LOWY INSTITUTE
FOR INTERNATIONAL POLICY

WORKING PAPERS IN
INTERNATIONAL ECONOMICS
JUNE 2005 • NO. 5.05

The Global Impact of Demographic Change

Nicoletta Batini
Tim Callen and
Warwick J McKibbin

International Economy Program

The Lowy Institute for International Policy is an independent international policy think tank based in Sydney, Australia. Its mandate ranges across all the dimensions of international policy debate in Australia - economic, political and strategic – and it is not limited to a particular geographic region. Its two core tasks are to:

- produce distinctive research and fresh policy options for Australia's international policy and to contribute to the wider international debate.

- promote discussion of Australia's role in the world by providing an accessible and high quality forum for discussion of Australian international relations through debates, seminars, lectures, dialogues and conferences.

The Global Impact of Demographic Change

by N Batini, T Callen, and W McKibbin[1]

June 2005

Abstract

The world is in the midst of a major demographic transition. This paper examines the implications of such transition over the next 80 years for the United States, Japan, the rest of the OECD and developing regions of the world using a dynamic intertemporal general equilibrium four-country model containing demographics calibrated to the 'medium variant' of the United Nations population projections. We find that population aging in industrial countries will reduce aggregate growth in these regions over time, but should boost growth in developing countries over the next 20-30 year, as the relative size of their working-age population increases. Demographic change will also affect saving, investment and capital flows implying changes in global trade balances and asset prices. We also explore the sensitivity of the results to assumptions about future productivity growth and country external risk for the developing country region.

[1] The research in this paper was partially funded by the Economic and Social Research Institute of the Japanese Cabinet Office International Collaborations Project and was prepared as background material for the September 2004 World Economic Outlook. The views expressed are those of the authors and do not necessarily reflect the views of the institutions with which the authors are affiliated.

I. INTRODUCTION

The world is in the midst of a major demographic transition. Not only is population growth slowing, but the age structure of the population is changing, with the share of the young falling and that of the elderly rising. Different countries and regions, however, are at varying stages of this demographic transition. In most advanced countries, the aging process is already well under way, and a number of developing countries in east and southeast Asia and central and eastern Europe will also experience significant aging from about 2020.[2] In other developing countries, however, the demographic transition is less advanced, and working-age populations will increase in the coming decades.[3]

This paper examines the economic implications of this demographic transition for Japan, the United States, the rest of the OECD (largely Europe), and developing regions of the world using a four-country version of the MSG-Cubed dynamic intertemporal general equilibrium model (or DSGE model from the macroeconomics literature) extended with an OLG Blanchard approximation. This model was developed by McKibbin and Nguyen (2004). The demographic transition is calibrated to the "medium variant" of the United Nations population projections. The model innovates upon existing OLG multi-country models by introducing a three-sector production technology, rule-of-thumb behavior, real and nominal rigidities, and different types of capital into more basic general equilibrium

[2] The term developing countries in this paper refers to emerging market and other developing countries.

[3] An excellent overview of the issue facing developing countries can be found in Birdsall, Kelley, and Sinding (2001).

optimizing OLG set-ups. In doing this it brings together features of real business cycle models—with a fully articulated analysis of forward-looking producers and consumers—and modern macroeconometric DSGE models—describing the effects of demand downturns in the face of wage (and price) stickiness.

We find four main results:

- Population aging in industrial countries will reduce growth, beginning in Japan in the next decade and then the rest of the OECD by the middle of the century.

- In contrast, as the relative size of their working-age population increases, developing countries will enjoy a "demographic dividend" that should result in stronger growth over the next 20–30 years, before aging sets in.

- Demographic change will also affect saving, investment, and capital flows. Japan and to a much lesser extent the rest of the OECD—the fastest aging countries—could see large declines in saving and a deterioration in their current account positions as the elderly run down their assets in retirement .

- Results are sensitive to assumptions made about productivity growth and external risk premia.

The paper is organized as follows. Section II summarizes key aspects of the current and expected global demographic transition. Section III reviews the recent literature that has explored the macroeconomic implications of demographic change and describes the model that we employ. Section IV presents our baseline results estimating the impact of demographic change from 2005 until 2080, and Section V examines how sensitive these are

to the assumptions made about growth and risk assessment in developing countries. Conclusions and policy implications follow (Section VI). Details of the model and the calibration/estimation are appended to the paper.

II. Some Background on Global Demographic Change

The world is in the midst of a historically unprecedented demographic transition that is having—and will continue to have—profound effects on the size and age structure of its population (Figure 1). Before 1900, world population growth was slow, the age structure of the population was broadly constant, and relatively few people lived beyond age 65. This began to change during the first half of the twentieth century as rising life expectancy boosted population growth, although initially there was little change in the age structure of the population.[4] The second half of the twentieth century saw the start of another phase in this transition. Fertility rates declined dramatically—by almost one-half—causing population growth to slow, the share of the young in the population to decline, and the share of the elderly to increase. The share of the working-age population, however, changed little.

These global developments mask considerable variation between countries and regions that are the result of very different fertility, mortality, and migration trends. For example, although fertility rates have fallen almost universally in recent decades, they remain much higher in developing than in advanced countries, where they are generally below the

[4]In a number of European countries the demographic transition began much earlier. Lee (2003) dates the beginning of the decline in mortality in northwest Europe to about 1800.

replacement rate.[5] Even among developing countries, considerable differences exist—fertility rates are high in Africa and the Middle East, but are below replacement rates in east Asia and central and eastern Europe. Likewise, while life expectancy has risen across the globe over the past 50 years—and the largest gains have generally been made in developing countries—life expectancy still remains much higher in advanced countries. Exceptions to the generalized increase in life expectancy are Africa—where as a result of the HIV/AIDS pandemic, life expectancy has declined by more than 25 percent in some countries—and the Commonwealth of Independent States (CIS) countries. Lastly, net immigration has made an important contribution to population growth in recent years in North America, but much less so in Europe and Japan.

As a consequence of all of these trends, population growth is much higher in developing countries—particularly in Africa and the Middle East—than in advanced countries. Indeed, in Japan and Europe, population growth is close to zero. The share of the young in the total population is also higher in developing countries, while the elderly account for a larger share of the population in advanced nations.

Looking ahead, the United Nations' current population projections (which extend to 2050) envisage that fertility rates in low fertility countries will recover modestly, that fertility in other countries will continue to decline, that further gains in life expectancy will be made in both advanced and developing country regions, and that migration will make an

[5] Replacement level fertility is estimated to be 2.1 births per woman in industrial countries and 2.4 births per woman in the developing countries. The level exceeds 2 in part because more boys are born than girls and in part because some children die before they reach reproductive age.

increasingly important contribution to total population growth in advanced countries, but will only modestly reduce population growth in developing countries.[6] This has the following consequences (Figure 2).

- *Global population growth will continue to slow*. By 2050, global population growth is projected to be only ¼ percent a year, compared with 1¼ percent at present. The population in a number of countries is actually expected to decline over the next 50 years, including by over 30 percent in some central and eastern European countries, by 22 percent in Italy, and by 14 percent in Japan. In developing countries—particularly in Africa and the Middle East, but also parts of Asia—population growth, although slowing, will remain robust, reflecting their higher fertility rates.

- *The world's population will continue to age*. The elderly will account for an increasing share of the population—although the pace and timing of aging varies widely between countries and regions—and the median age of the world is expected to increase by over 10 years during 2000–50 to 37 years. The elderly dependency ratio—which shows the population aged 65 and older as a share of the working-age (aged 15–64) population—is projected to rise dramatically in Japan and Europe, with lesser increases anticipated in the United States (Figure 3).[7] Further, the elderly

[6] The projections discussed in this section refer to the "medium variant" of United Nations (2003).

