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IS AGING BAD FOR THE ECONOMY? MAYBE

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The world's aging population is expected to shape the future of economies across the globe. Without behavioral adaptation by current and future generations, this demographic transformation is likely to slow down economic growth. However, aging will also induce behavioral adjustments in savings and labor force participation. Will these adjustments be large enough to reverse the negative effects of demographic change? The answer depends on a number of conditions. This note suggests that determining whether aging is driven by an increase in longevity or by a decrease in fertility is important for understanding the size and direction of these demographic effects. Moreover, the type of unfunded social security system that exists in the economy could also influence the net effect of aging.

Changing demographics in modern times are continuing to break records. First, it was the remarkable speed of population growth. According to United Nations (UN) calculations, the world population nearly doubled in the last 40 years, increasing from about 3.7 billion in 1970 to 6.9 billion in 2010. Next, it will be about slowing down. Total population is expected to grow by only 40 percent within the next 40 years, reaching about 9.6 billion by 2050.

In addition to slowing population growth, the median age of Earth's inhabitants will continue to get older, a phenomenon known as demographic aging. Table 1 shows that the median age has increased by 7.1 years since 1970, and it is expected to increase by another 7.8 years to reach 37 by 2050.

To put these two trends into perspective, it is important to remember that aging and population growth are mainly driven by two factors. The first factor is longevity. Mortality rates for each age group have been declining steadily for many decades. On average, people now tend to live longer. The second factor is fertility. The average number of births per woman has also declined sharply in the last several decades. These trends in increasing longevity and decreasing fertility rates are expected to continue, and will

reshape both the scale and age composition of the world's population in coming decades, albeit by different degrees across countries.

Table 1 shows that the "big jump" in the median age has already occurred in high-income countries (HICs). In 2010, the median age in HICs was 9.5 years older than in 1970, and is expected to increase an additional 5.9 years by 2050. In comparison, middle- (MICs) and low-income countries (LICs) are expected to have such jumps within the next 40 years. However, these changes will happen in different ways due to variations in fertility and longevity trends.

First, compared to the last 40 years, the reduction in fertility rate will not be as dramatic in MICs, while it will continue to decrease significantly in LICs. Second, the increase in life expectancy at birth will slow down in both groups. However, the increase in life expectancy at the age of 60, a measure of longevity, will slow down in MICs and accelerate in LICs (see last column of table 1). Between 1970 and 2010, the increase in life expectancy at the age of 60 was 3.4 years in MICs and 2.5 years in LICs. These will change to 2.6 and 3.4 years, respectively, by 2050.

What effects will these changes have on different economies? There is no obvious answer to this question concerning

Table 1. Demographic Trends by Income Groups

	Median age			Total fertility rate			Life expectancy at birth			Life expectancy at age 60		
	1970	2010	2050	1970	2010	2050	1970	2010	2050	1970	2010	2050
Low-income countries	18.0	20.0	27.5	6.7	4.6	2.8	45.1	57.5	69.7	14.3	16.8	20.2
Middle-income countries	19.5	28.1	37.7	5.7	2.5	2.1	54.4	67.2	73.9	15.2	18.6	21.2
High-income countries	29.6	39.1	45.0	2.6	1.7	1.8	69.2	77.8	83.7	17.7	22.8	26.2
World	22.1	29.2	37.0	5.0	2.6	2.2	55.5	66.5	73.9	16.2	19.8	21.9

Source: Onder, Hernandez, and Usmani (2014), based on UN population projections.

such a multi-dimensional process. A number of consequences will clearly be unfavorable. For example, with aging comes an increase in the old-age dependency ratio, or in other words, an increase in the number of elderly individuals per young person. This, in turn, leads to imbalances in unfunded (pay-as-you-go [PAYG]) pension budgets. However, some of the consequences could be positive: for instance, a slowdown in population growth could relieve some of the pressures on limited environmental resources.

