DEMOGRAPHY AND FINANCIAL MARKETS

Australian Government

The Treasury

G-20

Reserve Bank of Australia

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Introduction

Christopher Kent, Anna Park and Daniel Rees

The world is in the midst of an unprecedented demographic transition. In developed and developing countries alike, populations are ageing as fertility rates decline and longevity increases. Together, these forces imply slower population growth and an increasing share of the elderly in the population, although the extent and speed of these changes will differ significantly across countries. Demographic change has many important implications for financial markets, including through its influence on labour supply, saving behaviour, capital accumulation, asset returns, international capital flows and the relative demand for different types of assets.

The likely magnitude, and even the direction, of these effects is the subject of considerable debate. Most prominent perhaps is the question of what might happen to asset prices. Some studies suggest that the attempts of large cohorts of retirees to sell their assets to smaller cohorts of workers will trigger an 'asset-price meltdown'. Other studies argue that these effects will be relatively minor.

Much of this debate centres on the validity of the life-cycle hypothesis (LCH), whereby people will tend to save a lot during their peak earning years and run down their savings during retirement. Hence, changes in the age distribution can influence aggregate saving. It is also important to account for the labour market effects of demographic change. In principle, a decline in fertility, by reducing the relative size of successive age cohorts, will reduce the supply of labour and raise the capital-labour ratio. On the other hand, rising longevity will encourage longer working lives (if retirement ages are flexible and health improves later in life), which by itself would push down the capital-labour ratio. However, longer lives are also likely to imply extra time spent in retirement. The need to fund these additional years in retirement will contribute to capital accumulation.[1] Combining these effects suggests that population ageing will lead to a (long-run) rise in the capital-labour ratio, raising wages and lowering returns to capital (and asset prices).[2]

Even so, the magnitude of this response will depend on a number of other factors. Parents who choose to leave bequests to their offspring might lower these either in response to fewer children or any tendency for rates of return to decline, which would work to keep the capital-labour ratio from rising. The openness of capital markets is also relevant. Capital flows from countries whose populations are relatively old can mitigate declines in returns to capital in these countries and boost wages in recipient countries with relatively young populations. There is also the practical concern of attempting to measure individuals' saving behaviour (including, for instance, accounting for the role of any public or corporate pensions they might have) and determining whether or not retirees, on average, draw down their savings.

1. This effect will be even larger to the extent that retirement ages are inflexible.
2. See Kulish, Smith and Kent (2006) for a more detailed discussion.

This discussion, however, does not directly address whether there is a need for policy-makers to respond to demographic change. The scope for this will depend on the existence of market failures preventing first-best outcomes. Such failures typically arise because of a lack of information or non-rational behaviour of individuals, but can also reflect the unintended consequences of existing policies.[3] Policy actions could take many forms, from the fairly unobtrusive – such as the collection and dissemination of information to help markets determine appropriate pricing for financial products – to the more interventionist – such as issuing public securities to create markets, or mandating individuals' participation in certain retirement income schemes.

This workshop, jointly hosted by the Australian Treasury and the Reserve Bank of Australia, continues the Group of Twenty's focus over recent years on demographic change.[4] Its aim was to bring together leading academic researchers in the field, financial market participants and policy advisors from the G-20 countries to consider questions relevant to demography and financial markets. What can theory and historical experience tell us about the impact of demographic change on financial markets? And what are the implications for policy-makers? This introduction summarises the papers presented at the workshop and the discussions that accompanied them.

Trends in Demography and their Economic Impacts

The first paper, presented by David Bloom (and co-authored by David Canning), summarises projected global demographic trends, analysing the role of greater longevity and declining fertility in driving population growth and ageing. Their main points are that the world's population will continue to grow, albeit at a slower rate, and that population ageing is a global phenomenon, but with considerable variation in its extent and timing across countries. Developed countries, where the process is well advanced, will experience negligible population growth and will see rapid increases in the number of retirees relative to working-age populations over the next few decades. In contrast, the populations of developing countries overall are still growing relatively rapidly and the share of their populations of

3. For a discussion of informational problems see Barr and Diamond (2006). Mitchell and Utkus (2003) provide a summary of the relevant behavioural economics literature, including evidence that individuals are far from the rational beings implied by many simple models.

