run.

1/ Shown empirically by Bordo (1980).

2. Only a few studies have examined the existence of long-run relationships between commodity prices and macro-economic variables. Durand and Blondal (1988) and BB test the inverse hypothesis to that analyzed by Frankel. That is, commodity price movements are indicators of consumer prices (in this case of the major seven OECD countries' inflation rates). Their results suggest that, though there is no clear quantitative long-run relationship, a temporal causality and feedback effect exists between rates of inflation and commodity prices. Powell (1989), applying integration and co-integration tests, has shown that it is not possible to reject the hypothesis that the terms of trade between commodity prices and manufactured goods prices is stationary.

3. The purpose of this paper is to employ integration and co-integration tests to investigate the hypothesis of a long-run relationship between commodity market prices at the aggregate and disaggregate levels and several macro-economic variables--focusing on interest rates and money supply and inflation, but including also industrial production and exchange rates. Section II discusses the ideas underlying co-integration, the integration and co-integration tests and their implications. Section III reports on the integration and co-integration tests and, where a co-integrating relationship is established, in Section IV the short-run and long-run dynamics of this relationship are analyzed by estimating error correction models (ECM). Section V applies Granger-Causality tests to establish the direction of causality between commodity prices and macro-economic variables. Finally, Section VI analyzes the results and draws conclusions.

II. LONG RUN RELATIONSHIPS: TESTS

4. The first question to be analyzed is whether there exists a stable, long-run relationship between the level of commodity prices PC_t and the level of interest rates (r_t). If so, it may be possible to make quantitative inferences about future commodity prices from observations of changes in interest rates.

5. As a first step we examine the stationarity of commodity prices and the interest rate, employing the integration test, since the co-integration test begins with the premise that for a long-run equilibrium relationship to exist between two variables it is necessary that they have the same intertemporal characteristics. The dynamic property of a time series can be described by how often it needs to be differenced to achieve time-invariant linear properties and provide a stationary process. A series that has at least invariant mean and variance and whose autocorrelation has "short memory" is called I(0), denoting "integrated of order zero". 1/ A series which needs to be differenced Δ times to become I(0) is said to be integrated of order Δ, denoted as I(Δ).

6. The order of integration is inferred by testing for unit roots. The most widely applied unit root tests are: (a) the Durbin-Watson test of Sargan

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1/ With "short memory" a small number of lagged observations explains current behavior.

and Bhagrava (1983) (CRDW); and (b) the Dickey-Fuller test (DF) or Augmented Dickey-Fuller test (ADF) (Dickey and Fuller 1979, 1981). All test the null hypothesis that the series are I(1) : Ho : $X_t \sim I(1)$. The three statistics employed are calculable by least squares regression 1/ as follows:

CRDW: $X_t = \alpha + e_t$, Ho : $X_t \sim I(1)$ if CRDW < 0.511 at 99%.

DF : $\Delta e_t = \alpha - \beta e_{t-1} + v_t$, Ho : $X_t \sim I(1)$ if β is negative and has 2/ a t-statistic lower than -3.37 (95%) or -4.07 (99%).

ADF : $\Delta X_t = \alpha - \beta e_{t-1} + \sum_{i=1}^{n} \gamma_i \Delta e_{t-1} + v_t$, Ho: $X_t \sim I(1)$ if B is negative and has a t-statistic lower than -3.17 (95%) or -3.77 (99%)

where e_t are the residuals from the X_t regression and n is selected to be large enough to ensure that the residuals v_t are white noise. A statistically significant, negative coefficient β signifies that changes in X_t or e_t can be reversed over time and that their levels are stable over the long term.

7. After establishing that commodity prices and interest rates are integrated, the next step is to see if they are also co-integrated. Two variables are said to be co-integrated if there exists a constant K such that

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1/ Their critical values with one, two and three variables are provided by Engle and Granger (1987) and Granger and Newbold (1989).

2/ The test statistic is the t-statistic for Beta, but the t-distribution is not appropriate.

$Z_t = PC_t - Kr_t$ is integrated of order zero I(0) (where Z_t is the residual, unexplained error). Z_t is then stationary with a positive, finite spectrum at zero frequency. This is a rather special condition, because it implies that both series have extremely important long-run components. However, in forming Z_t these long-run components cancel out. To test whether the series are cointegrated, a two-stage test similar to that applied to test for integration is followed. In the first stage, the coefficient K is estimated by OLS; in the second stage the resulting series $Z_t = PC_t - Kr_t$ is tested as I(0) rather than I(1). The null hypothesis Ho : $e_t \sim I(1)$ is rejected for $DW \geq 0.511$ at 99% and for β being positive and significantly different from zero. The same test statistic, but with different critical values, is used when three variables such as commodity price, interest rate and rate of inflation are tested for co-integration. 1/ Co-integration between say X_1 and (X_2, X_3) in this case means that all X_{it}, i = 1,2,3 are integrated of order one, I(1), and a co-integrating row vector λ (λ_2, λ_3) exists so that $X_{1t} - \lambda X_t$ is I(0), where X_t is a column vector consisting of X_{2t} and X_{3t}. If the series are co-integrated, a robust estimate for λ (the long-run co-integrator) can be expected. Phillips (1986) has shown that the estimated parameters of cointegrated variables converge in the limit to constants. Another important implication of co-integration is that if PC_t and r_t are co-integrated, PC_t and $br_{t-g} + w_t$ will also be co-integrated for any g where w_t is integrated of order zero, though probably with a change in the co-integrating parameter K. Also, as it has been proven by Yoo (1986), the long-run optimal forecast of the co-integrated variables PC_t and r_t will "hang together" and therefore will produce better forecasts than any other univariate forecast.

1/ The critical values will differ for different degrees of freedom.

Finally, since PC_t is an I(1) variable and r_t is an I(1) policy controllable variable, then PC_t and r_t will be co-integrated if optimal control is applied (see Nickell (1985)).

III. INTEGRATION AND COINTEGRATION TEST RESULTS

(a) Integration Test

8. Tables 1 and 2 report the Sargan-Bhagrava (CRDW), Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) test statistics for the 13 series listed. The first five series are price indices for various primary commodity groups and are expressed in deflated terms. All other series are also expressed in real terms. The ADF test was also carried out after fitting various lags to the data, where the number of lags were sufficient to ensure that the residual v_t is white noise (these results are in column 5 of Tables 1 and 2). Results of the Lagrange Multiplier test for third order residual autocorrelation, LM(3)--distributed as χ^2_3 in large samples, under the null hypothesis that there is no autocorrelation--are presented in the sixth column of the tables (the critical value at 95% level of significance for χ^2_3 is 7.81).

9. The integration tests of the untransformed data (Table 1) showed that all the series, regardless of the sample period, are non-stationary at the 99% level of significance. Therefore, we tested whether the rate of change of the variables was stationary. From the test results on the first-differenced series in Table 2 it appears that all the series, apart from the first difference of the consumer price index for the major 7 OECD countries, CPIG7, are stationary at the 99% level. The CPIG7 series must be differenced twice to become stable at the same level of significance. Thus, CPIG7 is integrated of order two, I(2), while all the other series have a unit root. Therefore, a

Table 1: INTEGRATION TESTS FOR THE LONG RUN: UNTRANSFORMED DATA

	Unit Root Test			No. of Lags in ADF	Serial Correlation Test
Series	CRDW (crit. value 99% : 0.532 95% : 0.386 90% : 0.322)	DF (crit. value 99% : -4.07 95% : -3.37 90% : -3.03)	ADF (crit. value 99% : -3.77 95% : -3.17 90% : -2.84)	$\sum_{i=1}^{n} \gamma \Delta e_{t-i}$	LM(3) : χ^2_3 for ADF
LnICP33	0.398	-1.981	-1.108	5	0.424
LnICPAG	0.355	-1.767	-1.187	5	1.375
LnICPMM	0.360	-2.039	-1.152	5	0.602
LnICPAGF	0.423	-1.972	-1.413	4	2.559
LnICPAGNF	0.363	-1.854	-1.262	4	1.960
TRB	0.192	-1.687	-1.431	3	1.737
LnIIP	0.022	-1.008	-2.226	4	1.326
LnCPIG7	0.009	2.329	-0.431	7	4.889
LnCPIG7T 1/	0.050	-1.547	-3.054	7	4.047
LnPOIL	0.126	-1.076	-1.373	4	2.818
LnEXR	0.092	-0.253	-0.669	4	0.096
LnGNP7	0.011	0.377	-2.354	7	1.326
LnMS	0.008	4.151	-0.204	5	1.885

Definitions: ICP33 is the World Bank's 33-commodity price index, ICPAG is the agricultural commodity price index, ICPMM is the metals and minerals price index, ICPAGF is the agricultural food price index, ICPAGNF is the agricultural non-food index; TRB is the 3-month Treasury Bill interest rate series in real terms; IIP is the industrial production index for the G-7 countries; CPIG7 is the GNP-weighted consumer price index for the G-7 countries; POIL is the crude oil price index; EXR is the aggregate of the real Yen, DM and Pounds sterling exchange values to the US dollar weighted by GNP; GNP7 is gross national product of the G-7 countries; MS is M2 of the United States plus reserves of US dollars held by foreign central banks. The price indices have been deflated by the index of unit values for manufactured exports from developed to developing countries. The GNP series were deflated by the GNP deflator for the respective countries.

1/ The CPIG7 variable includes a trend which is proven in the estimation:

$$CPIG7 = -2.827\ (0.049) + 0.050T\ (0.002) + e_t \qquad R^2 = 0.942 \qquad D.W. = 0.050.$$

(Standard errors inside the parentheses).

In this case we can proceed to test CPIG7 for a unit root either by allowing the trend to be included [illegible] e_t or by de-trending. This is what we did for CPIG7 and CPIG7T, respectively.