There are some consequences for which there is no consensus on whether the outcomes would be beneficial or not. A particularly important one is the effect of aging on capital accumulation and economic growth. The conventional wisdom is that aging would lead to slower growth, because the old save less, which translates into higher interest rates, lower investments, and lower labor productivity. In contrast, others think aging may actually increase economic growth because people will adapt by saving more and working longer (*The Economist* 2014). Bloom, Canning, and Sevilla (2001) discuss different approaches regarding the link between economic growth and demographic change. Overall, this debate has not yet been concluded.

Dedry, Onder and Pestieau (forthcoming) investigate this last effect by separating the incidences of increased longevity and reduced fertility on capital accumulation. Results show that the type of aging is important in determining the outcomes. This is mainly because changes in fertility and longevity rates provide different incentives for individuals to save more or work more. These differences could be more pronounced depending on the type of social security system in a given economy.

This note starts with an investigation of the implications of the demographic transition without a discussion of the changes in incentives or associated behavioral adjustments, focusing on accounting effects only, and then introduces the behavioral effects as discussed in Dedry, Onder and Pestieau (forthcoming).

Other Things Being Equal, Aging Is Bad for the Economy

A simplistic way of demonstrating the economic impact of aging is to use a counterfactual analysis. This is, in essence, an accounting exercise that studies the relative size of demographic shifts in the absence of behavioral adjustments. In the first step, historical growth rates in gross domestic product (GDP) are decomposed into three components: labor productivity growth, population growth, and growth in labor force participation rate (box 1). Next, the last two components are replaced with projections of future demographic changes, while the first component is held constant. A comparison of this new “counterfactual” GDP series with the original shows how a reduction in population and labor force participation would have affected GDP growth in the absence of a change in productivity.

Figure 1 shows the results of such an exercise for 167 countries from all income categories. On average, had the world already experienced the future demographic transition within the last 40 years, the average GDP growth rate would have fallen by about 1.2 percentage points annually. To put this into perspective, a reduction of this size in the annual growth rate would translate into an almost 40 percent decrease in countries’ GDPs by the end of 40 years. The reduction in the GDP growth rate reflects both the slowdown in population growth and the increase in old age dependency ratios. In comparison, the GDP per capita growth rates control for the change in the size of population (see also box 1). As a result, growth rates would be reduced by only 0.4 percentage points annually.

These results, however, are not the same across countries. Whereas all HICs (except Estonia) would have experienced a reduction in growth rates, many LICs and some MICs would have benefitted from the prospective dynamics of their demographics. This contrast mainly arises from the “differences in differences.” Remember that the counterfactual exercise basi-

Box 1. Counterfactual Exercise

This counterfactual analysis provides a rule-of-thumb method for illustrating the implications of a forthcoming demographic change on GDP growth. The first step involves reorganizing the GDP per working-age population to explicitly identify the population size and age structures.

Let Y_t and P_t be the GDP (measured in purchasing power parity terms) and total population in year t , respectively. Then, the following equation presents an identity that must hold for all values:

$$\frac{Y_t}{P_t} = \frac{Y_t/L_t}{P_t/L_t}$$

where L_t shows the working-age population. By using a log transformation and rearranging, the above identity becomes:

$$\ln(Y_t/P_t) = \ln(Y_t/L_t) + \ln(L_t/P_t)$$

Whereas the left-hand side denotes the income per capita in year t , the first term on the right-hand side shows the output per working-age person, and the second term shows the share of working-age group in total population. The first and second terms on the right-hand side of this equation can be interpreted as average labor productivity and employment ratio, respectively, under a set of assumptions. These include the absence of unemployment, full labor force participation in working-age cohorts, and no labor force participation among the elderly and children.