4. The members of the G-20 are the Finance Ministers and Central Bank Governors of 19 countries: Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, Saudi Arabia, South Africa, South Korea, Turkey, the United Kingdom and the United States of America. The European Union is also a member, represented by the rotating Council Presidency and the European Central Bank. The Managing Director of the International Monetary Fund (IMF) and the President of the World Bank, plus the chairs of the International Monetary and Financial Committee and Development Committee of the IMF and World Bank, also participate in G-20 meetings on an *ex-officio* basis. Demography has already been a subject of several G-20 workshops. Under the German chair in 2004, the French Ministry of Finance hosted a workshop on demography and growth. Under the Chinese chair in 2005, the Australian Treasury and the Reserve Bank of Australia hosted a workshop on demographic challenges and migration.

working age will increase until roughly 2030. However, developing countries are also experiencing population ageing; it is not a phenomenon confined solely to the developed world.

The paper also considers some of the likely macroeconomic effects of changes in a population's rate of growth and age structure. The authors note that simplistic arguments that the demographic transition is purely good or bad for the economy have been replaced by more nuanced theories that stress the importance of policy and institutional environments. In particular, good health and education systems, effective labour-market institutions, trade openness and sensible retirement policies will all help to ensure that countries reap the benefits of demographic changes. Bloom and Canning also summarise the (still inconclusive) debate about whether there is a biological limit to longevity and what this might be, and outline some risks to the population projections they present. They conclude that although demographic trends have considerable momentum, they are still inherently uncertain, so policy-makers should design institutions that are robust to a range of demographic outcomes.

What Can Theory Tell Us?

Four papers examine the potential effects of population ageing by means of theoretical models. The first of these, by Henning Bohn, takes a close look at how demographic change will affect financial markets through its effect on capital intensity (that is, the capital-labour ratio). Bohn considers responses to population ageing using three different closed-economy models: a Solow-Swan growth model with a fixed saving rate; an overlapping generations (OLG) model with individuals maximising their own utility over their life-cycle; and a dynastic model in which individuals also value their children's utility. In the first two models, population ageing increases the capital intensity of the economy thereby pushing down the rate of return to capital. But in a dynastic setting, any tendency for the rate of return to decline would prompt parents to reduce bequests since they would be better off consuming extra wealth rather than passing it on to their children. This would ensure a relatively stable capital-labour ratio in the presence of demographic changes. Bohn argues that in many developing countries, the dynastic model will provide the better approximation of future patterns of saving and capital accumulation because public pension and other transfer systems in these countries are more rudimentary, and most wealth is concentrated in family-based firms where ownership tends to be inherited and not purchased. However, where financial markets make it possible for retirees to mobilise their accumulated wealth for consumption purposes relatively efficiently, the LCH appears to provide a reasonable guide to future saving patterns.

The three other theoretical papers presented use calibrated OLG models to examine the potential for international capital flows to moderate the effects of demographic change. Ralph Bryant's paper explores how macroeconomic variables, including international capital and trade flows as well as exchange rates, might evolve in response to differences in the demographic transition across two regions – the developed and developing economies. He constructs a two-economy OLG model in which capital gradually flows across international borders in response to differences in returns. Bryant shows that the effects of demographic change will depend on whether declining fertility or increasing longevity is the most significant cause of population ageing, and that the short-run effects of demographic change will differ from the long-run effects. In line with standard OLG results, Bryant posits a long-term rise in capital intensities globally (and hence a decline in returns to capital), but with differences across countries due to ageing occurring at different rates. An especially interesting outcome of this exercise relates to the size and direction of future capital flows. Bryant argues that the faster pace of ageing in developing countries will reduce the net capital flows (relative to output) from developed to developing countries (although he expects developed countries to remain capital exporters for the foreseeable future). This challenges the widely held view that savers in developed countries will be able to avoid lower rates of return due to population ageing by investing in developing economies. A key conclusion of his paper is that the size of required exchange rate adjustments (required to absorb the more rapidly growing output of developing economies) will depend inversely upon the extent of substitutability of goods across countries.