Table 2: INTEGRATION TESTS FOR THE LONG-RUN: FIRST DIFFERENCED DATA

Series	Unit Root Test: CRDW (crit. value 99% : 0.532; 95% : 0.386; 90% : 0.322)	Unit Root Test: DF (crit. value 99% : -4.07; 95% : -3.37; 90% : -3.03)	Unit Root Test: ADF (crit. value 99% : -3.77; 95% : -3.17; 90% : -2.84)	No. of Lags in ADF: $\sum_{i=1}^{n} \gamma \Delta e_{t-1}$	Serial Correlation Test: LM(3) : χ^2_3 for ADF
Δ LnICP33	1.939	-5.892	-4.255	3	2.056
Δ LnICPAG	2.030	-6.177	-4.237	3	2.044
Δ LnICPMM	1.558	-4.737	-3.555	3	0.304
Δ LnICPAGF	1.950	-6.604	-3.919	3	0.152
Δ LnICPAGNF	2.116	-6.472	-5.817	3	2.396
Δ TBR	1.706	-5.246	-3.341	3	0.898
Δ LnIIP	2.389	-7.988	-3.783	3	4.781
Δ LnCPIG7	0.420	-2.384	-1.540	5	0.454
Δ^2 LnCPIG7T 1/	1.867	-9.906	-4.111	3	4.336
Δ LnPOIL	1.787	-5.399	-3.606	1	0.762
Δ LnEXR	1.048	-3.606	-4.140	3	0.862
Δ LnGNP7	2.057	-6.562	-2.084	6	2.006
Δ LnMS	0.807	-3.915	-1.698	3	2.240

1/ It was not necessary to include the trend in the first and second order integration test for the CPIG7, because it was not significant.

Notes: For variable definitions see Table 1.

Δ indicates that the first difference of the variables has been taken. Δ^2 indicates second differencing.

long-run relationship cannot be established between the levels of the commodity price and consumer price series.

(b) Co-integration Test Results

10. The critical values of the co-integration tests, shown in Table 3, indicate that a stationary long-run relationship exists between the levels of the aggregate commodity price index (ICP 33) and the sub-indices of the deflated commodity prices (agriculture, metals and agriculture non-food) and the levels of real interest rates as represented by the rates on 3-month US Treasury Bills. No such relationship was found between real interest rates and the price index for agricultural foods (according to the DF and ADF tests). However, in this case, co-integration is accepted when the real oil price (POIL) is included in the regression. 1/ For the other price indices tested, the negative co-integrated coefficient on the real interest rate variable is significant at the 99% confidence interval. This result implies that interest rates are good indicators of the movements of commodity prices.

11. Because the lags used in the ADF test are significant, the ADF test becomes more reliable than the DF test. The CRDW test values are much higher than the upper-bound critical value at the 99% confidence interval, while the ADF test results are significant at the 95% interval. The DF test results are significant only at the 90% interval for the reason given. The statistical

1/ Holthan (1989) has suggested that the use of macro-economic variables may have a role in establishing co-integration. This is not a result which is used later.

significance of the co-integration coefficient and the size of the parameter varies between the commodity price indices indicating differences in responses to interest rate changes. These differences are probably due to differences in the nature of the commodities as inputs in the production process, in consumpton and in stockholding. Therefore, it is more appropriate to consider the commodity price indices separately than as an aggregate index.

12. The introduction of the money supply variable into the commodity price-interest rate relationship, $PC_t = f(r_t, MS_t)$, as suggested by Frankel (1986), did not provide any additional information about the long-run relationship. It can be concluded, therefore, that any effect on commodity prices is passed through interest rates. In fact, the collinearity between money supply and interest rates is very strong, resulting in a change in the sign of the coefficient on the interest rate variable when the money supply variable is added to the equation. 1/ Money supply and commodity price indices were found not to be co-integrated (see Table 4).

1/ When money supply was regressed on interest rates (excluding the constant) a positive relationship between the two variables was found (a 1% change in MS is associated with a 10% increase in TRB). The R^2 of the regression is 0.8.

Table 3: CO-INTEGRATION TEST: REAL COMMODITY PRICE INDICES AND REAL INTEREST RATES

Dependent variable	Independent Variable			Co-integration Tests		
	Intercept	TRB	LnPOIL	CRDW	DF	ADF
LnICP33	4.889	-3.729		0.892	-3.311	-3.822
	(0.046)	(0.803)				
LnICPAG	4.902	-4.044		0.784	-2.887	-3.337
	(0.051)	(0.893)				
LnICPMM	4.946	-3.795		0.703	-3.043	-3.854
	(0.059)	(1.031)				
LnICPAGF	4.857	-3.458		0.759	-2.823	-2.910
	(0.050)	(0.879)				
LnICPAGF	4.687	-4.782	0.072	0.855	-3.079	-3.080
	(0.096)	(1.195)	(0.045)			
LnICPAGNF	5.081	-6.548		0.929	-3.315	-3.968
	(0.070)	(1.223)				

N. Standard errors are in parenthesis. Critical values for CRDW: 0.369<CRDW<0.570 at 95% confidence interval and 0.515<CRDW<0.720 at 99% confidence interval (see Sargan and Bhargava, 1983). Critical values for DF and ADF as in Table 1.

Table 4: CO-INTEGRATION TEST: REAL COMMODITY PRICE INDICES AND MONEY SUPPLY

	CRDW	DF	ADF	$\sum_{t=1}^{h} \gamma \Delta e_{t-i}$
LnICP33	0.519	-2.381	-1.406	5
LnICPAG	0.588	-2.477	-1.212	5
LnICPMM	0.360	-1.971	-1.247	5
LnICPAGF	0.676	-2.700	-1.634	5
LnICPAGNF	0.520	-2.321	-0.911	5

Notes: See Table 3.

IV. ERROR CORRECTION MODEL

13. An important implication of the co-integration theorem presented by Engle and Granger (1987) is that, if a long-run relationship has been established between a pair or set of variables, there always exists a dynamic error correction model (ECM) of the relationship (see Davidson, Hendry, Sbra and Yeo (1978)).

14. Derivation of the ECM involves two steps. The first consists of the integration and cointegration tests as they have been reported above. In the next step the residuals (Z_t) from the co-integrated regression are entered into the error correction model.

15. Not only must the co-integrated variables, in this case PC_t and r_t, follow an error correction model, but also the error correction model must be co-integrated (i.e., its residuals have to be I(0)). Since both PC_t and r_t are integrated of order one and their differences are I(0) then so is every term in the error correction model, provided Z_t is I(0). The value of Z_t in the ECM at any point in time shows the distance of the system from its equilibrium level.

16. Given co-integration between commodity prices and the real interest rate we proceed to the second stage of the Engle and Granger (1987) procedure. In this stage the residuals defined as $Z_{it} = PC_{jt} - \hat{K}\ TRB_t$ and derived from the equations presented in Table 3, are entered into the dynamic

error correction formulations.

17. Initially, the error correction formulation of the dynamic model is specified using only the real commodity price indices and the real interest rate variables 1/. Following the 'general-to-simple' modelling methodology [Hendry (1986)], a parsimonious representation (as few variables as possible) of the data-generating process was obtained (Table 5). The main finding from the estimated dynamic model is that the error correction term Z_t is statistically very significant in each of the equations. Tests for serial correlation, normality and out-of-sample forecasting performance indicate strongly that the models have been specified correctly. As a test of their forecasting stability, the equations were also estimated after excluding the last ten periods and used to forecast the last 10 periods. The results are graphed in Annex A with the error bars showing standard errors at 5%. The forecasting performance of the equations is excellent except in the 1985-87 period, when the actual price of each commodity index is considerably lower than the forecast. This may be due to the weakening of the dollar in this period. This hypothesis is tested later in the paper.

1/ The real interest rate is defined as ln (1 + r/100), where r is the nominal rate. This definition produces a series almost identical to the use of r/(1+inflation).

Table 5: ERROR CORRECTION FORMULATION: COMMODITY PRICES AND INTEREST RATES

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33 Commodity Index (sample 1952-88)

$$\Delta \, LnICP33 = \underset{(0.012)}{-\,0.015} \; \underset{(0.103)}{-\,0.459} \, \Delta \, LnICP33_{t-2} \; \underset{(0.125)}{+\,0.193} \Delta \, LnICP33_{t-3}$$

$$\underset{(1.075)}{-\,1.989} \Delta \, TRB_{t-2} \; \underset{(0.103)}{-\,0.174} \, Z_{t-1}$$

$R^2 = 0.604$ s.e $= 0.073$ Serial Correlation LM : F $[3,29] = 0.22$.