[7] These elderly dependency ratios are only an approximation to the support needs of an elderly population. Some people continue to work after they have reached 65, while not everyone in the 15–64 age group is in employment—they may be still in school,

(continued…)

themselves are getting older. The number of people aged 80 years and over is increasing at nearly twice the rate of that of those over 65. Among the developing country regions, aging is already under way in central and eastern Europe, a process that is expected to accelerate from about 2015. Aging will also begin to accelerate in Asia and Latin America around this time—with China experiencing particularly rapid aging—but the share of the elderly in Africa and the Middle East, while rising, will remain relatively small.

- *The share of the working-age population will fall in advanced countries, but increase in many developing countries*. In Japan and some European countries, this decline has already started and is projected to accelerate. In the United States, a high rate of immigration and higher fertility rates result in a more modest projected decline until 2025, after which the share of the working-age population stabilizes. In developing countries, the share of the working-age population is projected to increase until 2015, and then stabilize at this higher level as a declining share of the young offsets a rising share of the elderly.

The demographic changes that are projected to take place in the coming years are striking. Clearly, caution must be exercised when using long-term projections of any kind, and demographic projections do become much more uncertain the further into the future one

---

unemployed, or outside the labor force. Further, in some countries, children younger than 15 are in full-time employment. It is possible to develop a measure of economic dependency that adjusts for these factors, but this alternative measure is difficult to calculate, particularly for developing countries.

goes. However, the basic trends outlined in this section—toward an increasing share of the elderly and a declining share of the young in the population—are apparent in most plausible scenarios, and the main issue therefore is the extent to which the global population will age over the next 50 years (and beyond). Against this background, it is important to understand how demographic change is likely to affect global economic and financial market outcomes.

III. Modeling the Economic Impact of Demographic Change

Numerous studies in the literature examine the impact of demographic change on one region of the world by simulating closed-economy multiple generation models. Multiple generation models of the kind used in these studies were first proposed by Samuelson (1958) and Diamond (1965). In their purest overlapping-generations (OLG) form, these innovate upon the Ramsey infinitely-lived representative-consumer hypothesis by introducing, at each point in time, individuals of different generations (see, for example, Auerbach and Kotlikoff, 1987). Work by Blanchard (1985), Buiter (1988), Weil (1989), and more recently Faruqee (2000, 2003) suggested simplified closed-economy alternatives to pure OLG models.

Multi-country extensions in the OLG tradition are relatively recent and include Buiter (1981), Cutler and others (1990), Faruqee, Laxton, and Symanski (1997), Attanasio and Violante (2000), INGENUE Team (2001), Brooks (2003), Börsch-Supan, Ludwig, and Winter (2003), McKibbin and Nguyen (2003), Fehr, Jokisch, and Kotlikoff (2003), and Bryant and McKibbin (2004) among others. Results from such models differ according to the way household consumption, saving, and wealth accumulation are treated in each model, as well as whether the models incorporate frictions in the adjustment to equilibrium and

whether and how they model fiscal (including pension schemes) and monetary policy arrangements.

The model used in this paper is a modified version of the MSG-Cubed model. The MSG-Cubed model is a three-sector—energy, nonenergy, and capital-producing—version of the G-Cubed model developed by McKibbin and Wilcoxen (1998), building on the earlier MSG2 model developed by McKibbin and Sachs (1989), and the Jorgenson and Wilcoxen (1990) model. The model in this paper is much smaller than the original model because of the incorporation of demographic variables. In this version the world is divided into four regions: Japan, the United States, the rest of the OECD (largely Europe), and the rest of the world (in essence, the world's developing bloc). It combines the modern intertemporal optimization approach to modeling economic behavior (as found in Blanchard and Fischer, 1989, and Obstfeld and Rogoff, 1996) with short-run rule-of-thumb behavior. In doing this it brings together features of real business cycle models—with a fully articulated analysis of forward-looking producers and consumers—and modern macroeconometric models—describing the effects of demand downturns in the face of wage (and price) stickiness. The main features of the model are as follows.

- *Demographics*. The model includes demographic considerations, such that economic agents in the model possess finite life spans and their income varies as they age. Specifically, this draws heavily on Faruqee (2000a, 2000b) who extended the Blanchard (1985) model of finitely lived agents to include aging considerations. Following Bryant and McKibbin (2001), the model used in this paper extends this approach to allow for children who are dependent on working parents for 16 years.

These children then become adult at a maturity rate *m*. Each adult has age specific productivity that rises over their life and then gradually deteriorates towards zero as they age. These workers are responsible for supporting their financially dependent children. Death occurs with a fixed probability[8].

- *Explicit optimization.* The model is based on explicit intertemporal optimization by agents (consumers and firms) in each economy. Thus, time and dynamics are of fundamental importance in the MSG-Cubed model, making its core theoretical structure like that of real business cycle models.

- *Rule-of-thumb agents.* To track the inertial dynamics of some key macroeconomic variables, the behavior of agents is modified to allow for short-run deviations from optimal behavior, owing either to myopia or to restrictions on the ability of households and firms to borrow at the risk-free bond rate on government debt.

- *Cash-in-advance constraints.* Holdings of financial assets including money are explicitly modeled. In particular, money is introduced into the model through a restriction that households require money to purchase goods.

- *Nominal rigidities.* The model allows for short-run nominal wage rigidity (by different degrees in different countries) and therefore allows for protracted periods of unemployment depending on the labor market institutions in each country.

[8] See McKibbin and Nguyen (2004) for a complete discussion of the theory.

- *Two types of capital.* The model distinguishes between the stickiness of physical capital within sectors and within countries and the flexibility of financial capital that can flow immediately where expected returns are highest. This distinction leads to a difference between the quantity of physical capital that is available at any time to produce goods and services and the valuation of that capital as a result of decisions about the geographical allocation of financial capital.

- *Estimation/calibration.* Key parameters in the model—such as the elasticities of substitution in production and consumption decisions—are estimated enhancing the model's ability to reproduce the dynamics of historical data.

As a result, the model exhibits a rich dynamic behavior, driven on the one hand by asset accumulation and, on the other hand, by wage adjustment to a neoclassical steady state. The core equations of the model and a description of the data used in the calibration are available at www.gcubed.com.

IV. How Will Demographic Change Affect the Global Economy?

The demographic changes projected over the coming years are large, but are they likely to have an important effect on the economies of advanced and developing countries? This section reports simulations from the MSG-Cubed model to assess this issue.

Our modeling approach is as follows. We first project the world economy from 1985 to 2100 assuming the UN mid range demographic projection (converted into the equivalent model variables given by the analytical framework). We also make assumptions about

productivity growth by sector and country using the approach outlined in Bagnoli and others (1996) extended in McKibbin and others (2004). This projection exercise gives us a baseline simulation containing the expected demographic transition. We then rerun the model removing the demographic transition from the model projection starting in 1985. Removing the demographic transition is defined as setting the birth rates of adults and children equal to the rates assumed in the long run steady state at 2200. These rates are arbitrary, but not implausible. They assume a child birth rate of 1.9 percent and an adult maturity rate of 1.5 percent plus a constant probability of death of adults of 1 percent and of children of 0.46 percent. Due to the requirement of the modeling approach that there be a well defined steady state with all countries growing at the same rate, we are forced to assume that all countries will eventually have the same demographics (in terms of growth rates) in the steady state (however, this is centuries into the future). The period of the current demographic bulge, from 1985 until the steady state, is interpreted as a temporary deviation from this long-run steady state. Thus removing the temporary deviation also gives us a measure of the impact of the demographic transition over the recent past and into the future.

The process of removing a shock of this nature is not a conceptually easy exercise because the model assumes rational expectations in a variety of markets. Thus the initial conditions for 1985 (i.e., the actual data) in the baseline have expectations about the demographic transition already embodied in stock variables such as physical capital stocks, net asset positions (both domestic and foreign), and human capital. We thus have a problem in the counterfactual exercise that in 1985, when we remove the demographic shock, we are capturing both the impact of the underlying demographics as well as the impact of the change in expectations about future demographic change. For a period after the new information is

realized there will be a large adjustment in asset stocks which reflects the expectations revision. To try and separate out the expectations revision from the underlying demographic change, we let the model run for 20 years to 2005 so that much of this initial asset adjustment is completed and we are capturing more of the pure demographic effect and less of the revision to expectations. Thus in the following analysis all results are presented from 2005 to 2080 after the asset stock adjustment and asset price volatility to the change in information in 1985 have washed through the economy.