Axel Börsch-Supan takes a somewhat similar approach in examining the effect of population ageing on saving rates, asset returns and international capital flows, but focuses on the response of the three largest euro-area economies and considers the implications of reforms to pension schemes. In a world of mobile capital, these large European economies initially export capital (to the US and the rest of the OECD) as their relatively large working-age populations save to support themselves in retirement. But from 2020, as their older households run down their wealth, these countries begin to draw down on their foreign capital holdings. Capital mobility is shown to benefit capital-exporting countries – which receive higher returns – and capital-importing countries – which pay lower rates of interest on their borrowings. In this way, capital market openness helps to moderate the impact of demographic change on rates of return and asset prices. Börsch-Supan examines reforms that make pay-as-you-go (PAYG) pension schemes less generous, with a shift to some pre-funding of retirement incomes. Such reforms are shown to increase aggregate private saving rates, particularly in rapidly ageing countries, lower the return to capital (albeit modestly) and lead to increased labour supply and international capital outflows (to take advantage of higher returns abroad). The proposed reforms reduce the welfare of older generations (who, with fewer years of work until retirement, receive less benefit from the freeze in aggregate contribution rates to the PAYG system), but these losses are lower in a world of greater capital mobility.

The paper presented by Laurence Kotlikoff (co-authored with Hans Fehr and Sabine Jokisch) also considers the implications of ageing in a world of open capital markets, but with an interesting focus on the role of China. Absent China, their modelling work suggests that there will be a capital shortage in the developed economies (of the European Union, Japan and the US) predicated on the adverse effect on workers' capital accumulation of rising payroll and income tax rates, which are required to pay pensions and health care benefits to increasingly older populations. Including China makes a substantial difference to the predicted effects of demographic change on capital accumulation and asset returns in the ageing developed economies. Although China is initially predicted to attract capital in their model, the authors suggest that China will become a substantial capital exporter by 2030. This raises real wages and capital-labour ratios in the developed countries; in response, stock prices decline over this century but in a steady fashion and by a modest amount.

Kotlikoff *et al* are less optimistic about the implications of demographic change for the sustainability of public pension schemes. They find that population ageing will require substantial increases in social security tax rates in developed economies, absent changes in other parameters of the pension system. The situation is worse if population ageing is greater than projected. They suggest a promising alternative is for governments to privatise state pension systems (by eliminating any new public pension benefit accrual and establishing private retirement accounts). In their model, such a reform more than doubles long-run capital-labour ratios and raises real wages by roughly a quarter.

Historical Evidence of Links between Demography and Financial Markets

Two papers presented at the workshop examine historical evidence to test the basic implications of the LCH.

Robin Brooks conducts a fixed-effects panel regression analysis with data for 16 countries over 80 years or more to examine the relationship between demographic variables and the prices of, and returns to, a range of different financial market assets. While previous work of this type has typically focused on a limited number of cohorts, Brooks examines the effects of many age groups on financial markets. By looking at many countries over a very long period of time, his approach also attempts to minimise one of the major limitations of the empirical work in this area, namely, that countries have experienced only part of one baby-boom episode. The results based on all countries in the sample are consistent with the idea that middle-aged individuals in their peak earning (and saving) years have a relatively high demand for equities. However, there is evidence of substantial heterogeneity across countries in terms of the link between financial market prices and returns and demographic variables. Brooks concludes that demographic change will not necessarily have an adverse effect on financial asset prices and returns and that any such effects are likely to be small.