Normality : $\chi^2_{(2)} = 0.085$ Forecast Stability Test : Chow $(10,29) = 1.39$

Agricultural Commodities (sample 1952-88)

$$\Delta \, LnICPAG = \underset{(0.019)}{-\,0.020} \; \underset{(0.115)}{-\,0.427} \Delta \, LnICPAG_{t-2} \; \underset{(0.107)}{+\,0.181} \Delta \, LnICPAG_{t-3}$$

$$\underset{(1.043)}{-\,1.903} \, \Delta \, TRB_{t-2} \; \underset{(0.093)}{-\,0.186} \, Z_{t-1}$$

$R^2 = 0.604$ s.e. $= 0.074$ Serial Correlation LM:F $[3,29] = 0.47$

Normality : $\chi^2_{(2)} = 5.346$ Forecast Stability Test : Chow $(10,22) = 1.45$

Minerals and Metals (sample 1954-88)

$$\Delta \, LnICPMM = \underset{(0.017)}{-0.003} \; \underset{(0.176)}{-0.474} \, \Delta \, LnICPMM_{t-2} \; \underset{(0.172)}{+\,0.432} \Delta \, LnICPMM_{t-5}$$

$$\underset{(1.426)}{-4.839} \; \Delta \, TRB_{t-5} \; \underset{(0.104)}{-\,0.210} \, Z_{t-1}$$

$R^2 = 0.552$ s.e. $= 0.096$ Serial Correlation LM:F $[3,27] = 0.67$

Normality : $\chi^2_{(2)} = 0.88$ Forecast Stability Test : Chow $(10,20) = 0.70$

Table 5: (Continued)

Agricultural Foods (sample 1952-1988)

$$\Delta \, LnICPAGF = \underset{(0.015)}{-\,0.014} - \underset{(0.109)}{0.426} \, \Delta \, LnICPAGF_{t2} - \underset{(0.130)}{0.198} \Delta \, LnIPCAGF_{t-3}$$

$$\underset{(1.225)}{-2.903} \Delta \, TRB_{t-2} + \underset{(0.061)}{0.094} \Delta \, LnPOIL_{t-2} - \underset{(0.109)}{0.198} \, Z_{t-1}$$

$R^2 = 0.551$ s.e.= 0.087   Serial Correlation LM:F [3,28] = 0.68

Normality: $\chi^2_{(2)} = 0.139$ Forecast Stability Test: Chow (10,21) = 1.73

Agricultural Non-Foods (sample 1952-1988)

$$\Delta \, LnICPAGNF = \underset{(0.018)}{-\,0.052} - \underset{(0.155)}{0.308} \, \Delta \, LnICPAGNF_{t-1} - \underset{(0.128)}{0.321} \Delta \, LnICPAGNF_{t-2} - \underset{(0.133)}{0.286} \Delta \, LnICPAGNF_{t-3}$$

$$\underset{(1.037)}{-1.758} \, \Delta \, TRB_{t-2} \; \underset{(0.109)}{-0.235} Z_{t-1}$$

$R^2 = 0.632$ s.e. = 0.099   Serial Correlation LM:F [3,28] = 0.23

Normality: $\chi^2_{(2)} = 0.16$ Forecast Stability Test: Chow (10,21) = 2.28

Notes: Standard errors in parenthesis.

18. To establish the degree of reliability of the error correction specification of the model, the restrictions implied by the prior co-integrated parameter (Z_t) can be relaxed and a free error correction equation estimated by including the lagged values of the commodity price indices and the interest rate. That is, the term Z_{t-1} is replaced by the lags t-1 of the two co-integrated variables. The results of estimation of the unrestricted model are presented in Table 6. The findings from these equations are very close to those of Table 5. The diagnostic tests suggest no evidence of autocorrelation or non-normality. It is also interesting to note that the out-of-sample stability test results indicate considerable parameter stability for these equations. Moreover, the F-test fails to reject the hypothesis that the estimations of the restricted and unrestricted equations are significantly different.

19. Finally, we estimate the static long-run solutions 1/ of the models estimated in Table 6. These results are presented in Table 7 and with one exception the coefficients on the real interest rate variables are statistically significant at 95% confidence intervals and very close to the co-integrated parameters given in Table 3. The coefficient on this variable in the equation for Agricultural Foods is higher by 2.5. This has probably resulted because of the interaction of the interest rate variable with the price of oil in the unrestricted regression. These results are, of course, in line with the theory of co-integration which claims that biases in parameter

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1/ The PC-GIVE software package used for these tests provides these solutions.

<u>Table 6</u>: UNRESTRICTED EQUATION ESTIMATES: COMMODITY PRICES AND INTEREST RATES

<u>33 Commodity Index</u> (sample 1952-88)

$$\Delta\,\mathrm{LnICP33} = \underset{(0.510)}{0.906} \; \underset{(0.123)}{-0.475}\Delta\,\mathrm{LnICP33}_{t-2} + \underset{(0.118)}{0.170}\Delta\,\mathrm{LnICP33}_{t-2} - \underset{(1.138)}{1.622}\Delta\,\mathrm{TRB}_{t-2}$$

$$- \underset{(0.104)}{0.184}\;\mathrm{LnICP33}_{t-1} - \underset{(0.617)}{1.124}\;\mathrm{TRB}_{t-1}$$

$R^2 = 0.616$ s.e. = 0.073 Serial Correlation LM:F [3,28] = 0.47

Normality: $\chi^2_{(2)} = 0.341$ Forecast Stability Test: Chow (10,22) = 1.24

Test against restricted equation F(1,37) = 0.474

<u>Agricultural Commodities</u> (sample 1952-88)

$$\Delta\,\mathrm{LnICPAG} = \underset{(0.462)}{0.909} \; \underset{(0.116)}{-0.438}\Delta\,\mathrm{LnICPAG}_{t-2} + \underset{(0.107)}{0.169}\Delta\,\mathrm{LnICPAG}_{t-3} - \underset{(1.094)}{1.679}\Delta\,\mathrm{TRB}_{t-2}$$

$$- \underset{(0.094)}{0.186}\;\mathrm{LnICPAG}_{t-1} - \underset{(0.590)}{1.080}\;\mathrm{TRB}_{t-1}$$

$R^2 = 0.611$ s.e. 0.075 Serial Correlation LM:F [3,28] = 0.62

Normality: $\chi^2_{(2)} = 6.98$ Forecast Stability Test: Chow (10,21) = 1.45

Test against the restricted equation F(1,31) = 0.419

Table 6: (Continued)

Minerals and Metals (sample 1954-88)

$$\Delta \mathrm{LnICPMM} = \underset{(0.522)}{1.072} \; \underset{(0.178)}{-0.469}\,\Delta \mathrm{LnICPMM}_{t-2} + \underset{(0.182)}{0.392}\Delta \mathrm{LnICPMM}_{t-5}$$

$$- \underset{(1.475)}{4.592}\Delta \mathrm{TRB}_{t-5} - \underset{(0.104)}{0.213}\,\mathrm{LnICPMM}_{t-1} - \underset{(0.74)}{1.259}\,\mathrm{TRB}_{t-1}$$

$R^2 = 0.56$ s.e. = 0.097 Serial Correlation LM:F [3,26] = 0.66

Normality: $\chi^2_{(2)} = 0.569$ Forecast Stability Test: Chow [10,19) = 0.77

Test against the restricted equation: F(1,29) = 0.302

Agricultural Foods (sample 1952-88)

$$\Delta \mathrm{LnICPAGF} = \underset{(0.531)}{0.987} \; \underset{(0.132)}{-0.452}\Delta \mathrm{LnICPAGF}_{t-2} + \underset{(0.135)}{0.144}\Delta \mathrm{LnICPAGF}_{t-3} - \underset{(1.295)}{2.855}\Delta \mathrm{TRB}_{t-2} + \underset{(0.063)}{0.117}\,\Delta \mathrm{LnPOIL}_{t-2}$$

$$- \underset{(0.112)}{0.190}\,\mathrm{LnICPAGF}_{t-1} - \underset{(0.974)}{0.783}\,\mathrm{TRB}_{t-1} - \underset{(0.027)}{0.022}\,\mathrm{LnPOIL}_{t-1}$$

$R^2 = 0.585$ s.e. = 0.087 Serial Correlation LM:F [3,26] = 0.92

Normality test: $\chi^2_{(2)} = 0.286$ Forecast Stability Test: Chow [10,19] = 1.73

Test against the restricted equation: F[1,29] = 0.881

Agricultural Non-Food (sample 1952-88)

$$\Delta \mathrm{LnICPAGNF} = \underset{(0.566)}{1.143} \; \underset{(1.158)}{-0.309}\Delta \mathrm{LnICPAGNF}_{t-1} - \underset{(0.131)}{0.321}\Delta \mathrm{LnICPAGNF}_{t-2} - \underset{(0.136)}{0.286}\Delta \mathrm{LnICPAGNF}_{t-3}$$

$$\underset{(0.058)}{-1.769}\Delta \mathrm{TRB}_{t-2} - \underset{(0.110)}{0.236}\,\mathrm{LnICPAGNF}_{t-1} - \underset{(0.919)}{1.473}\mathrm{TRB}_{t-1}$$

$R^2 = 0.632$ s.e. = 0.101 Serial Correlation LM:F[3,27] = 0.23

Normality test: $\chi^2_{(2)} = 0.198$ Forecast Stability test: Chow (10,20) = 2.18

Test against the restricted equation: F(1,30) = 0.606

estimates derived from a co-integrating regression will be of the order 1/T, even when all the complex dynamic effects are not explicitly allowed for in the model. An implication of these results is that both approaches support the existence of an equilibrium relationship as defined in the portfolio adjustment theory, and that the solution of this equilibrium relationship is unique.

20. An extension of this approach to testing the relationship between commodity prices and interest rates is to specify a model that incorporates both short-run dynamics and long-run solutions. Among the variables expected to be included in the equilibrium solutions are variables indicating shifts in commodity demand--either Gross National Product (GNP), or the Index of Industrial Production (IIP) whenever appropriate, real exchange rates (EXR), and the oil price (POIL).

21. The time-series behavior of these series in logarithms (Ln) was presented in Table 1 and 2. The three tests CRDW, DF and ADF indicated that the three series are I(1). 1/ Given that each commodity price index has the same linear properties as the macro-economic variables under consideration, we proceed to the specification and estimation of restricted and unrestricted dynamic error correction models. The results of estimating the error correction formulation are presented in Table 9. A noteworthy feature of these equations is the significance of the error correction term Z_{t-1}. It

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1/ These variables were also tested for co-integration with the commodity price indices. The results indicate that such co-integration exists (see Table 8).