We convert the UN population projections (mid-case scenario) into the parameters of the model given the constant probability of death for adults and a different but constant probability of death for children. This is done in a way which gives us, as close as possible, the aggregate adult and child populations over time for each country as projected by the United Nations. It is not an exact representation of the UN projections because the probability of death is changing over time and at this stage of the research we are unable to incorporate this. Thus the results should be interpreted as illustrative rather than as precise predictions about the future.

Figure 4 presents the deviation of the child birth rate and adult maturity rates from the long-run steady state rates. These are the basic shocks that are removed from the baseline in the counterfactual simulation. Several important points can be seen in these figures. In the United States and the developing country bloc, the child birth rates and adult maturity rates, although declining, are well above the rates in their steady state rates and populations are rising. For Japan and the rest of the OECD, child birth rates and adult maturity rates are currently below steady state levels, and populations are falling. The pace at which child birth rates and adult maturity rates are declining, however, are faster in developing countries, and

in this important sense the demographic transition in developing countries is greater than in the advanced regions.

Results for the impact of demographic change on the global economy for the period from 2005 to 2080 are shown in Figure 5. Each figure contains results for each of the four regions showing the estimated impact of demographic change—that is the difference between the baseline which includes demographic change and an alternative scenario in which the demographic variables are at their steady state rates of growth. The results are expressed in such a way that a positive number is a variable which is higher because of the impact of changing demographics than it would otherwise have been. For example, the level of Japanese GDP in 2050 is estimated to be 30 percent lower than would have been the case without the impact of the demographic transition—the decline in the labor force is only partly offset by a higher capital stock (see below). On the other hand, developing country GDP is estimated to be 60 percent higher by 2050 as a result of the strong increase in the labor force due to the demographic transition. It is important to stress that results for all countries depend on the demographic change in each country and the spillover between countries.[9]

In Figure 5 it is clear that the demographic transition is important in affecting the GDP growth rate, with growth in developing countries more than 2 percent higher by 2020 than without the demographic change, and growth falling in Japan after 2010 to reach a low point of 1.3 percent below the situation in the “no demographic change” scenario by 2040.

[9] The relative impact of own and cross border demographic change is considered further in McKibbin (2005).

The US and rest of the OECD are intermediate between these cases, although it should be stressed that within Europe and within developing countries there are also large differences in demographic outcomes which are averaged away in the aggregation we are using in this paper[10]. The picture per adult (the proxy for per capita in the model) is quite different to that for the real growth rate. The Japanese outcomes are a point to note. GDP per adult is projected to be higher in Japan out to 2025 and still be above what would have been experienced until 2050. This demonstrates that in a world with falling labor forces it is important to focus on per capita variables rather than aggregate variables in thinking through the welfare impacts of demographic change.

As expected, the changing population and labor force has important impacts both on private investment through changes in the expected marginal product of capital as well as on consumption and saving decisions. The increase in the labor force in developing countries raises the marginal product of capital and stimulates higher investment, with the investment to GDP ratio 4 percent higher by 2025. There is also initially an increase in investment in Japan as a result of the need to substitute capital for a diminishing supply of workers over time, although eventually investment begins to fall as the declining labor force needs less capital to equip it. The substitution of workers with capital is clear in the change in the capital output ratio in Japan.

The response of households to both a change in youth dependency and an expected change in elderly dependency can be seen in the right hand panels of Figure 6. In Japan,

[10] This is explored further in McKibbin (2005) where the rest of the OECD and developing country blocks are further disaggregated.

private saving has been boosted in recent years as the working age population move through their high saving years, but is projected to fall over time as the increasing number of elderly dissave to supplement their falling employment income. The ratio of saving-to-GDP is 4 percentage points higher by 2005 due to the demographic transition, but by 2070 is projected to be 11 percentage points lower. In the United States, the saving-to-GDP ratio in 2005 is 3 percentage points lower due to demographic changes, but is projected to be 5 percentage points higher by 2040 as an increasing number of the population move into their high saving years. Aggregate private consumption reflects these trends with consumption rising in developing countries (and to a lesser extent in the United States) and falling in Japan. Per capita consumption (not shown), however, actually rises initially in Japan and is only slightly lower by 2050[11].

It is clear that the demographic transition has important impacts on saving and investment behavior and consequently current account and trade balances. As a result of the demographic transition occurring both in Japan and the rest of the world, the Japanese current account in 2005 is 2.6 percent of GDP in surplus relative to the case of no demographic change. Over time, however, as saving falls in Japan, and there is a rise, then fall, in investment, the current account surplus narrows. The current account position also deteriorates—albeit more modestly in the rest of the OECD—while the United States and developing countries see an improving current account position. These changes result in a substantial reallocation of global capital, as Japan and the rest of the OECD repatriate capital to maintain consumption in the face of falling labor incomes. These changes in current

[11] See McKibbin and Nguyen (2004) for detailed discussion of the per capita behavior.

account positions are consistent with the results presented in IMF (2004) from simulations of the INGENUE model and econometric estimates. It is also worth noting here that the changes in saving behavior in the simulations here are not dissimilar to those from the INGENUE model (although in the later model the decline in saving in Europe is larger due to the explicit inclusion of a pension system in the model).[12]

The global asset adjustment is reflected in real exchange rates as a result of demographic change. There are a number of factors driving real exchange rates in this model.[13] A key factor is the assumption that all goods enter into consumers consumption bundles identified by country of origin. Thus, if the supply of goods from one country shrinks, the relative price of those goods will tend to rise taking all other factors as given. Thus, as the labor force falls in Japan and less Japanese goods are produced, the relative price of all Japanese goods will tend to rise. This will be reflected in an appreciation of the real exchange rate of Japan. By 2050 the Japanese real exchange rate is appreciated by close to 60 percent. Similarly the real exchange rate of developing countries is depreciated by close to 60 percent because of the large increase in supply of developing country goods on world markets. In addition to these underlying factors the adjustment of global capital flows will also tend to reinforce this effect. With income being repatriated back into countries with

[12] Social security contributions have to be raised to finance the large increase in pension expenditures in Europe. This effectively transfers resources from the working age population—which has a higher propensity to save—to the older generations who have a lower propensity to save in the model.

[13] See Bryant and de Fleurieu (2005) for a detailed analysis of the exchange rate sensitivity to a wide variety of assumptions.

aging populations from countries with expanding populations, the real exchange rate of the aging economies will also tend to appreciate.

Finally, real interest rates in developing countries are 1.5 percent (150 basis points) above what they would have been because of demographic change, reflecting the rising marginal product of capital as the labor force rises in these economies. This is not arbitraged away because of adjustment costs in physical capital accumulation that prevent large differences in marginal products of capital from being exploited because developing countries cannot absorb quickly large amounts of capital. This differential is reduced over subsequent decades. In Japan the changing capital labor ratios as a result of demographic change is estimate to reduce real interest rates by up to 1.5 percent by 2050. Long-term interest rates fall much sooner than this given the expectations in the model. At the same time equity markets summarized by Tobin's q (lower right hand corner) are expected to rise especially in developing countries, again reflecting the changing marginal product of capital over time. In Japan and the rest of the OECD as the demographic transition matures, equity markets fall below what they would have been by 2020 in Japan and 2040 in the rest of the OECD.[14]

Overall these preliminary results suggest that the demographic transition is already, and will increasingly, impact global growth and the distribution of this growth across regions. Saving, investment, and current account balances in different regions will also be affected. Clearly there are a myriad of assumptions underlying the model used in this

[14] See IMF (2003) for an overview of how population aging may affect financial markets.

analysis. The following section puts the magnitudes of these results in the context of some other assumptions that might impact the variables that have been explored in this section.