E Philip Davis' paper also investigates the historical relationship between ageing and overall asset demand. In addition, he considers the effects of ageing on the demand for different types of assets and the structure of the financial system. He argues that, in theory, older individuals are likely to save less and demand more bonds relative to equities, and notes that both price and quantity adjustments can be expected in financial markets. Using macroeconomic data from 72 countries over 1960–2002, Davis finds evidence that relatively large middle-aged cohorts have a strong positive effect on saving while relatively large older retired cohorts have a negative effect, consistent with Brooks' full sample results. Davis notes a switch in demand from equities into bonds as cohorts age, and that increases in the relative size of middle-aged and older cohorts have positive effects on the size of both the banking sector and the financial sector overall. Davis also considers the effects of ageing on cross-border flows. Consistent with Börsch-Supan and Kotlikoff *et al*, Davis suggests that capital is likely to flow initially from developed economies towards developing economies, and that flows will be reversed later when older cohorts in developed economies draw down their wealth in retirement and the share of middle-aged cohorts in developing economies rises.

Financial Markets and Age-related Risks

An ageing global population, and the trend towards greater reliance on private funding arrangements for retirement incomes, has seen a transfer of ageing-related risks to households. Against this background, the paper presented by Olivia Mitchell and John Piggott (co-authored with Michael Sherris and Shaun Yow) surveys financial products which might enhance old-age risk management. The main focus is on annuity products (which provide insurance against out-living wealth in retirement), insurance against long-term care costs, and financial products suited to managing the risks associated with the process of decumulating wealth in retirement (such as reverse mortgages and inflation-indexed bonds). The authors highlight that these types of markets are thin or missing in many countries. To take annuity markets as an example, they suggest that this may reflect limited demand (due to myopic consumers), and limited supply in the presence of uncertainties about future mortality trends and information asymmetries leading to moral hazard and adverse selection. While these problems may be partially addressed by innovations in institutional products, as described in the paper, Mitchell *et al* suggest that policy-makers (both national governments and supra-national organisations) could take a more proactive stance in supporting the development of markets and products required to manage old-age risks. This might require them to identify, develop and regulate these markets, possibly in partnership with private firms. Given the problems associated with small national markets, they emphasise that supra-national institutions may be better placed to issue instruments such as longevity bonds or to oversee global markets for products such as annuities. These supra-national organisations are also well placed to co-ordinate the compilation and dissemination of data useful for the pricing of risks, such as accurate mortality tables and data on the incidence of long-term care for the elderly.

Drawing on extensive work done at the International Monetary Fund, the paper presented by Todd Groome (co-authored with Nicolas Blancher, Parmeshwar Ramlogan and Oksana Khadarina) describes existing policies to address the financial challenges of population ageing, including changes in the regulation of pension funds and education programs to improve the financial literacy of households. Like Mitchell *et al*, the paper notes that financial instruments to manage the risks associated with population ageing, and their related markets, remain underdeveloped or non-existent. Long-term and inflation-indexed bond markets are shallow in many countries, and a lack of publicly traded benchmarks, tax disincentives and the strong liquidity of corporate balance sheets have discouraged private issuance of such instruments.

The paper focuses on three areas where policy intervention might be especially productive. First, governments could encourage the private sector to address incomplete markets, offering tax incentives for the development of new products, providing more timely and reliable data on longevity and house prices to facilitate the creation of appropriate hedging instruments, and introducing mandatory risk pooling, possibly through compulsory annuitisation of retirement savings. Second, governments could act as an 'insurer of last resort' by assuming some risks directly. Third, governments could help households to manage age-related risks by developing improved statistical tools to identify at-risk groups, encouraging risk-sharing through multi-pillar pension systems, and simplifying tax and regulatory regimes.

Conclusions

On the question of the effect of demographic change on financial markets, much of the debate centred on the validity of the LCH and testing its implications. While mindful of the role of bequests, the LCH still appears to be a useful characterisation of behaviour in many economies, with the implication that globally, capital-labour ratios will tend to rise in response to population ageing. This is consistent with what appear to be plausible, measurable effects of demographic variables on asset prices and returns, although the evidence available suggests that any decline in asset prices and returns in response to population ageing will be relatively small.

On the role for policy in responding to ageing pressures, it was agreed that, with countries ageing at different speeds, cross-border capital flows can play an important role in helping to ameliorate the impact of ageing. The magnitude of the flows required may well be unprecedented, emphasising the importance of existing G-20 initiatives in supporting the development of both open and well-functioning capital markets. Even so, greater capital mobility alone will not be sufficient, in part because ageing is a global phenomenon. In this context, there was also considerable discussion of the role of housing, which constitutes a large share of individual wealth and bequests in many countries, and is an asset which is not readily tradeable across borders.