Table 7: STATIC, LONG-RUN SOLUTIONS OF THE UNRESTRICTED ERROR CORRECTION MODEL

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33 Commodity Index (sample 1952-88)

$$\underset{}{LnICP33} = \underset{(0.084)}{4.906} \quad \underset{(1.576)}{-5.549}\ TRB_t$$

Agricultural Commodities (sample 1952-88)

$$LnICPAG = \underset{(0.127)}{4.832} \quad \underset{(2.140)}{-5.189}\ TRB_t$$

Minerals and Metals (sample 1954-88)

$$LICPMM = \underset{(0.129)}{5.035} \quad \underset{(2.169)}{-\ 5.826}\ TRB_t$$

Agricultural Foods (sample 1952-88)

$$LnICPAGF = \underset{(0.196)}{4.737} \quad \underset{(2.309)}{-\ 7.279}\ TRB_t + \underset{(0.079)}{0.075}\ LnPOIL$$

Agricultural Non-Food (sample 1952-88)

$$LnICPAGNF = \underset{(0.271)}{4.893} \quad \underset{(3.641)}{-6.424}\ TRB_t$$

Note: Standard errors are in parantheses.

Table 8: CO-INTEGRATION TESTS: REAL COMMODITY PRICE INDICES AND MACRO-ECONOMIC VARIABLES /a

	CDRW	DF	ADF
LnICP33	1.360	-4.421	-5.049
LnICPAG	1.240	-4.245	-4.328
LnICPMM	1.215	-4.073	-3.018
LnICPAGF	1.187	-4.029	-4.123
LnICPAGNF	1.675	-6.528	-3.306

Note: See Table 1 for variable definitions.

/a The co-integrated macro-economic variables included on the right-hand side of the above tests are: three-month US treasury bill as proxy for the real interest rate, the real price of oil, the real exchange rate and real GDP of the G-7 countries.

Table 9: ERROR CORRECTION FORMULATION: REAL COMMODITY PRICES AND MACRO-ECONOMIC VARIABLES

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33 Commodity Index (sample 1952-88)

$$\Delta\, LnICP33 = -\underset{(0.009)}{0.023} - \underset{(0.116)}{0.301}\,\Delta^2 LnICP33_{t-2} - \underset{(0.694)}{0.869}\,\Delta^2 TRB_{t-2} - \underset{(0.155)}{0.507}\Delta\, LnEXR_{t-2}$$

$$+ \underset{(0.134)}{0.206}\,\Delta^2 LnGNP_{t-1} + \underset{(0.028)}{0.093}\Delta^2 LnPOIL_t + \underset{(0.038)}{0.061}\Delta\, LnPOIL_{t-2} - \underset{(0.080)}{0.276}\, Z_{t-1}$$

$R^2 = 0.764$ s.e. = 0.059 Serial Correlation LM:F[3,26] = 0.29

Normality: $\chi^2_2 = 1.019$ Forecast Stability Test: Chow (10,19) = 1.08

Test against unrestricted equation: F(1,28) = 0.474.

Agricultural Commodities (sample 1955-88)

$$\Delta\, LnICPAG = -\underset{(0.011)}{0.070} - \underset{(0.097)}{0.606}\,\Delta\, LnICPAG_{t-2} - \underset{(1.106)}{1.694}\Delta^2\, TRB_{t-3} - \underset{(0.178)}{0.467}\Delta^2 LnEXR_{t-2} + \underset{(0.172)}{0.54}\Delta\, LnIIP$$

$$+ \underset{(0.152)}{0.139}\,\Delta^2\, LnIIP_{t-2} + \underset{(0.152)}{0.304}\Delta\, LnIIP_{t-5} + \underset{(0.034)}{0.549}\Delta\, LnPOIL_t + \underset{(0.046)}{0.233}\Delta\, LnPOIL_{t-2} - \underset{(0.079)}{0.257}\, Z_{t-1}$$

R^2=0.8[illegible]9 s.e. = 0.046 Serial Correlation LM:F[3,22] = 1.20

Normality: $\chi^2_{(2)} = 0.305$ Forecast Stability Test: Chow (10,15) = 1.45

Test against unrestricted equation: F(1,24) = 0.533

Minerals and Metals (sample 1959-88)

$$\Delta\, LnICPMM = -\underset{(0.028)}{0.079} + \underset{(0.094)}{0.264}\Delta^2\, LnICPMM_{t-1} - \underset{(1.564)}{2.129}\Delta\, TRB_{t-3} - \underset{(0.328)}{0.647}\Delta\, LnEXR_{t-3} + \underset{(0.285)}{0.320}\Delta\, LnIIP_t$$

$$+ \underset{(0.424)}{0.982}\Delta\, LnIIP_{t-3} + \underset{(0.259)}{0.519}\Delta\, LnIIP_{t-4} + \underset{(0.039)}{0.129}\Delta^2\, LnPOIL_t - \underset{(0.092)}{0.384}\, Z_{t-1}$$

R^2=0.685 s.e. = 0.085 Serial Correlation LM:F[3,24] = 1.44

Normality: $\chi^2_{(2)} = 0.437$ Forecast Stability Test: Chow (10,17) = 1.01

Test against unrestricted equation: F[1,26] = 0.612

Table 9: (continued)

Agricultural Foods (sample 1954-88)

$$\Delta \, LnICPAGF = \underset{(0.011)}{-\,0.032} \; \underset{(0.077)}{-\,0.116}\Delta^2 \, LnICPAGF_{t-2} \; \underset{(0.641)}{-\,1.177}\Delta^2 \, TRB_{t-3} \; \underset{(0.226)}{-\,0.614}\Delta \, LnEXR_{t-3} \; \underset{(0.206)}{+\,0.910}\Delta \, LnGNP_{t-1}$$

$$\underset{(0.039)}{+\,0.156} \, \Delta \, LnPOIL_t \; \underset{(0.049)}{+\,0.103}\Delta \, LnPOIL_{t-3} \; \underset{(0.09)}{-\,0.557} \, Z_{t-1}$$

R^2=0.806 s.e. = 0.061 Serial Correlation LM:F[3,24] = 0.07

Normality: $\chi^2_{(2)}$ = 0.639 Forecast Stability Test: Chow (10,17) = 2.34

Test against unrestricted equation: F(1,26) = 0.881

Agricultural Non Foods (sample 1952-88)

$$\Delta \, LnICPAGNF = \underset{(0.012)}{-\,0.068} \; \underset{(0.110)}{-\,0.544}\Delta \, LnICPAGNF_{t-1} \underset{(0.083)}{-0.311}\Delta \, LnICPAGNF_{t-2} \underset{(0.092)}{-0.436}\Delta \, LnCPAGNF_{t-3} \; \underset{(0.827)}{-1.866}\Delta^2 \, TRB_{t-2}$$

$$\underset{(0.217)}{-\,0.547}\Delta \, LnEXR_{t-2} \; \underset{(0.267)}{-\,0.652}\Delta \, LnEXR_{t-3} \; \underset{(0.156)}{+\,3.365}\Delta^2 \, LnIIP_t \; \underset{(0.039)}{+\,0.151}\Delta^2 \, LnPOIL \; \underset{(0.100)}{-\,0.183} \, Z_{t-1}$$

R^2=0.836 s.e. = 0.071 Serial Correlation LM:F[3,24] = 0.31

Normality: $\chi^2_{(2)}$ = 1.578 Forecast Stability test: Chow (10,17) = 1.90

Test against unrestricted equation: F[1,26] = 0.371

Note: Standard errors are in parantheses.

indicates that, even after the inclusion of other important macro-economic variables in the equation, the direction of change in each of the commodity price indices takes into account the size and the sign of the previous equilibrium error, Z_{t-1}. The diagnostic tests for serial correlation, normality and forecast stability suggest no evidence of autocorrelation, non-normal errors or instability. The introduction of the LnEXR variable into the equations eliminates the forecast errors in the period 1985-87 (compare graphs in Annex A and B).

22. Changes in exchange rates have an impact on commodity prices after a two or three year lag. This suggests that producer pricing reactions are slow--a result consistent with Feenstra (1987) for cars, and Varangis and Duncan (1988) for coffee, cocoa, copper and steel. The index of industrial production gives better results for most of price equations than does use of the GDP variable. This result supports Gilbert's (1989) findings. Also, the oil price variable has significant immediate and lagged effects on commodity prices. The negative asset pricing effect of interest rates is strongly established across all equations.

23. The diagnostic tests for the unrestricted dynamic model equations and the equilibrium solutions for the interest rate are presented in Table 10. The LM test for serial correlation indicates that only in the agricultural price equation is there some degree of autocorrelation, while the normality test suggests that the errors are normal. The parameters also exhibit a high degree of stability when the last ten observations are excluded from the estimations. The F test compares the restricted equations with the

Table 10: DIAGNOSTICS, TESTS AND EQUILIBRIUM ELASTICITIES OF THE UNRESTRICTED ESTIMATIONS

		LnICP33	LnICPAG	LnICPMN	LnICPAGF	LnICPAGNF
	h	26	22	24	24	24
R^2		0.786	0.881	0.689	0.827	0.845
s.e.		0.058	0.045	0.087	0.059	0.070
LM: test for serial correlation	F(3,h)	0.54	4.28	1.46	0.62	0.76
Normality	$\chi^2_{(2)}$	1.370	0.365	0.502	1.673	1.642
Forecast Stability Chow: 1979-88	F(10,h)	1.09	1.410	1.300	1.940	1.490
Test against restricted equations 1/	F(1,h)	0.474	0.533	0.612	0.881	0.371
Long-Run Solutions of TRB from the Unrestricted Estimates						
TRB		-5.682	-5.804	-4.630	-4.283	-3.681
LnPOIL					0.016	

Note: h is the number of degrees of freedom for the test.

1/ These results are in Table 7.

unrestricted equations. This test rejects the hypothesis that the two equations are significantly different. The equilibrium elasticities of these equations are presented at the bottom of Table 10.