V. SENSITIVITY ANALYSIS

In this section, we change some assumptions both to see how important these might be for the analysis above, as well as to give a benchmark to compare the size of the adjustments we have presented in the previous section. The first assumption we explore is what happens if productivity growth outside the United States grows faster for a decade from 2005. The second assumption we explore is what happens if there is a fall in the country risk premium facing developing countries (which is benchmarked in the model to that which existed in 1985).

A. Faster Global Growth Through More Rapid Technological Convergence

In this section we explore the implications of more rapid technological convergence than in the underlying baseline projection. This is modeled as a rise in productivity growth (defined as labor augmenting technical change) of 1 percent per year for 50 years from 2005 to 2054 in the developing country region, a rise of 0.1 percent per year over the same time in Japan and Europe, and no change in underlying productivity growth from baseline in the United States.

Results are presented in Figures 6 for the same set of variables as for the demographic shock. As expected faster technical change leads to higher real GDP over time. In developing countries this growth begins immediately, although for the rest of the world GDP

growth is actually slightly lower as resources are initially channeled into developing countries. This can be seen in the deterioration of the developing country current account. After a decade, however, real GDP growth rises in the rest of the world with Japan and the rest of the OECD experiencing their own growth from domestic productivity as well as income growth from higher growth in developing countries.

The surge in the growth rate initially reduces investment in all countries. This may seem surprising but it reflects the rise in consumption by households in anticipation of higher future income which reduces savings and raises real interest rates thereby crowding out private investment. It takes a decade before investment rates rise above baseline in developing countries. This rise of consumption in anticipation of higher incomes and the initial fall in investment results in a fall in capital output ratios in all countries (which is consistent with higher real interest rates). Higher real interest rates persist for five decades while productivity growth is high, but then falls below baseline when the growth surge concludes. This overshooting of interest rates reflects the overshooting of capital accumulation which can be seen in the sharp investment reversal after 2050. Despite the presence of rational consumers and firms in the model there is also considerable persistence through the presence of backward-looking households and firms.

In comparison with the results for the demographic transition we can make several observations. The first is that higher productivity growth in developing and modestly higher productivity growth in developed economies can offset the impact of demographic change on aggregate GDP. Higher productivity growth of 0.1 per year in Japan and the ROECD offsets half of the fall in GDP caused by demographic change. For developing countries, the higher growth rate almost removed the expected future decline in growth rates caused by their aging

after 2030. This is also true for the aggregate consumption outcomes. It does, however, place more upward pressure on real interest rates in the short run.

B. Improving Capital Market Access for Developing Countries

Reforms to improve the investment climate are assumed to result in a reduction in the risk premium associated with investing in developing country assets. The risk premium is assumed to be 1 percent lower forever.[15] Figure 7 shows the results for the same set of variables as in the earlier figures. The reduction in the risk premium encourages more capital to flow into developing countries, and this reduces real interest rates and has a considerable impact on real GDP. Domestic saving increases for several decades in the developing countries as the rate of return on domestic capital improves as a result of the reforms, further reinforcing the positive effect on growth. The current account position of developing countries deteriorates, while the advanced country regions—the suppliers of the capital to the developing countries—experience improvements in their external balances. The change in risk premia relocates production from the industrial economies to the developing countries causing the capital output ratio to rise in developing countries and fall in industrial countries.

In comparison with the growth shock, the transmission of growth from developing countries' productivity is more positive for industrialized economies than the fall in developing country risk which leads to a reallocation of global production and higher global income but all of the gains are captured by consumers in developing countries.

[15] The issue of changes in country and equity risk premia using the same model but without demographics is considered in McKibbin and Vines (2003).

VI. Conclusions and Policy Implications

The impact of ongoing demographic shifts across the globe will be wide ranging. The modeling in this paper suggests that in advanced countries, population aging will likely reduce per capita growth rates in the future, while in developing countries increases in the relative size of the working-age population could lead to stronger per capita growth provided the additional labor resources are effectively utilized. International capital flows could also be substantially affected. The results presented in this paper suggest that large changes in saving, investment, and current account balances could take place over the next 80 years as a result of demographic change.

There are, however, considerable uncertainties, and our understanding of how demographic change will affect economic performance is far from complete. For example, the impact of demographic change on external balances and capital flows will critically depend on the reaction of private saving, but it remains unclear to what extent households will adjust their behavior as the demographic transition unfolds. Further, the size of the potential changes need to be considered in the context of the scale of a wide range of other shocks that might occur in coming decades such as changes in productivity growth in various countries. It is clear that substantially more research is required to explore these issues.

References

Attanasio, Orazio and Violante, Giovanni L., 2000. "The Demographic Transition in Closed and Open Economies: A Tale of Two Regions," Working Papers 412, Inter-American Development Bank, Research Department.

Auerbach, Alan and Lawrence J. Kotlikoff, 1987 *Dynamic Fiscal Policy* (Cambridge: Cambridge University Press).

Bagnoli, Philip, McKibbin Warwick, and Peter Wilcoxen, 1996, "Future Projections and Structural Change," in N. Nakicenovic, W. Nordhaus, R. Richels, and F. Toth (ed) *Climate Change: Integrating Economics and Policy*, CP 96-1 , International Institute for Applied Systems Analysis (Austria), pp181–206.

Blanchard, Olivier J., 1985, "Debt, Deficits, and Finite Horizons," *Journal of Political Economy*, Vol. 93, pp. 223-47.

———, and Stanley Fischer, 1989 *Lectures on Macroeconomics* (Cambridge, Massachusetts: MIT Press).

Bloom, David E., and Jeffrey G. Williamson, 1997, "Demographic Transitions, Human Resource Development, and Economic Miracles in Emerging Asia," in Jeffrey Sachs and David Bloom, (eds.), *Emerging Asia* (Manila: Asian Development Bank).

Brooks, Robin. (2003) "Population Aging and Global Capital Flows in a Parallel Universe" IMF Staf Papers vol 50, no 2.

Bryant Ralph C., 2004, "Demographic Pressures on Public Pension Systems and Government Budgets in Open Economies," paper prepared for the February 2004 *International Forum of Collaboration Projects*, Tokyo.

———, and Marc de Fleurieu, 2005, "Exchange Rate and External Balance Consequences of Asymmetric Demographic Transitions: Key Determinants of Cross Border Substitutability," paper prepared for the February 2005 *International Forum of Collaboration Projects*, Tokyo.

Bryant, Ralph C., and Warwick J. McKibbin, 1998, "Issues in Modeling the Global Dimensions of Demographic Change," Brookings Discussion Paper in International Economics No. 141. (Washington: Brookings Institution).

———, 2004, "Incorporating Demographic Change in Multi-Country Macroeconomic Models," in P. Onofri (ed) *The Economics of an Ageing Population: Macroeconomic Issues*, Edward Elgar.

Bryant, Ralph C., Hamid Faruqee, Delia Velculescu, and Elif Arbatli, 2004, "Fertility Declines and Youth Dependency: Implications for the Global Economy," Brookings Working Paper in International Economics # 163. (Washington: Brookings Institution).

Börsch-Supan, Axel, Alexander Ludwig, and Joachim (2003), "Aging, Pension Reform, and Capital Flows: A Multi-Country Simulation Model," MEA Discussion Paper No. 28–30 (Mannheim, Germany:Mannheim Research Institute for the Economics of Aging).

Buiter, Willem, 1981, "Time Preference and International Lending and Borrowing in an Overlapping Generations Model," *Journal of Political Economy*, 89 August, pp769-797.

———, 1988 "Death, Birth Productivity Growth and Debt Neutrality," *Economic Journal*, 98 June. pp279-293.

Cutler David, James Poterba, Louise Sheiner and Lawence Summers, 1990, "An Aging Society: Challenge or Opportunity?" *Brookings Papers on Economic Activity*, 1: pp1-74.

Diamond, Peter, 1965, "National Debt in a Neoclassical Growth Model", *American Economic Review* 55, 1965, 1125-1150.