Finally, the population can be removed from the left-hand side to focus on GDP growth.

$$\ln(Y_t) = \ln(Y_t/L_t) + \ln(L_t/P_t) + \ln(P_t)$$

Iterating this identity for one period and subtracting gives us the growth rates in each component:

$$g_{t+1} \equiv \frac{\ln(Y_{t+1}) - \ln(Y_t)}{\text{Output growth}} = \underbrace{\left[\ln\left(\frac{Y_{t+1}}{L_{t+1}}\right) - \ln\left(\frac{Y_t}{L_t}\right) \right]}_{\text{output per worker growth}} + \underbrace{\left[\ln\left(\frac{L_{t+1}}{P_{t+1}}\right) - \ln\left(\frac{L_t}{P_t}\right) \right]}_{\text{employment ratio growth}} + \underbrace{[\ln(P_{t+1}) - \ln(P_t)]}_{\text{population growth}}$$

The first term in square brackets on the right-hand side shows the growth in per worker output, thus the growth in labor productivity. The second term shows the growth in working-age group to population ratio, thus the change in the dependency ratio. Finally, the third term shows population growth.

In the spirit of Bloom, Canning and Fink (2011), the second stage of the experiment uses the above decomposition to generate counterfactual GDP growth rates. Specifically, the average annual employment ratio growth and population growth rates between 2010 and 2050 are plugged into the equation along with the actual values of output per worker growth from the period 1970–2010. The results show what the average annual growth rate of GDP would be between 1970 and 2010 had the country in discussion already experienced the forthcoming demographic change.

Source: Onder, Hernandez, and Usmani 2014.

cally compares future demographic changes with the past. Those with favorable demographic dynamics in the coming decades, or those who already completed the demographic transition to a new stable level, would have relatively smaller differences between the actual and counterfactual growth rates. In comparison, those in the midst of the transition would exhibit large impacts because the demographic changes in the future could be substantial compared to changes in the past.

But, Other Things Will Not Be Equal

The counterfactual analysis is useful for demonstrating the relative magnitude of future demographic changes. However, in practice, aging affects the economy through other channels as well. Individuals can change their behavior to cope with a new economic reality. Overall, this adaptation can significantly influence the impact of aging on economic growth.

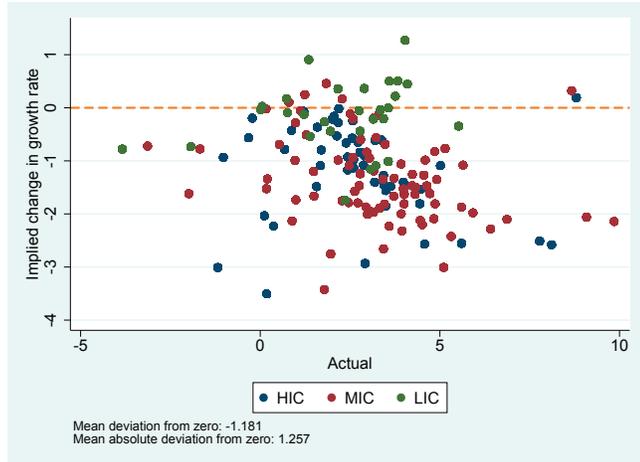
The first important behavioral adjustment can occur via savings. As people live longer lives after retirement, or as their retirement incomes change due to demographic transition, their incentives to save or dissave will also change. Changes in savings will, in turn, affect the productivity of labor by changing the capital available per worker.

The second important behavioral adjustment could occur in decisions regarding labor force participation. A longer life span could induce individuals to extend their active work life if retirement is not mandatory. Thus, the size of the labor force may not shrink as much as the demographic simulations predict.

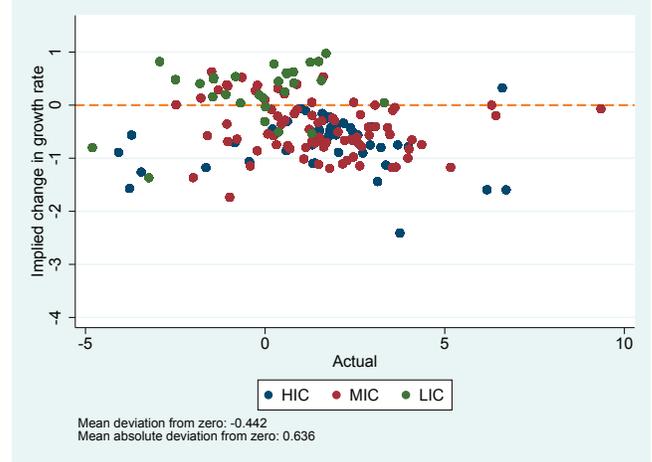
By holding the age of retirement and labor productivity growth constant, the counterfactual exercise above shuts down these behavioral channels. Therefore, aging and the slowdown in population growth always bring about negative consequences in the accounting exercise. Therefore, the next