It was also widely accepted that governments should encourage longer working lives as an important part of the adjustment to rising longevity. Maintaining flexibility with respect to ages for pension eligibility will help to make both public and corporate retirement schemes more resilient to demographic shocks. But again, this will not be sufficient in itself.

Efficient and stable financial markets will also have a significant role to play in managing the adjustment to population ageing. With recent reforms to retirement income systems in many countries transferring responsibility for managing ageing-related risks from corporations and governments to individual households, policy-makers may have an important role to play in helping the development of financial markets and assisting households to manage their retirement risks.

Where supply constraints are limiting the development of particular financial markets, policy-makers might consider: improving the provision of information, for example, data on mortality and house prices required to support the development of longevity bond and reverse mortgage markets; ensuring there are no unnecessary regulatory or tax impediments to the development of these markets; and, more controversially, public issuance of some of the instruments that private markets have failed to provide, to ‘make’ the market, or at least provide useful benchmarks. On this possibility, participants cautioned that there would be a need to manage the associated public sector risks carefully and ensure that any funds raised were put to efficient use.

There also appears to be scope for policy to assist individuals to plan for and manage retirement adequately. Individuals frequently suffer from a lack of understanding of complex markets and retirement arrangements, and may not always be sufficiently forward-looking, nor well-informed of the risks they face. It seems reasonable to think that there is a role for education in this regard. However, some participants thought that this would be much more effective if combined with efforts to simplify what have typically become very complex tax and regulatory arrangements for retirement incomes. Some emphasised the importance of reducing the risks individuals face by maintaining a mixture of public and private income provision for retirement, especially in light of large and persistent swings in asset markets that history suggests will occur occasionally, for reasons unrelated to demographic change. Others highlighted the fact that governments frequently use mandatory requirements and (tax) incentives to encourage prudent behaviour.

Finally, an issue that was touched on during the workshop, and is likely to warrant more attention in the future, is whether markets allocate and manage people’s savings efficiently. An important aspect of this – particularly in light of the trend towards private pre-funding arrangements for retirement incomes – is the efficient provision of administrative and management services. Efforts to encourage economies of scale in administration and enhance competition between fund managers may help.

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Opening Remarks

Glenn Stevens

On behalf of the Reserve Bank of Australia and on behalf of Martin Parkinson, my colleague from the Australian Treasury, I'd like to welcome you all to this G-20 Workshop on Demography and Financial Markets.

This is the third of three G-20 workshops for the year. We've had one very ably hosted by our Japanese colleagues in Tokyo early in the year on the Bretton Woods reform, and one hosted in Banff a month or so back by our Canadian colleagues – I note that the Sydney winter weather is rather akin to the summer Canadian weather. The demographic theme continues quite a long thread of work within the G-20, stretching back over several years now to the German chair who introduced this in 2004. It was continued last year under the chairmanship of our Chinese colleagues and we are seeking to add to the stock of knowledge by trying to introduce a financial market theme to the demographic issue this year.

Our feeling is that while there has been a lot of discussion on the fiscal impacts of population ageing, and a lot of discussion on things like immigration and its role, great or small, in confronting the problems of ageing, there will also be financial market counterparts that ought to be explored. So that's what we'd like to do at this workshop. I think the G-20 – given its composition of 19 countries plus the EU and the International Financial Institutions, and the seniority of representation that's available at the higher-level meetings – is a key group in trying to address some of these problems and issues which are common to many countries. For today and tomorrow I'd identify four key sets of questions that I think we ought to address if we can.

The first of those is: what will be the effect of demographic change on saving and investment patterns and on rates of return as private agents and governments respond to this phenomenon? How much do we know about this from theory and history and how do we find out more if we don't know enough? That's the first set of questions.

The second set of questions is: how will all of that be affected by international capital mobility, given that all countries face demographic change but at different times and at different speeds? To what extent is it plausible to think that capital flows across borders will assist in addressing the issues that come with demographic change?