Endo, Yukihiko, and Eiji Katayama, 1998, "Population Aging and Japanese Economic Performance," in Bosworth, B. and Burtless, G. (eds), *Aging Societies: The Global Dimension*, Chapter 5, pp. 240–65. (Washington: The Brookings Institute Press).

Faruqee, Hamid, 2000a, "Population Aging and its Macroeconomic Implications," in *Japan: Selected Issues*, IMF Staff Country Report No.00/144. (Washington: International Monetary Fund).

———,2003a, "Debt, Deficits, and Age-Specific Mortality," *Review of Economic Dynamics*, Vol. 6 (2003), pp. 300–12.

———, 2003b, "Population Aging in Japan: Demographic Shock and Fiscal Sustainability," *Japan and the World Economy*, Vol. 15 (2003), pp. 185-210.

———, and Douglas Laxton, 2000, "Life Cycles, Dynasties, Saving: Implications for Closed and Small Open Economies," IMF Working Paper No. 00/126. (Washington: International Monetary Fund).

Faruqee, Hamid, Douglas Laxton, and Steve Symansky, 1997, "Government Debt, Life-Cycle Income and Liquidity Constraints: Beyond Approximate Ricardian Equivalence," *IMF Staff Papers*, 44 (September), pp. 374–82.

Guest Ross, and Ian McDonald, 2003, "The Effect of World Fertility Scenarios on International Living Standards," presented at the Conference of Economists conference,

Higgins, Matthew, and Jeffrey G. Williamson, 1997, "Age Structure Dynamics in Asia and Dependence on Foreign Capital," *Population and Development Review*, Vol. 23 (June), pp. 261–93.

Higgins, Matthew, 1998, "The Demographic Determinants of Savings, Investment, and International Capital Flows," *International Economic Review*, Vol. 39 (1998), pp. 343–69.

IMF, 2004, *World Economic Outlook*, September (Washington: International Monetary Fund).

INGENUE Team, 2001, "INGENUE: Une Modélisation Intergénérationnelle et Universelle" (Paris: Banque de France).No. 3, pp. 393–41.

Lee, Ronald D., 2003, "The Demographic Transition: Three Centuries of Fundamental Change," *Journal of Economic Perspectives*, Vol. 17 (Fall), pp. 167-90.

McKibbin, Warwick, 2005, "Global Demographic Change: Implications for Japan," paper presented at the paper presented at the 2005 ESRI Conference on the International Collaborations Project (February). (Tokyo: Japan).

McKibbin, Warwick, and Peter J. Wilcoxen, 1998, "The Theoretical and Empirical Structure of the G-Cubed Model," *Economic Modelling*, Vol. 16, No. 1, pp. 123–48, also available as Brookings Discussion Paper in International Economics No. 18 (Washington: Brookings Institute).

McKibbin, Warwick, and David Vines, 2003, "Change in Equity Risk Perceptions: Global Consequences and Policy Responses," Brookings Discussion Paper in International Economics No. 155 (Washington: Brookings Institute).

——— 2000, "Modelling Reality: The Need for Both Intertemporal Optimization and Stickiness in Models for Policymaking," *Oxford Review of Economic Policy*, Vol. 16, No 4.

McKibbin, Warwick and Jeremy Nguyen, 2004, "Modelling Global Demographic Change: Results for Japan," Lowy Institute for International Policy Working Paper No. 3/04, presented at the 2004 ESRI Conference on the International Collaborations Project, (Tokyo: Japan).

McKibbin, Warwick, David Pearce, and Alison Stegman, , 2004, "Long-Run Projections for Climate Change Scenarios," Lowy Institute for International Policy Working Paper No. 1/04.

Obstfeld Maurice, and Kenneth Rogoff, 1996, *Foundations of International Macroeconomics* (Cambridge, Massachusetts: MIT Press).

Ogawa, Naohiro, and Robert D. Retherford, 1993, "The Resumption of Fertility Decline in Japan, 1973-1992," *Population Development Review*, Vol. 19, No. 4, pp. 703–41.

Samuelson, Paul, 1958, "An Exact Consumption-Loan Model of Interest With or Without the Social Contrivance of Money", *Journal of Political Economy* 46, pp 467-482.

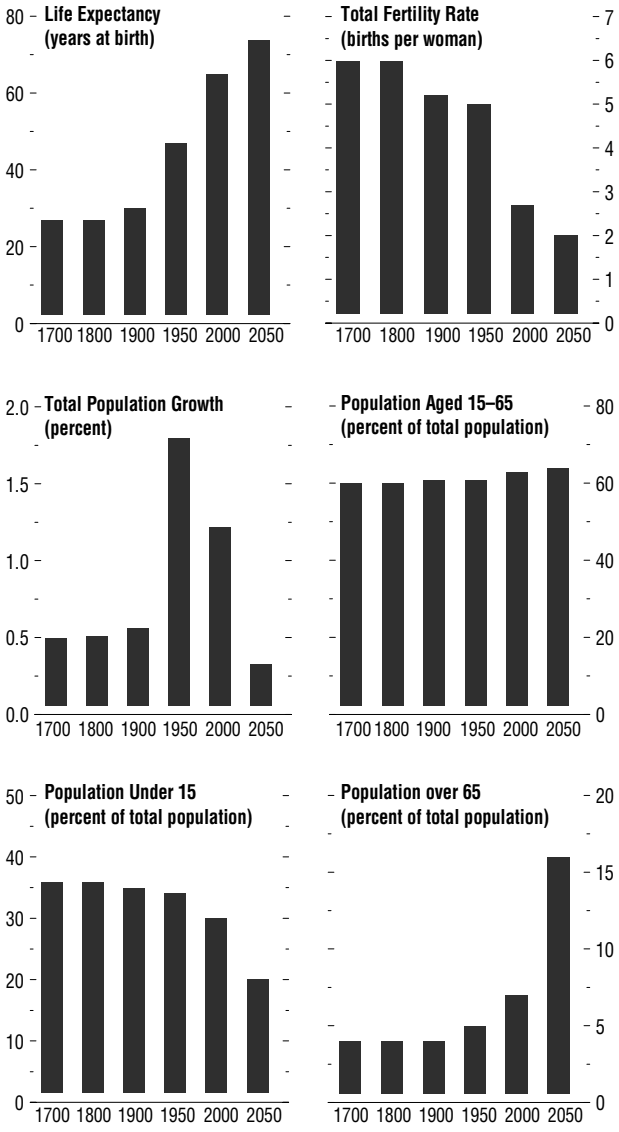
United Nations , 2004, "World Population Prospects: The 2004 Revision", Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, http://esa.un.org/unpp.

Weil, Philippe, 1989, "Overlapping Families of Infinitely-Lived Agents," *Journal of Public Economics* Vol. 38, pp. 183-98.

Yaari, Menahem E., 1965, "Uncertain Lifetime, Life Insurance, and the Theory of the Consumer," *Review of Economic Studies*, Vol. 32 (April), pp. 137-50.