Figure 1. What Would Demographic Dynamics from 2010–50 Imply for Growth Rates in 1970–2010?

a. GDP



b. GDP per capita



Source: Onder, Hernandez, and Usmani (2014), based on Penn World Tables 8.0; the United Nations World *Population Prospects: The 2012 Revision*, <http://esa.un.org/wpp/>; and World Bank staff calculations.

obvious question is: can behavioral adjustments overcome the negative accounting effects?

Types of Aging and Social Security Systems Matter

Dedry, Onder, and Pestieau (forthcoming) contribute to the discussions on behavioral adaptations by showing that adjustments may differ under different types of aging and social security systems. Their analysis uses a two-period overlapping generations (OLG) model with endogenous retirement decisions. The model separates the factors that change the scale and age composition of the population, for example, decreases in fertility and increases in longevity. Savings are motivated by financing consumption in life after retirement. Therefore, changes in fertility and longevity have different impacts on optimal savings.

Behavioral adjustments can affect capital per worker and labor productivity through two channels. First, individuals prefer to smooth consumption over their lifetime. Therefore, when needed, they increase the savings to finance their consumption in old age. Higher savings will then increase the capital per worker, thus increasing labor productivity. Second, individuals can increase the length of their active work life, especially when life spans increase. However, in contrast to savings, higher labor force participation decreases productivity, mainly because there are more workers for a given level of capital stock.

The study also compares three unfunded pension systems: defined contribution (DC), defined benefit (DB), and defined annuity (DA). In all cases, total contributions are collected in the form of payroll taxes and fully distributed as benefits. Therefore, the pension system is financially balanced. The main difference of these systems

emerges in the way that they respond to demographic changes. Under the DC system, contributions are fixed, and any reduction in the number of contributors leads to a reduction in benefits per beneficiary. In comparison, under the DB system, the benefits are fixed; hence, any loss due to a reduction in the number of contributors is compensated by increasing the contribution rate. The DA system is similar to the DB system—the only difference is that benefits are paid in lump sum under the DB, whereas under the DA they are paid in annuities. Therefore, the DB system is not affected by changes in the life span, whereas total benefits under the DA system increase if the individual lives longer.

To see how different pension systems and types of aging may influence the impact of aging on capital accumulation, it is useful to begin with a benchmark case.

Benchmark case with no pension system or work in old age

The well-known standard Diamond model can be used as an appropriate benchmark. In this model, individuals live two periods in the absence of social security and work after retirement. Table 2 summarizes the results. Whether longevity increases or fertility decreases, aging increases the capital accumulation in the standard case.

When aging is driven by a decrease in fertility, capital per worker increases because savings do not change, but the number of workers decreases compared to the case without any change in fertility rate. When an increase in longevity is the reason for aging, the increase in capital per worker is driven by an increase in per person savings. This adjustment is a result of consumption-smoothing motives; for example, individuals need more savings to support themselves if they live longer. Thus, with higher savings comes more rapid capital accumulation.

Table 2. Aging's Impact on Capital per Worker under Different Unfunded Pension Systems

	Standard case	Defined contribution	Defined benefits	Defined annuities
Mandatory early retirement				
Decrease in fertility	> 0	> 0	≧ 0	≧ 0
Increase in longevity	> 0	≧ 0	≧ 0	≧ 0
Optimal retirement				
Decrease in fertility	> 0	> 0	≧ 0	≧ 0
Increase in longevity	> 0	≧ 0	≧ 0	≧ 0

Source: Dedry, Onder, and Pestieau forthcoming.

An unfunded pension system with defined contributions

In this case, pension benefits adjust to satisfy the fiscal balance when fertility rate changes. Changes in longevity, on the other hand, do not create imbalances in the DC case.