V. CAUSALITY-FEEDBACK TESTS

24. This section examines whether the commodity price indices are generated separately from the interest rate, money supply and inflation series. When generated separately, commodity price indices offer no information for characterizing interest rates, for example, and vice versa. A series is generated separately from another series if it is a deterministic series, i.e., it can be forecast from its own past, and therefore there is no possibility that any other series contains information concerning the forecast (t + k) of this series. If, however, the two series are not generated separately, then one variable may provide information on the forecast values of the other. Feedback can occur wherein both series provide information about the other.

25. Most of the causality tests are based on the least squares fit of an equation of the form:

$$PC_t = \sum_{j=1}^{n} d_{1j} PC_{t-j} + \sum_{j=1}^{n} d_{2j} r_{t-j} + e_{1t} \tag{2}$$

where e_t is taken to be white noise. The null hypothesis that r_t does not cause PC_t corresponds to $d_{2i} = 0$ and the usual F-test is applied. Sims (1972) suggested a causality test based on the infinitely-lagged, two-sided regression of the form:

$$PC_t = \sum_{j=-\infty}^{\infty} \beta_j r_{t,t-j} + e_{2t} \quad (3)$$

Geweke, Meese and Dent (1983) added the lagged term of PC_t into the left-hand side of the equation (2) yielding,

$$PC_t = \sum_{j=-\infty}^{\infty} \beta_j r_{t,t-j} + \sum_{j=-\infty}^{\infty} \gamma_j PC_{t,t-j} + e_{3t} \quad (4)$$

The same F statistic is used to test the same null hypothesis.

26. A study by Nelson and Schwert (1982) suggests a strong preference for the Granger and Sims test over the Geweke, Meese and Dent test. They suggested a causality test procedure of two steps. First, apply least squares regression to obtain the error variance estimate $\hat{\sigma}_1^2$ of equation (2). Then drop the term $\sum_{j=1}^{k} d_{2j} X_{2,t-j}$ from the equation and estimate the residual variance $\hat{\sigma}_2^2$ for this regression. The test statistic is

$$T = n\,(\hat{\sigma}_2^2 - \hat{\sigma}_1^2)/\hat{\sigma}_1^2$$

which has an asymptotic χ^2 distribution with k degrees of freedom. In this case the null hypothesis that r_t does not cause PC_t is tested.

27. In Table 11 the causality test results between interest rates and commodity price indices are presented. Tests for reverse causation are also included. The (1) $\chi^2_{(m)}$ test, where m is the number of restrictions, rejects the hypothesis that the lagged values of interest rates do not contribute to the forecasted t + k observations of the commodity price indices, given the

Table 11: CAUSALITY TESTS ON REAL COMMODITY PRICES AND INTEREST RATES

	LnICP33 1/	LnICP33 2/	LnICPAG 1/	LnICPAG 2/	LnICPMM 1/	LnICPMM 2/
Intercept	1.985 (0.825)	0.434 (0.457)	1.482 (0.796)	0.372 (0.471)	2.361 (0.821)	0.378 (0.536)
t-1 3/	0.795 (0.192)	0.933 (0.178)	0.921 (0.209)	1.018 (0.184)	0.798 (0.191)	1.049 (0.176)
t-2	-0.604 (0.198)	-0.682 (0.201)	-0.543 (0.287)	-0.781 (0.255)	-0.635 (0.240)	-0.720 (0.248)
t-3	0.627 (0.193)	0.832 (0.199)	0.629 (0.241)	0.898 (0.237)	0.370 (0.292)	0.603 (0.286)
t-4	-0.221 (0.162)	-0.181 (0.179)	-0.459 (0.234)	-0.385 (0.204)	0.002 (0.213)	-0.016 (0.215)
t-5			0.087 (0.167)	0.164 (0.171)		
TRB_{t-1}	-0.233 (1.077)		-1.481 (1.193)	0.139 (1.606)		
TRB_{t-2}	-2.708 (1.595)		-0.939 (1.877)	-2.782 (2.334)		
TRB_{t-3}	2.218 (1.660)		1.325 (1.813)	1.695 (2.313)		
TRB_{t-4}	-1.405 (1.281)		1.704 (1.849)	-2.380 (1.750)		
TRB_{t-5}			-2.478 (1.325)			
Sample	1953-84	1953-84	1954-84	1953-84	1953-84	1953-84
h	36	36	35	35	36	36
R^2	0.856	0.793	0.862	0.789	0.826	0.761
s.e.	0.0736	0.0823	0.0767	0.0862	0.1060	0.1170
(1) $\chi^2_{(m)}$ 4/	$\chi^2_{(4)} = 9.014$		$\chi^2_{(5)} = 7.289$		$\chi^2_{(4)} = 7.859$	
(2) $\chi^2_{(m)}$ 5/	$\chi^2_{(4)} = 3.108$		$\chi^2_{(5)} = 4.176$		$\chi^2_{(4)} = 3.767$	

Table 11: (Continued)

	Independent Variables			
	LnICPAGF 1/	LnICPAGF 2/	LnICPAGNF 1/	LnICPAGNF 2/
Intercept	1.779 (0.854)	0.803 (0.600)	2.314 (0.729)	0.468 (0.376)
t-1	0.722 (0.192)	0.872 (0.189)	0.309 (0.173)	0.453 (0.162)
t-2	-0.118 (0.259)	-0.410 (0.258)	-0.038 (0.170)	-0.097 (0.176)
t-3	0.434 (0.219)	0.639 (0.232)	-0.029 (0.172)	0.168 (0.178)
t-4	-0.169 (0.222)	-0.152 (0.247)	0.295 (0.131)	0.364 (0.138)
t-5	-0.234 (0.176)	-0.124 (0.191)		
TRB_{t-1}	-0.262 (1.295)		-0.156 (1.540)	
TRB_{t-2}	-2.765 (1.941)		-3.123 (2.719)	
TRB_{t-3}	1.952 (2.057)		4.038 (2.134)	
TRB_{t-4}	2.574 (2.152)		-4.189 (1.530)	
TRB_{t-5}	-3.200 (1.764)			
Sample	1954-88	1954-88	1953-88	1953-88
h	36	35	36	36
R^2	0.811	0.708	0.866	0.806
s.e.	0.092	0.104	0.097	0.109
(1) $\chi^2_{(m)}$	$\chi^2_{(5)} = 9.823$		$\chi^2_{(4)} = 9.302$	
(2) $\chi^2_{(m)}$	$\chi^2_{(5)} = 5.872$		$\chi^2_{(4)} = 0.093$	

1/ Corresponds to equation (2)
2/ Corresponds to equation (3)
3/ t-1,...,t-n corresponds to the lag dependent variable for each commodity price index.
4/ Chi-squared text for the causality of interest rates of prices.
5/ Chi-squared test for the causality of prices on interest rates.

reverse causation, (2) $\chi^2_{(m)}$ do not support the existence of feedback between the two series.

28. Though a stationary, long-run relationship does not appear to exist between the level of commodity prices and the level of money supply, a qualitative relationship between these variables may still exist and can be tested using the causality test. The results (B.1) in Table 12 indicate that changes in commodity prices do not 'cause' changes in money supply, but there is support for the notion that changes in the money supply cause changes in commodity price indices with the exception of the non-food price index (see Table 12 (B.2)). This does not mean, however, that a measurable relationship exists.

29. There has also been some interest as to whether fluctuations in commodity prices are indicators of OECD inflation (see BB). Given the fact that commodity prices 1/ are I(1) and consumer price indices are I(2), i.e., the two series have different intertemporal properties, co-integration tests cannot be applied. Therefore, causality tests were conducted and the results suggest that the aggregate commodity price index (excluding fuel), the aggregate agricultural price index and the non-food price index strongly "Granger-cause" the consumer price index of major OECD countries. The minerals and metals price index and the food price index do not appear to affect the consumer price index. 2/ Given the decreases in minerals and

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1/ Here we use nominal commodity price indices which are also I(1).

2/ This confirms the results of Durand and Blondal (1988).

Table 12: CAUSALITY TESTS ON NOMINAL COMMODITY PRICE INDICES, CONSUMER PRICES, AND MONEY SUPPLY

	Commodity Price Indices						
	LnICP33	LnICPAG	LnICPMM	LnICPAGF	LnICPAGNF	LnICPAGOF 1/	LnICPAGB 2/
	A.1 Commodity Price Fluctuations "Cause" CPIG7 Fluctuations						
$\chi^2_{(5)}$	22.235	20.186	0.476	4.770	28.019	26.246	10.098
	A.2 Consumer Price Fluctuations (CPIG7) "Cause" Commodity Price Fluctuations						
$\chi^2_{(5)}$	3.484	4.869	6.675	5.487	7.542	6.682	30.253
	B.1 Commodity Price Fluctuations "Cause" Money Supply Fluctuations						
$\chi^2_{(5)}$	4.370	0.362	7.220	2.913	6.763	5.242	0.263
	B.2 Money Supply Fluctuations "Cause" Commodity Price Fluctuations						
$\chi^2_{(5)}$	13.725	21.150	11.136	37.879	0.930	9.293	6.597

Note: Critical values for $\chi^2_{(5)}$ are: 15.086 at 99.9%, 12.832 at 97.5%, 11.071 at 95% and 9.236 at 90% level of significance.

1/ LnICPAGOF is the price index for foods other than beverages.

2/ LnICPAGB is the beverage price index.

metals prices in the 1980s due to declines in their cost of production, causality between this price index and the consumer price index was also tested after excluding the observations for the 1980-88 period. For this shorter period also there is no evidence of causation. The results of this test are detailed in Table 12 (A.1). These results imply that commodity prices may play some role as an indicator of the development of future inflation. The reverse is not true (see Table 12 (A.2)).

30. Because of the surprising insensitivity of inflation to changes in the food price index (Table 12 (A.1)) the food price index was split into beverages and other foods and causality tests carried out on the relationship between these price indices and the CPIG7 (see Tables 12 and 13). The test results show that both food price indices strongly cause changes in the consumer price index. However, because of the different temporal properties of the series, the long-run relationship between them cannot be quantified. It is obvious, therefore, that the contrary movements in the beverage and other food indices, especially during the periods 1954-58 and 1973-86, distorted the relationship of the aggregate index with the CPI.