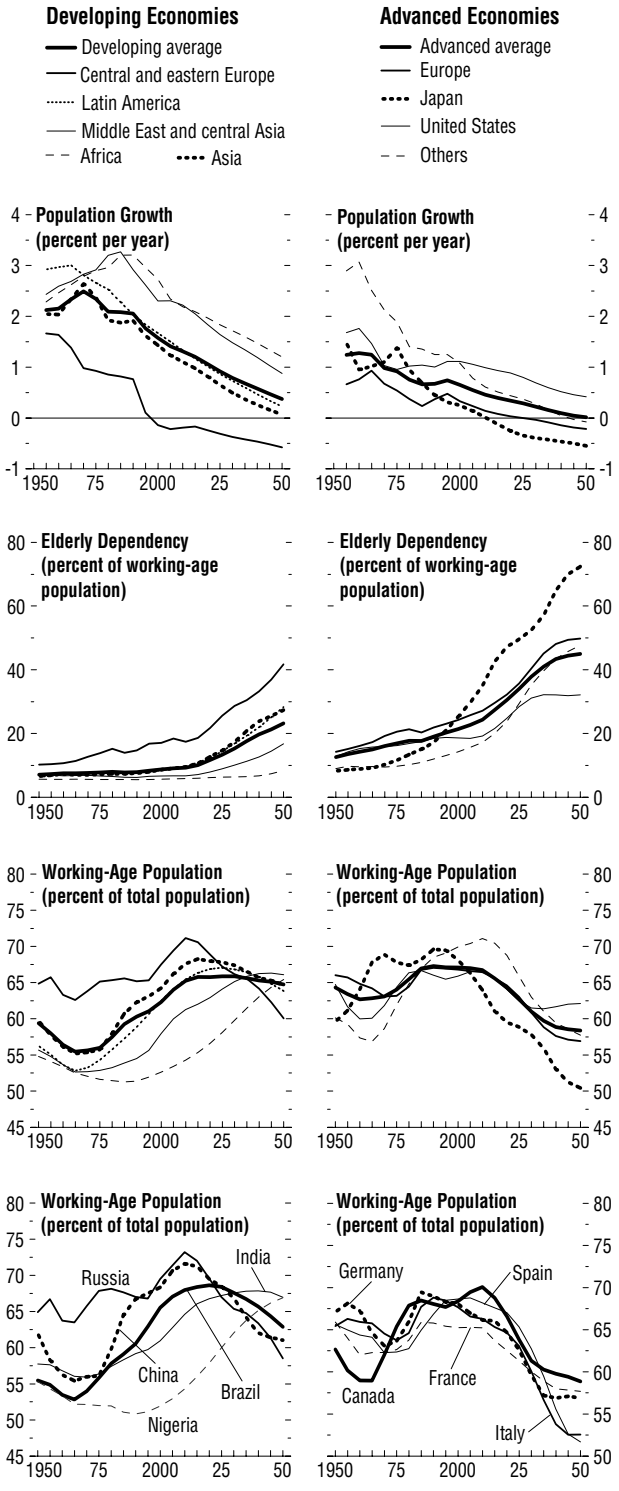
Yashiro, Naohiro, and Akiko Sato Oishi, 1997, "Population Aging and the Savings-Investment Balance in Japan," in: M.D. Hurd and N.Yashiro (eds.), *The Economic Effects of Aging in The United States and Japan*, (Chicago: University of Chicago Press).

Figure 1. Global Demographic Transition, 1700–2050



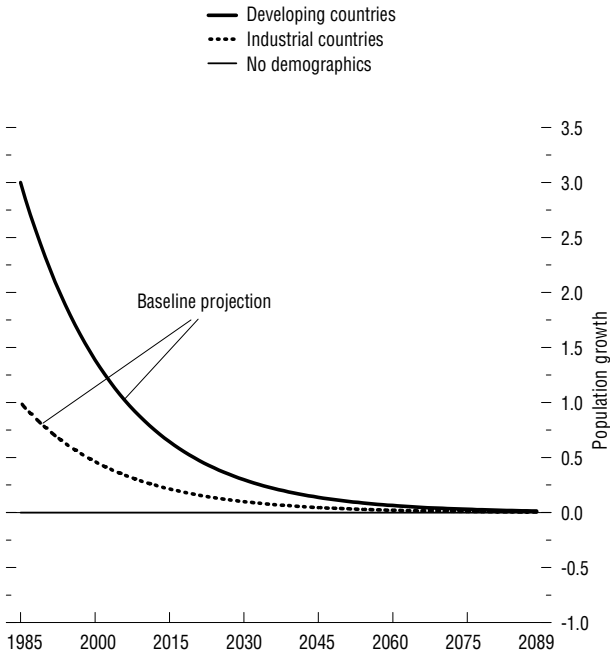
Source: Lee (2003).

Figure 2. Population Structure, 1950–2050



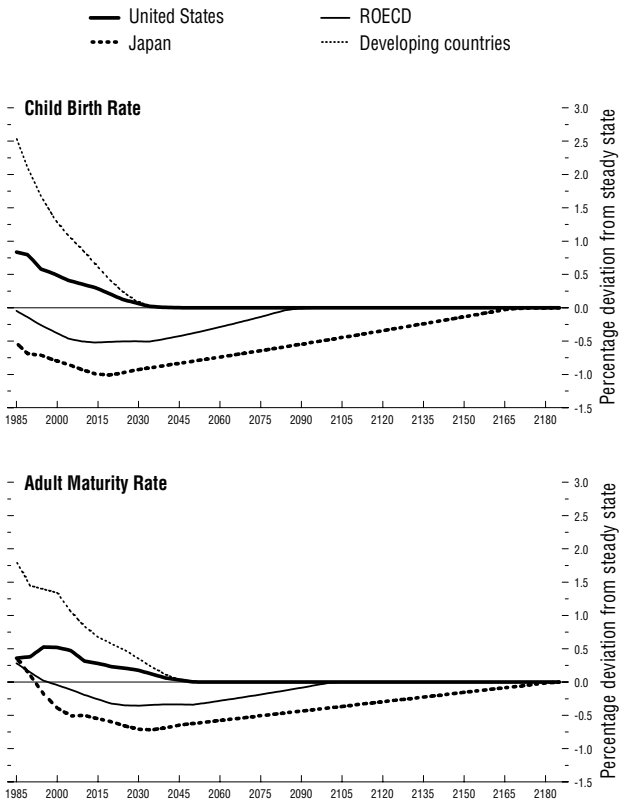
Source: United Nations, *World Population Prospects: The 2002 Revision* (2003).

Figure 3. Removing the Demographics (a Stylized Representation)



Sources: Authors' estimates

Figure 4. Child Birth and Adult Maturity Rate (Relative to Steady State)



Sources: Authors' estimates

Figure 5. Impact of Global Demographic Transition - 4 Region MSG3 Model

(Percent deviation from baseline unless otherwise noted)