To see the impact of a reduction in fertility, remember that there are two demographic factors that are relevant here. First, the number of pension contributors decreases. This translates into a decrease in pension benefits. In response to this reduction in old-age income, individuals save more. Second, the number of workers decreases. Therefore, with the number of workers shrinking and savings simultaneously increasing, the fertility rate decrease has a positive impact on capital accumulation.

In contrast, the positive result from the benchmark case weakens, and is possibly reversed, when there is an increase in longevity and a PAYG pension system with DCs and the possibility of work in old age are introduced. Remember, increasing longevity has multiple effects on decision makers. First, other things being equal, a longer life span induces higher savings via the consumption-smoothing channel. Second, as life spans increase, individuals would choose to work longer if retirement age is not regulated. However, this second adjustment could weaken or even reverse the need to save compared to the benchmark case. Therefore, the net effect of an increase in longevity on capital per worker is ambiguous under a DC pension system.

An unfunded pension system with defined benefits

Unlike DC pension systems, when the fertility rate changes under a DB system, pension contributions adjust to satisfy the pension system balance. Changes in longevity, however, do not create imbalances, as in the previous case.

When the fertility rate decreases, contribution rates increase to reestablish the balances in the social security system. This reduces first-period income. As a result, individual savings decrease to allocate adjustment costs across the periods as implied by the consumption-smoothing motive. At the same time, the number of workers decreases with the reduction in fertility rate. Overall, the net effect on capital per worker is ambiguous because lower savings have a negative impact and fewer workers have a positive impact on capital per worker.

In the context of increased longevity, the outcomes are identical for both DC and DB systems. This is mainly because the change in longevity has no effect on pension balances, because the pension lump sum payment is invariant to the length of the second period. Thus, there is no adjustment via pension contributions or benefits channel.

An unfunded pension system with defined annuities

Under a DA pension system, changes in both longevity and fertility affect the contribution ratios (box 2). Therefore, a decrease in the fertility rate or an increase in longevity that is more than the endogenous change in optimal retirement age lead to higher contribution rates to rebalance the pension fund.

The impact of a decrease in the fertility rate on capital accumulation with defined annuities is identical to the DB case. The net effect is ambiguous, and it is determined by two opposing forces: a reduction in number of workers, which increases per worker capital, and a reduction in per person savings, which decreases it. In the end, country-specific characteristics will determine which effect dominates.

The effects of an increase in longevity are complex in a DA system. In contrast to other social security systems, an increase in life span increases second-period income. With mandatory retirement, this is solely because each individual receives the annuity for a longer period. When individuals can choose the retirement age, however, a longer work life will optimally contribute to second-period income via wage earnings as well. The increase in old-age income, in turn, reduces the young generation's incentives to save. However, savings may still increase if the annuities are small compared to first-period income, resulting from the need to finance a longer life span. Thus, the net effect on savings is indeterminate, as is the net effect on capital per worker.

Simulations and More Technical Results

There are two results that are interesting from more specialized perspectives. First, in the numerical simulations performed by Dedry, Onder, and Pestieau, the net effect of both decreasing fertility and increasing longevity on capital accumulation and utility remained positive in all ambiguous cas-

Box 2. Modeling the Effects of Demographic Change on Capital Accumulation

Dedry, Onder, and Pestieau (*forthcoming*) use a standard two-period overlapping generation model with endogenous retirement to investigate the impact of demographic changes on capital accumulation and growth.

An individual belonging to generation t lives in two periods: t and $t + 1$. The first period of the individual's life has a unitary length, while the second one has a length $l \leq 1$, where l reflects variable longevity. In the first period, the individual works and earns w_t , which is devoted to the first period's consumption, c_t , saving s_t , and pension contribution τ . In the second period, the individual works an amount of time $z_{t+1} \leq l \leq 1$ and earns $z_{t+1} w_{t+1}$. This earning, the proceeds of saving $R_{t+1} s_t$, and the PAYG pension p finances second-period consumption, d_{t+1} . The model assumes that working in the second period z_{t+1} implies a monetary disutility $v(z_{t+1}, l)$, with $\frac{\partial v}{\partial z} > 0$, $\frac{\partial^2 v}{\partial z^2} > 0$ for the existence of a unique solution, and $\frac{\partial v}{\partial l} < 0$, which reflects the idea that an increase in longevity fosters later retirement.