Table 13: CAUSALITY BETWEEN CONSUMER PRICE INDEX (CPIG7) AND OTHER FOODS [ICPAGOF] AND BEVERAGE [ICPAGB] PRICE INDICES

	Independent Variables			
	LnCPIG7 1/	LnCPIG7 2/		LnCPIG7 1/
Intercept	0.093	0.017		0.058
	(0.048)	(0.025)		(0.029)
t-1	1.558	2.125		2.022
	(0.263)	(0.183)		(0.182)
t-2	-0.363	-2.634		-1.488
	(0.476)	(0.403)		(0.405)
t-3	0.023	0.752		0.661
	(0.389)	(0.378)		(0.393)
t-4	0.004	-0.220		0.028
	(0.212)	(0.242)		(0.240)
t-5	-0.205	-0.026		0.208
	(0.133)	(0.125)		(0.144)
$LnICPAGOF_{t-1}$	0.095		$LnICPAGB_{t-2}$	-0.109
	(0.029)			(0.019)
$LnICPAGOF_{t-2}$	-0.151		$LnICPAGB_{t-2}$	-0.010
	(0.038)			(0.019)
$LnICPAGOF_{t-3}$	0.072		$LnICPAGB_{t-3}$	0.044
	(0.043)			(0.021)
$LnICPAGOF_{t-5}$	0.038		$LnICPAGB_{t-5}$	-0.034
	(0.022)			(0.017)
Sample	1954-88	1954-88		1954-88
n	35	35		35
R^2	0.999	0.999		0.999
s.e	0.0127	0.0168		0.0148
(1) $\chi^2_{(m)}$	$\chi^2_{(5)}$ = 26.246			$\chi^2_{(5)}$ = 10.098
(2) $\chi^2_{(m)}$	$\chi^2_{(5)}$ = 6.682			$\chi^2_{(5)}$ = 30.253

Notes: See footnotes to Table 11.

CONCLUSIONS

31. The research reported here has found that the interest rate plays an important role in both short-run and long-run determination of non-fuel primary commodity prices--the World Bank's 33 commodities price index and its sub-indices, agriculture (food and non-food) and minerals and metals. Co-integration and error correction techniques were applied. The central conclusion of these estimations is that the hypothesis that there is a stationary long-run relationship between the levels of commodity prices and interest rates cannot be rejected. These results are in line with the theory of commodities as financial assets and contrast with Powell's (1989) findings that interest rates play "little role in either the short run or the long run".

32. After establishing the existence of co-integration between commodity prices and interest rates an error correction model was developed for each commodity price index and the interest rate. This estimated relationship confirms the results of the co-integration tests and evidences a remarkable forecasting ability. What is also interesting is the fact that the introduction of the price of oil as a macro-economic variable in the error correction models has a significant impact in explaining the variation in commodity prices.

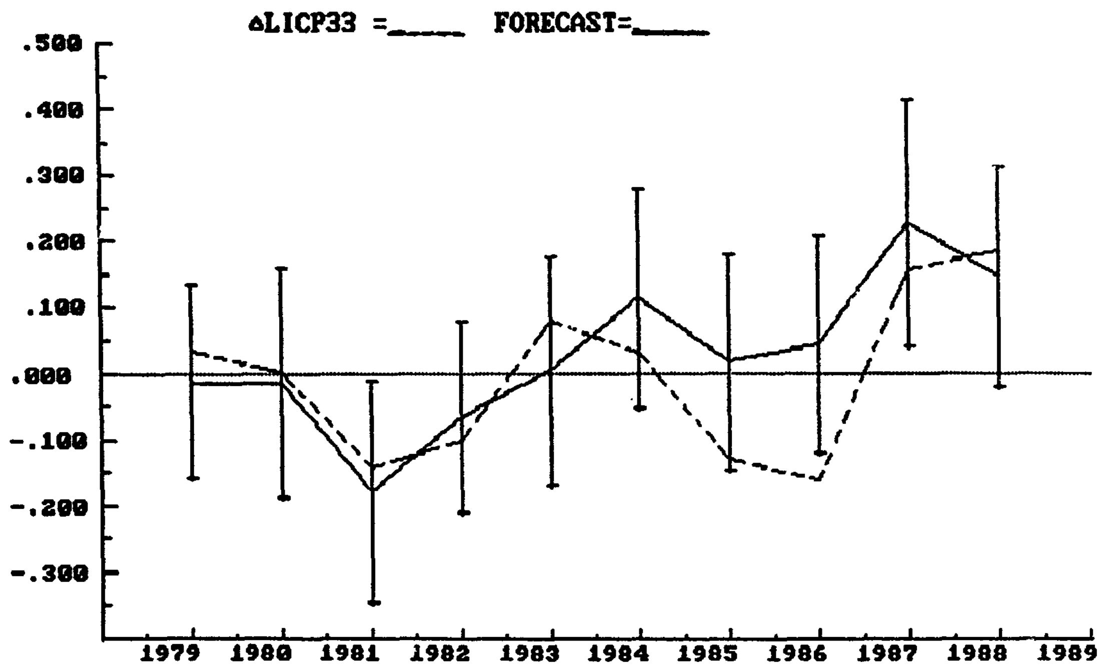
33. Though a stationary long-run relationship cannot be established between the commodity price indices and money supply movements, causality

tests show that fluctuations in the money supply cause fluctuations in commodity price indices, while the reverse does not hold. The same test also confirms that movements in the commodity prices indices--excluding the mineral and metals index--strongly "Granger-cause" movements in consumer price indices of the major OECD countries.

34. The results from splitting the food price index into beverages and other foods show that one has to be careful in the aggregation of commodities. In this case the contrary movements in important commodities such as coffee and grains led to misleading results when the indices are combined.

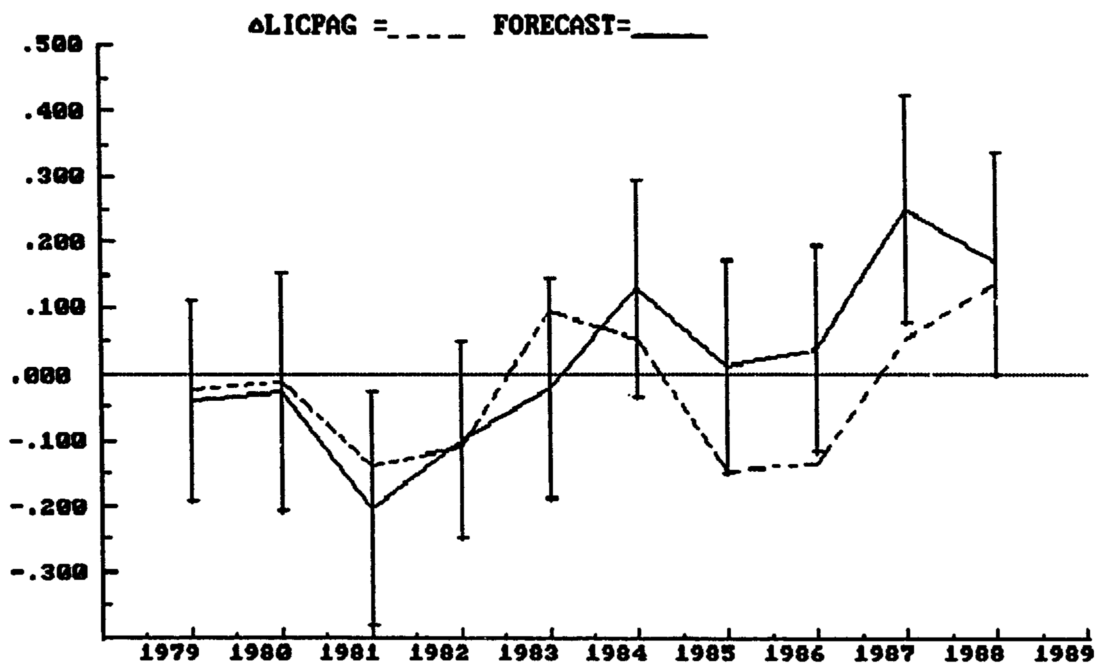
ANNEX A: ACTUAL COMMODITY PRICE CHANGES, FORECASTS AND ERROR BARS (BASED ON ESTIMATIONS OF TABLE 5)