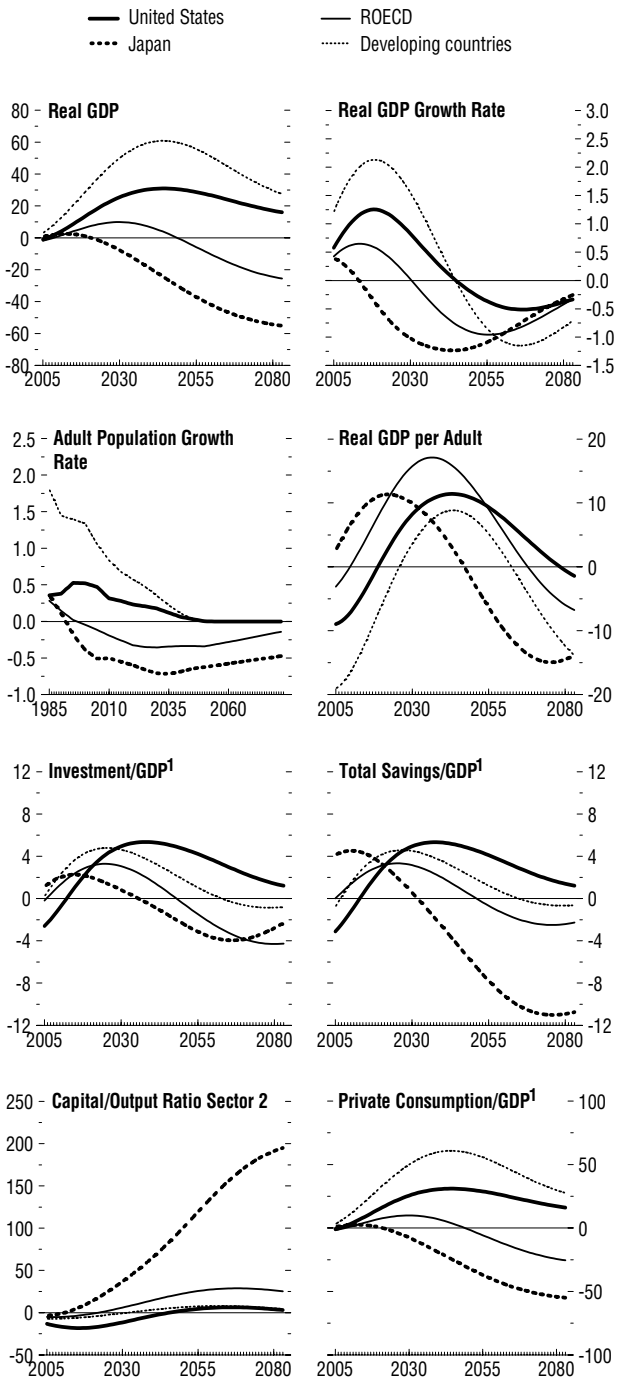
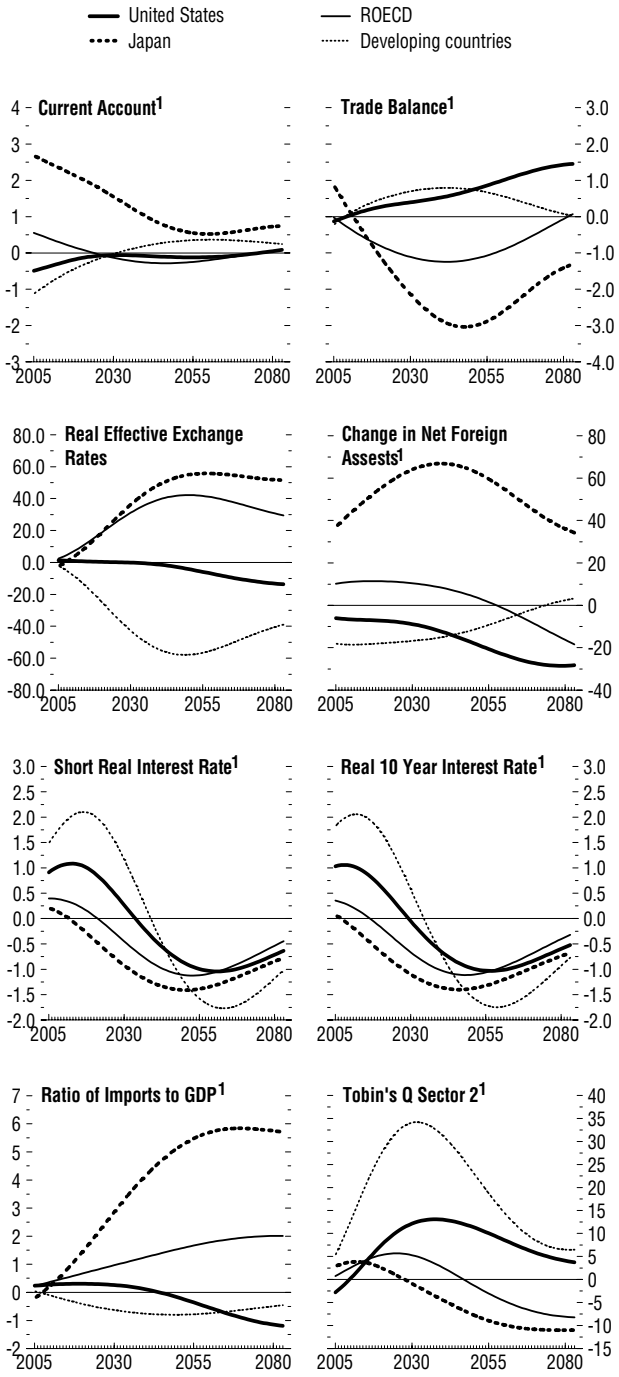


Figure 5. (concluded)



Source: Authors' estimates
[1]Percent point deviation from baseline.

Figure 6. Implications of 1% Faster Growth for 50 Years in Developing Countries - 4 Region MSG3 Model

(Percent deviation from baseline unless otherwise noted)

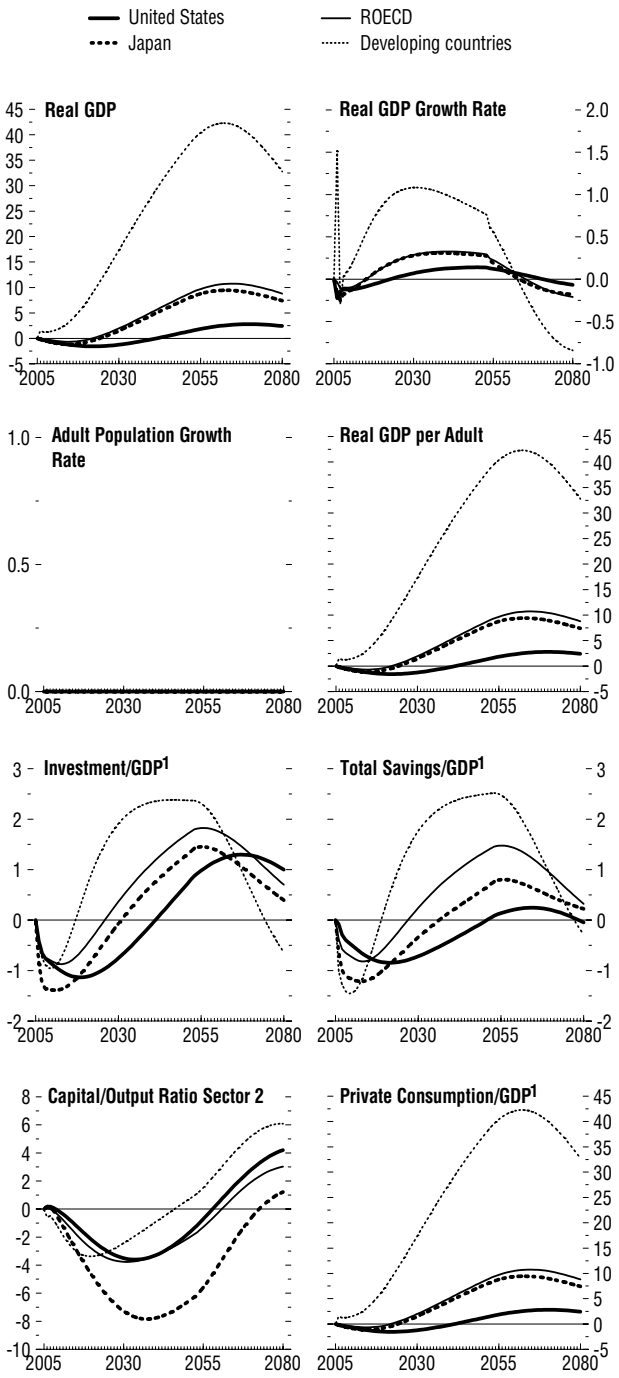
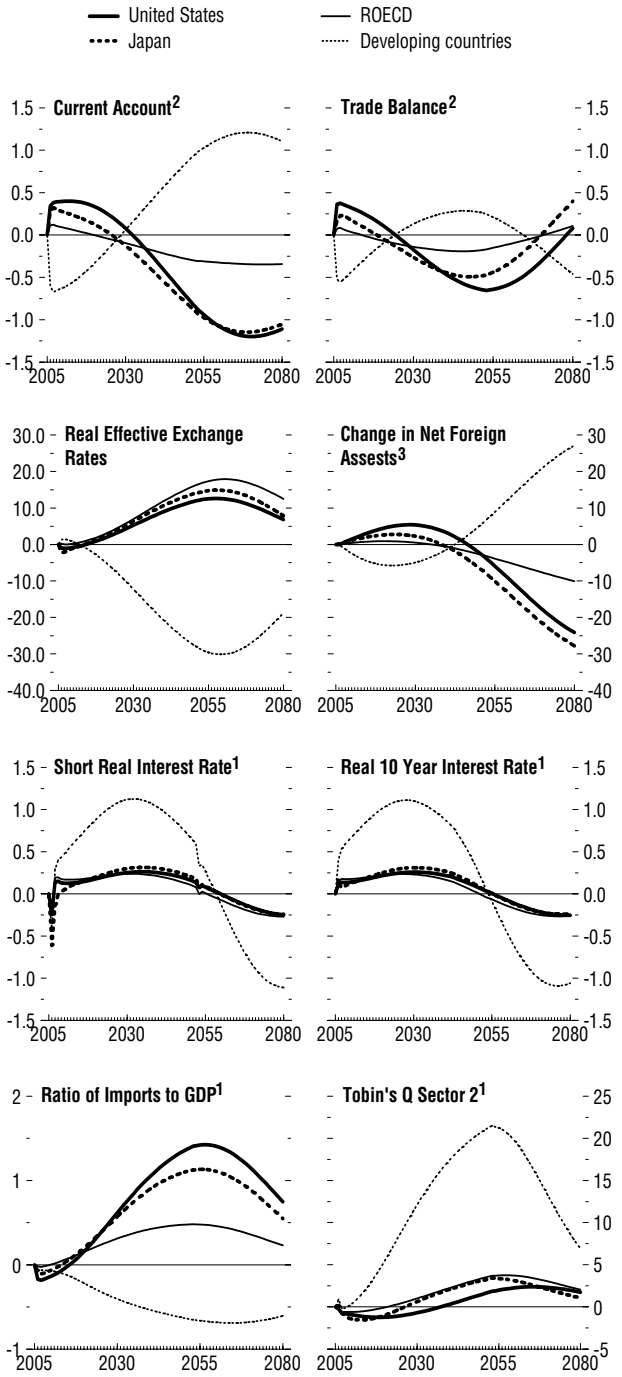