Note that, for simplicity, the earnings in the second period of life are not taxed. Intuitively, the end of the first period can be interpreted as the statutory age of retirement. Dedry, Onder, and Pestieau (*forthcoming*) also abstract from modeling the funded social security system by assuming it is identical to the standard savings. Thus, the pension contribution parameter τ measures the relative size of the unfunded pensions. In other words, $\tau = 0$ implies that the whole pension system is funded.

Denoting by $u(\cdot)$ the utility function for consumption c or d and U the lifetime utility, the problem of an individual of generation t is:

$$\max_{s_t, z_t} U_t = u(w_t - \tau - s_t) + \beta l u \left(\frac{w_{t+1} z_{t+1} + R_{t+1} s_t + p - v(z_{t+1}, l)}{l} \right),$$

where β is time discount factor and the link between pension contributions (τ) and benefits (p) is defined by the particular pension system as follows:

$$\begin{aligned} \text{Defined contribution:} & \quad \tau(1+n) = \bar{p} \\ \text{Defined benefit:} & \quad \bar{\tau}(1+n) = p \\ \text{Defined annuity:} & \quad \bar{a}(l-z) = \tau(1+n), \end{aligned}$$

where n is the population growth rate and a denotes the annuities under the defined annuity system. Production side of the economy is characterized by a Cobb-Douglas production function with constant returns to scale:

$$Y_t = F(K_t, N_t) = AK_t^\alpha N_t^{1-\alpha},$$

and where K_t is the stock of capital, A is productivity parameter, and N_t is the labor force. Capital accumulates according to the rule: $K_{t+1} = L_t s_t$, where L_t is the size of generation t .

The analysis proceeds by solving for the equilibrium saving and retirement-age decisions for individuals under different social security systems. Impacts of changing fertility and longevity are analyzed separately.

Source: Dedry, Onder, and Pestieau *forthcoming*.

es. However, these are all long-term effects which appear in the steady state. A dynamic simulation exercise revealed that, in the short term, a transitory decrease in utility is likely when aging is driven by a reduction in fertility and a DC pension system is in place. Second, the analysis assumes underinvestment in all cases, for example, the equilibrium is on the good side of the “golden rule,” thus, more savings are good. Interestingly, and again in all cases, mandatory retirement produced more desirable outcomes than optimal retirement, despite the distortions it imposed on the economy. These outcomes are mainly due to the fact that forced retirement induces workers to save more than they would save if they were freely choosing their own retirement age.

Conclusion

This analysis shows that the net effect of demographic aging on economies may differ across countries. In the absence of

behavioral adjustments, the results are mainly driven by accounting effects (for example, less workers and more dependents per worker in the economy), and are therefore necessarily negative.

However, once behavioral adjustments are considered, this picture may change substantially. First, workers could become more productive due to higher savings and, thus, increased capital accumulation. Second, individuals may choose to work longer, thus, the labor force could be larger than the levels used by demographic projections with constant ages of retirement.

This note highlights the importance of considering pension system characteristics and types of aging when assessing the extent to which behavioral adjustments may enhance or reverse the negative results suggested by the accounting effects. Results show that savings, thus capital accumulation, could increase when aging is mainly driven

by decreasing fertility rates and the pension system is characterized by defined contributions. This effect is weaker in DB and DA systems. In comparison, when aging is driven by increasing longevity, the effects on savings are ambiguous in all types of unfunded pension systems. However, if regulations allow, labor force participation among the older population could increase. This is especially true in DC and DB systems.

Considering the important differences in aging styles and social security systems across countries, and particularly between developing and advanced economies, studies that investigate the economic impacts of aging would do well to take these differences into consideration.

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