GRAPH 1a: ACTUAL COMMODITY PRICE CHANGES ΔLICP33 FORECASTS AND ERROR BARS



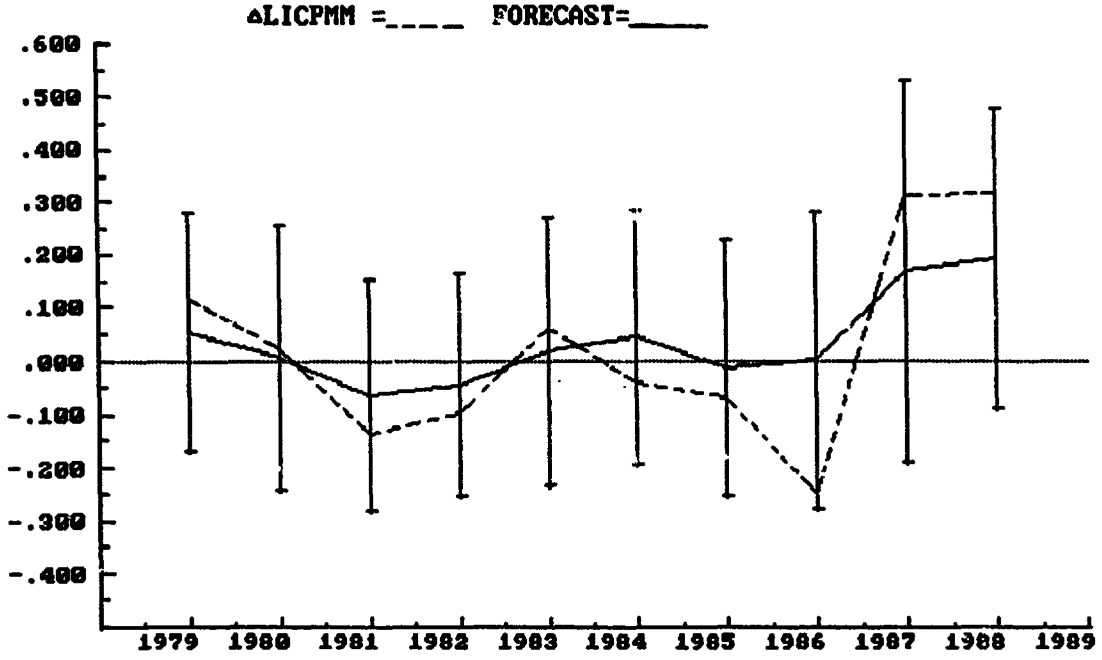
Forecasted Sample Period: 1979-1988

GRAPH 2a: ACTUAL COMMODITY PRICE CHANGES ΔLICPAG, FORECASTS AND ERROR BARS



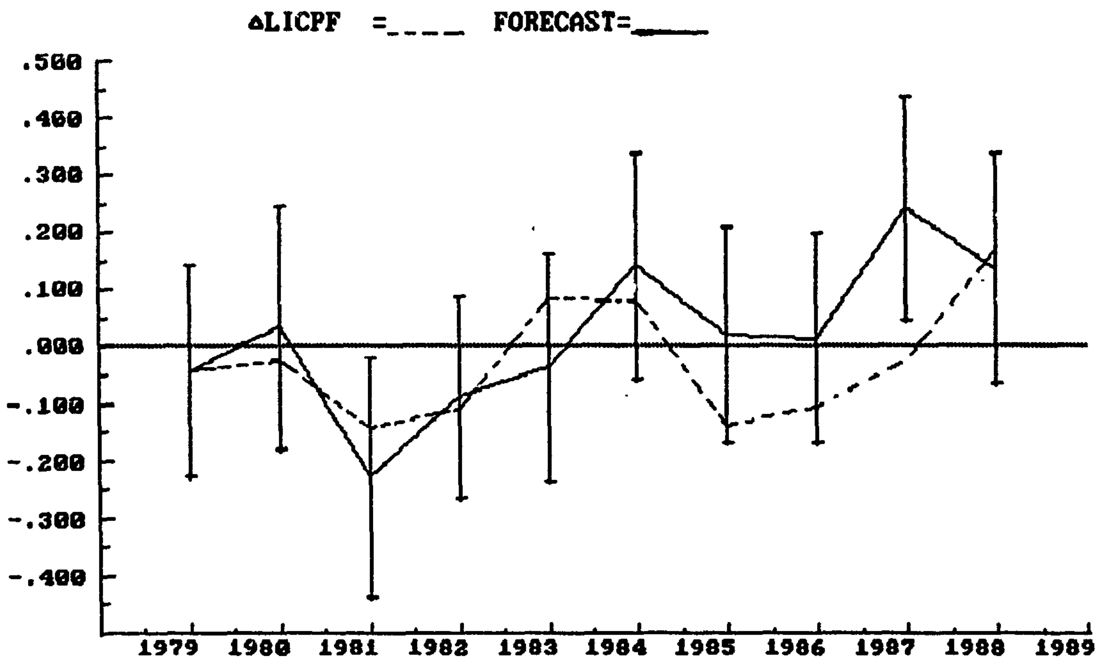
Forecasted Sample Period: 1979-1988

GRAPH 3a: ACTUAL COMMODITY PRICE CHANGES ΔLICPMM, FORECASTS AND ERROR BARS



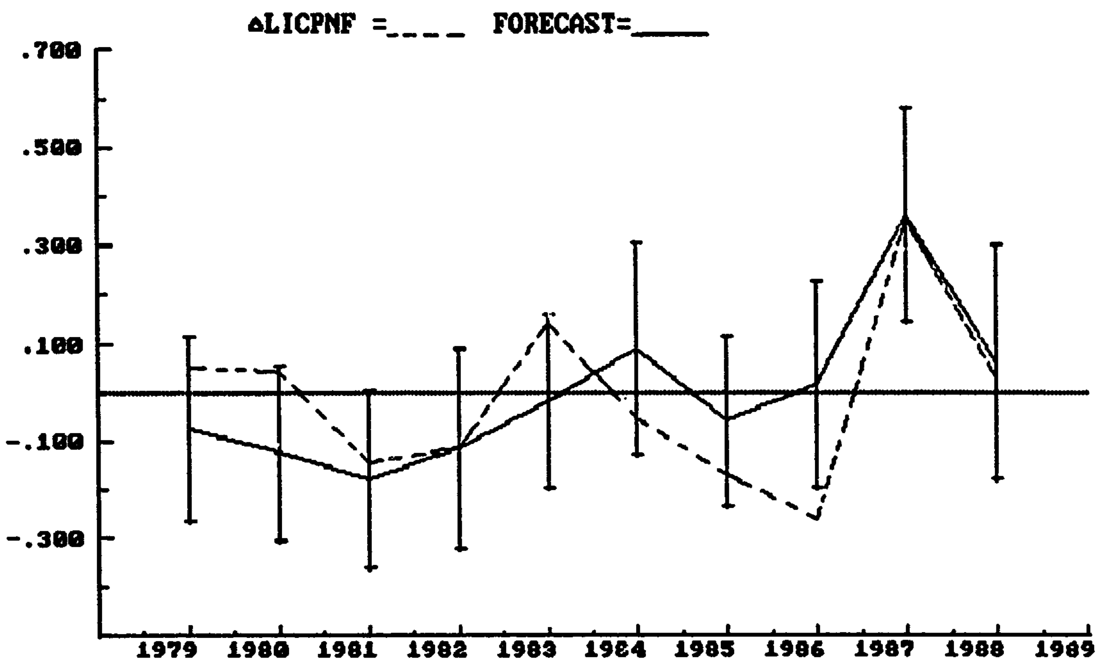
Forecasted Sample Period: 1979-1988

GRAPH 4a: ACTUAL COMMODITY PRICE CHANGES ΔLICPF, FORECASTS AND ERROR BARS



Forecasted Sample Period: 1979-1988

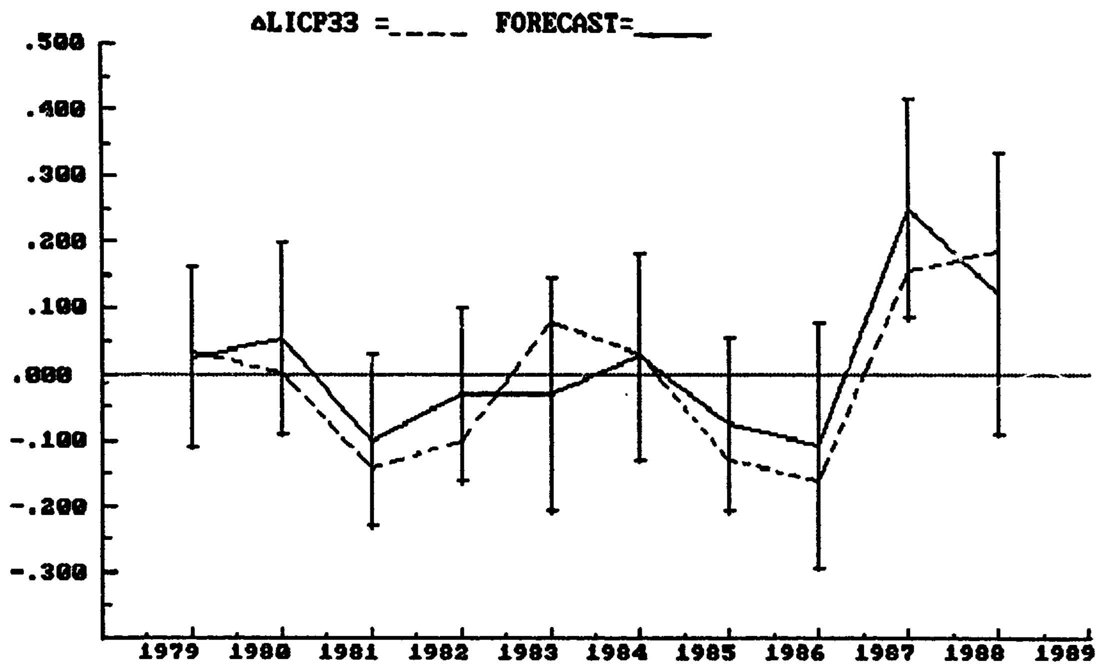
GRAPH 5a: ACTUAL COMMODITY PRICE CHANGES ΔLICPNF, FORECASTS AND ERROR BARS



Forecasted Sample Period: 1979-1988

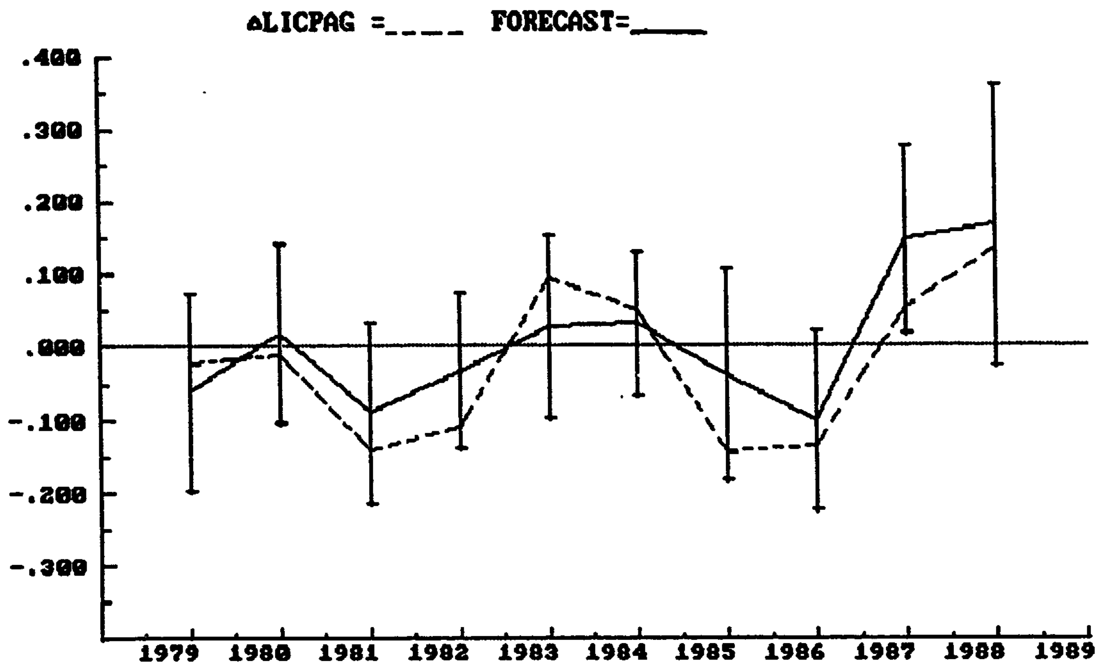