Figure 6. (concluded)



Source: Authors' estimates
[1]Percent point deviation from baseline.
[2]Change as percent of baseline GDP.
[3]Percent of baseline GDP.

Figure 7. Implications of 1% Point Decline in Developing Country Risk - 4 Region MSG3 Model

(Percent deviation from baseline unless otherwise noted)

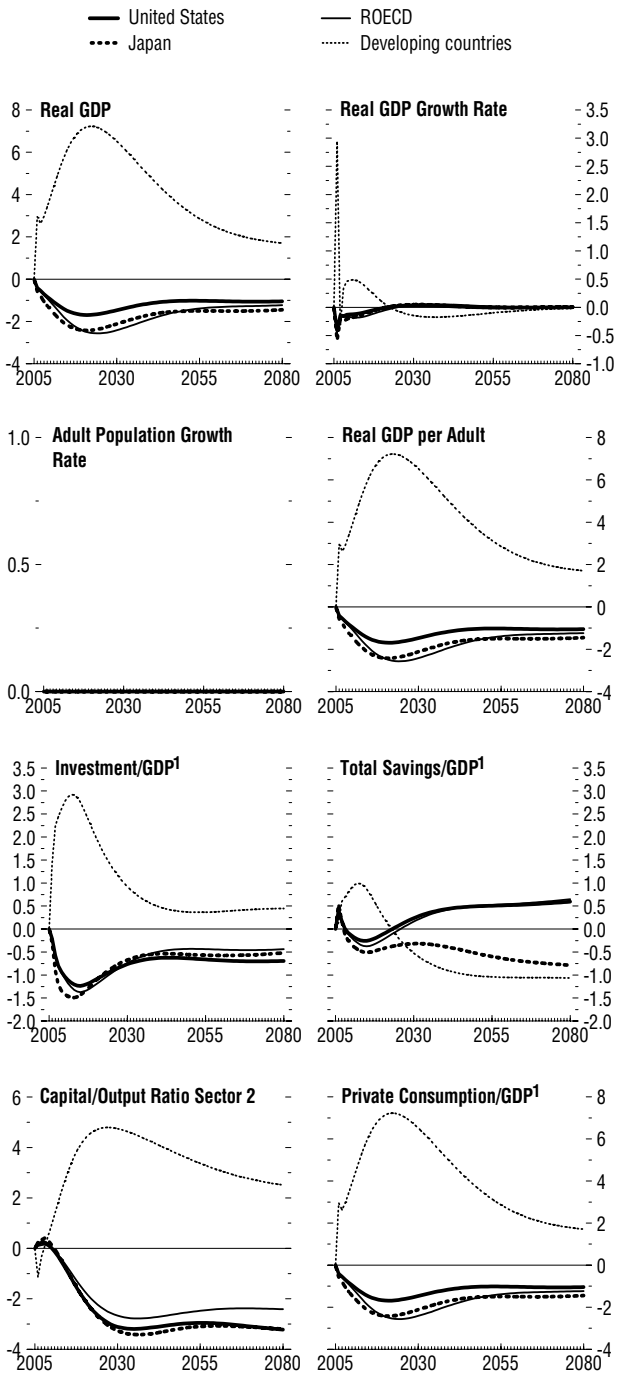
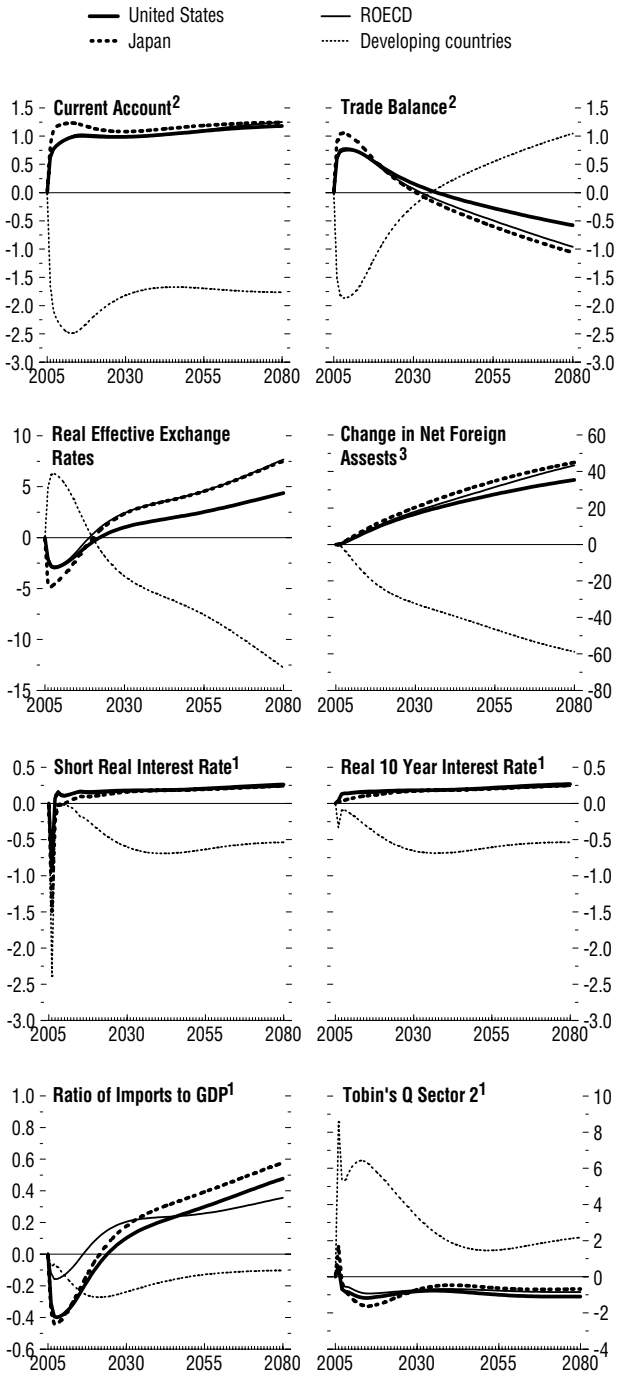


Figure 7. (concluded)



Source: Authors' estimates
[1]Percent point deviation from baseline.
[2]Change as percent of baseline GDP.
[3]Percent of baseline GDP.