Thirdly, are there existing market mechanisms which will allow private agents to manage the risks that they face appropriately – assuming, that is, that they recognise the risks that they face? I am mindful here that in many countries risks that are associated with longevity are increasingly being transferred to households and away from large corporations, who once upon a time took on those risks through defined-benefit pension plans. So the question I think is whether market mechanisms exist to help those households, or to allow them to manage those risks, or whether it is the case that there are missing markets and missing instruments. If there are market failures, what useful role could public policy play in addressing these problems of market incompleteness? And if the policy response involves governments taking on certain risks themselves, how will they go about managing those risks?

A fourth set of issues that I think will probably be increasingly important over time relates to the question of what resource cost is being incurred in the management of people's savings. That is, just how efficient is the intermediation process? Are the fees being charged by the intermediaries, the fund managers and so on, good value for money or not, and are there any public policy implications that come from that?

To my mind these questions are certainly important ones. Hopefully we can address them during the next day and a half. It's not necessarily an exhaustive list and no doubt there are other questions which will arise.

What we are seeking to do is address these and other questions in a way that ultimately will allow us to shape a useful discussion of demography and financial markets at the next G-20 Deputies meeting in October and ultimately shape a good discussion for our Ministers and Governors when they meet in Melbourne in November. I think it is key to keep in mind that we are seeking to shape useful discussions for policy-makers, not just to have an academic debate. As interesting and important as that would be, we're going to be trying to extract from our discussions some useful themes that policy-makers will be able to take up and perhaps do something about when they meet.

That's all I would like to say before I hand over to Chris to chair the first session. Martin, anything you'd like to add?

Martin Parkinson

Colleagues, let me join with Glenn in welcoming you to Sydney. I'm not going to say anything more now. I'll speak during the course of the sessions but I hope that we're all able to leave here tomorrow feeling that we have actually helped to better define some of the key policy challenges in front of us and, if we can do that, then I think we will have made a good contribution. Good luck, thanks.

Global Demography: Fact, Force and Future

David E Bloom and David Canning[1]

Abstract

In the past 50 years, the world accelerated its transition out of long-term demographic stability. As infant and child mortality rates fell, populations began to soar. In most countries, this growth led to falling fertility rates. Although fertility has fallen, the population continues to increase because of population momentum; it will eventually level off. In the meantime, demographic change has created a 'bulge' generation, which today appears in many countries as a large working-age population. This cohort will eventually become a large elderly population, in both developed and developing countries. Population growth has been the subject of great debate among economists and demographers. Until recently, most have agreed on a middle ground, in which population growth *per se* has no effect on economic growth. New evidence suggests that changes in the age structure of populations – in particular, a rising ratio of working-age to non-working-age individuals – leads to the possibility of more rapid economic growth, via both accounting and behavioural effects. The experiences of east Asia, Ireland and sub-Saharan Africa all serve as evidence of the effect of demographic change on economic growth (or lack thereof). Both internal migration (from rural to urban areas) and international migration complicate this picture. The overall implications of population growth for policy lie in the imperative for investments in health and education, and for sound policies related to labour, trade and retirement. Understanding future trends is essential for the development of good policy. Demographic projections can be quite reliable, but huge uncertainties – in the realms of health, changes in human life span, scientific advances, migration, global warming and wars – make overall predictions extremely uncertain.

1. David E Bloom is Professor of Economics and Demography at the Harvard School of Public Health (dbloom@hsph.harvard.edu). David Canning is Professor of Economics and International Health at the Harvard School of Public Health (dcanning@hsph.harvard.edu). The authors thank the John D. and Catherine T. MacArthur Foundation, the William and Flora Hewlett Foundation and the National Institute of Aging for supporting much of the research on which this paper is based. The authors also thank Larry Rosenberg for his assistance with this work.

1. Introduction[2]

For much of human history, demographic patterns were reasonably stable; human populations grew slowly, and the age structures, birth rates, and death rates of populations changed only gradually. Epidemics and pandemics had huge effects on populations, but these effects were short-lived and had little bearing on long-term trends.