ANNEX B: ACTUAL COMMODITY PRICE CHANGE FORECASTS AND ERROR BARS (BASED ON ESTIMATIONS OF TABLE 9)

GRAPH 1b: ACTUAL COMMODITY PRICE CHANGES ΔLICP33 FORECASTS AND ERROR BARS



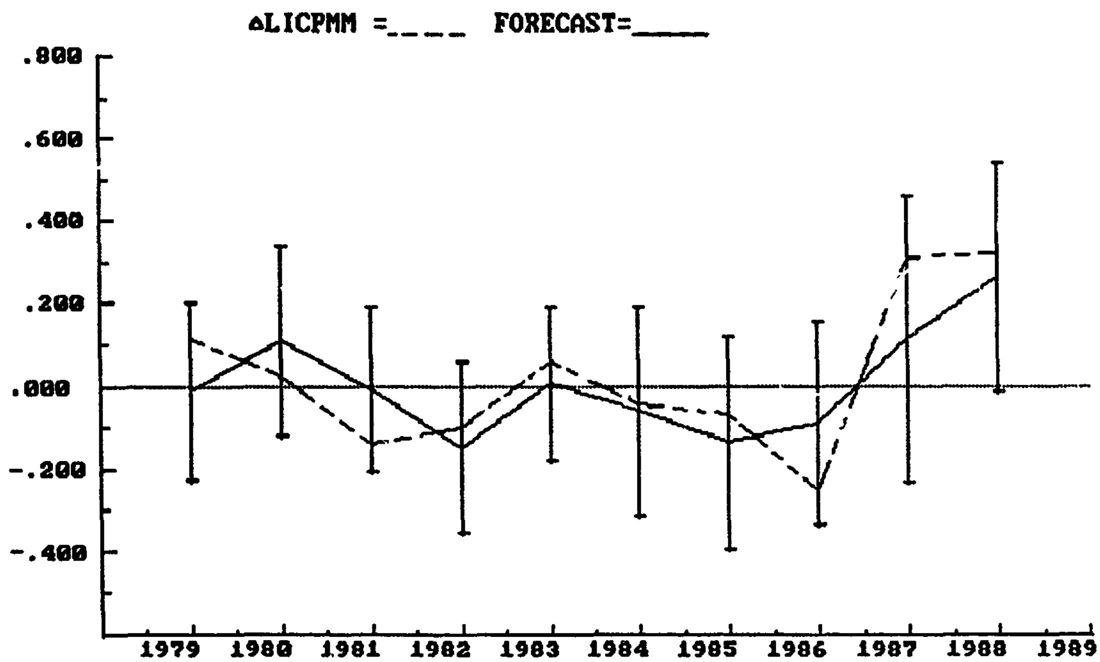
Forecasted Sample Period: 1979-1988

GRAPH 2b: ACTUAL COMMODITY PRICE CHANGES ΔLICPAG FORECASTS AND ERROR BARS



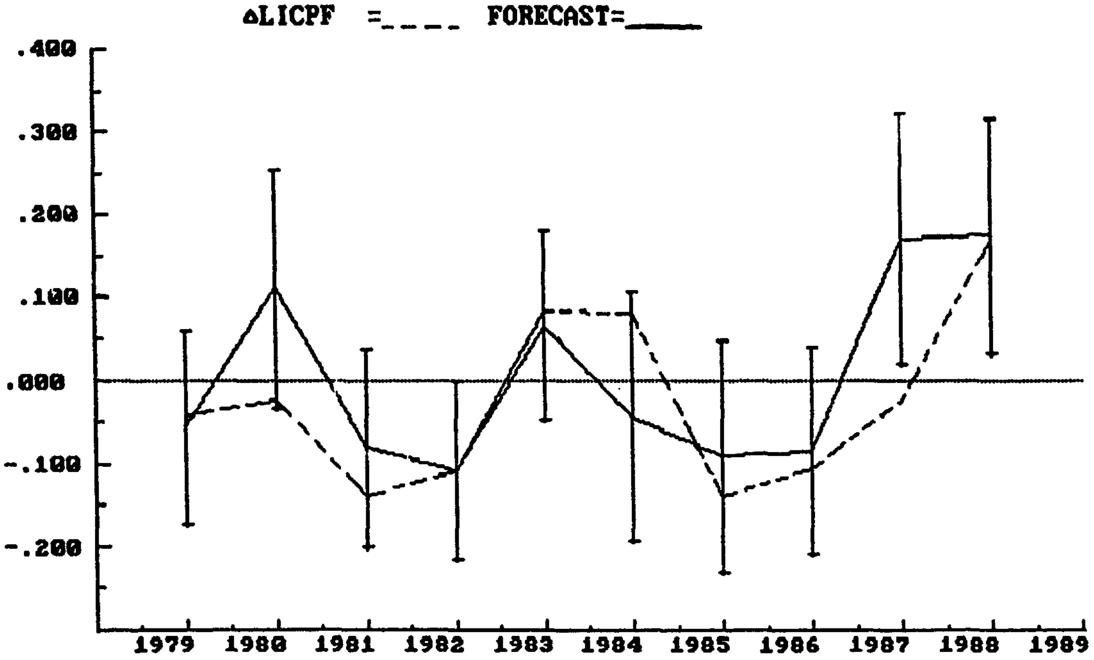
Forecasted Sample Period: 1979-1988

GRAPH 3b: ACTUAL COMMODITY PRICE CHANGES ΔLICPMM FORECASTS AND ERROR BARS



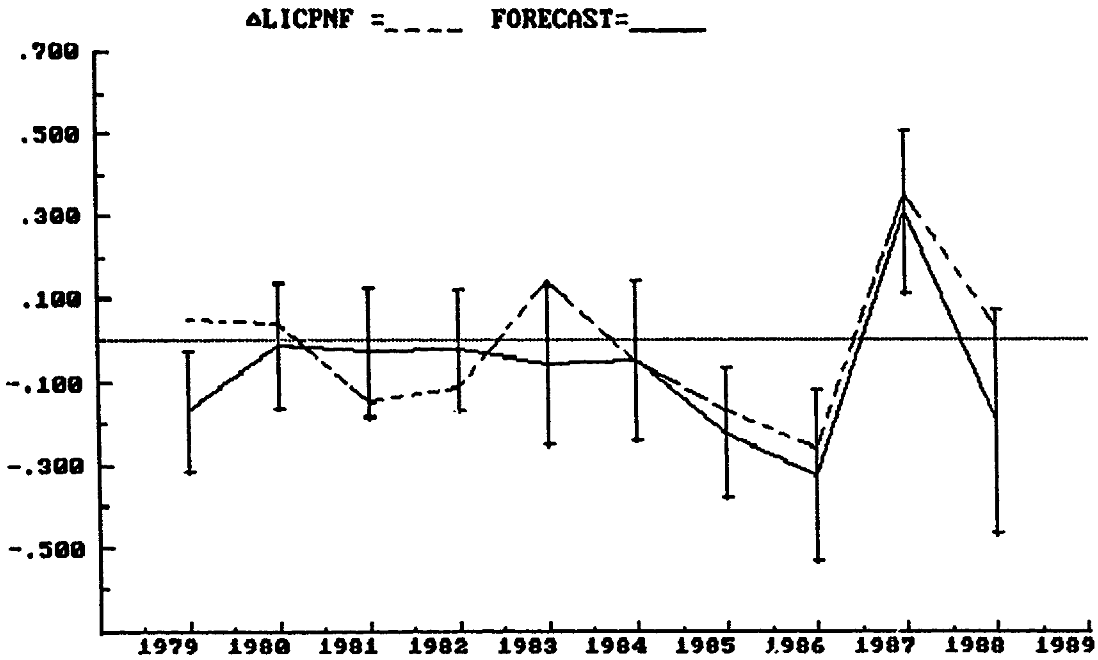
Forecasted Sample Period: 1979-1988

GRAPH 4b: ACTUAL COMMODITY PRICE CHANGES ΔLICPF FORECASTS AND ERROR BARS



Forecasted Sample Period: 1979-1988

GRAPH 5b: ACTUAL COMMODITY PRICE CHANGES ΔLICPNF FORECASTS AND ERROR BARS



Forecasted Sample Period: 1979-1988

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