In the past 50 years, however, this trend of long-term stability has given way to the biggest demographic upheaval in history, an upheaval that is still running its course. In the developed world, a sharp post-war rise in fertility was followed by an equally sharp fall. These changes in fertility transformed age structures through the creation of a 'baby boom' generation. The ageing of this generation and continued declines in fertility and old-age mortality are shifting the population balance in developed countries from young to old. In the meantime, the developing world has experienced a population explosion, the result of improved nutrition, public health infrastructure and medical care.

Even if high fertility – the main underlying cause of rapid population growth – were to suddenly adjust to the long-run replacement level of 2.1 children per woman, humanity would continue to experience demographic change for some time. The rapid increase in the global population over the past few decades has resulted in large numbers of people of childbearing age. This creates 'population momentum', in which the populations of most countries, even those with falling birth rates, will grow for many years to come. This is particularly true of developing countries.

Population changes have potentially huge implications for the pace and progress of economic development. For example, an increasing proportion of elderly may act as a drag on economic growth where smaller working populations must provide for a larger number of non-working dependents. Rising life expectancy can also bolster an economy by creating a greater incentive to save and to invest in education, thereby boosting the financial capital on which investors draw and the human capital that strengthens economies. Where a country has experienced a baby boom followed by a decline in fertility, the relative size of the workforce is increased. Countries that are able to absorb the baby boom generation into productive employment can experience a rapid increase in economic growth. Countries unable to take advantage of this opportunity run the risk of creating large, chronically underemployed and increasingly restive working-age populations.

2. Notes on sources used, United Nations projections and definitions of demographic indicators appear in Appendix A.

2. Global Demographic Trends and Patterns

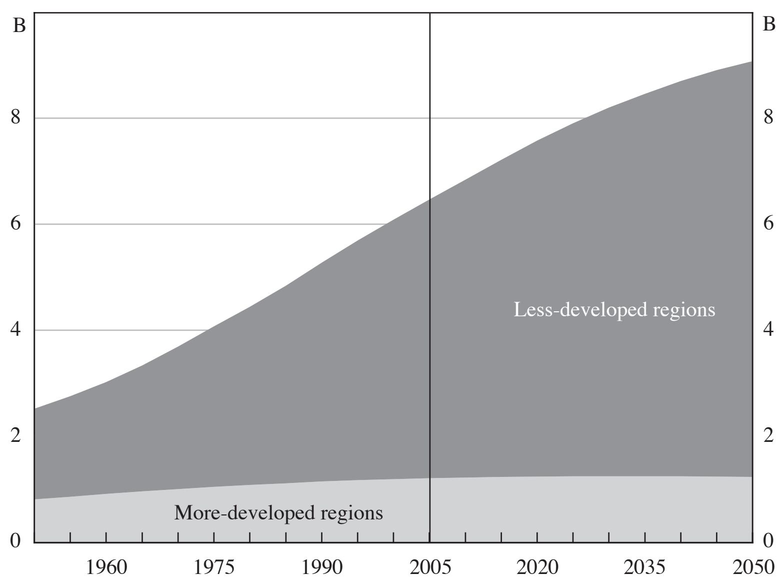
The global population, which stood at just over 2 billion in 1950, is 6.5 billion today. The world is currently gaining new inhabitants at a rate of 76 million people a year (representing the difference, in 2005, between 134 million births and 58 million deaths). Although this growth is slowing, middle-ground projections suggest the world will have 9.1 billion inhabitants by 2050, when growth will be approximately 34 million a year.

These past and projected additions to world population have been, and will increasingly be, distributed unevenly across the world. Today, 95 per cent of population growth occurs in developing countries (see Figure 1). The population of the world's 50 least-developed countries is expected to more than double by the middle of this century, with several poor countries tripling their population over the period. By contrast, the population of the developed world is expected to remain steady at around 1.2 billion, with population declines in some wealthy countries.

The disparity in population growth between developed and developing countries reflects the existence of considerable heterogeneity in birth, death and migration processes, both over time and across national populations, races and ethnic groups. The disparity has coincided with changes in the age-group composition of populations. An overview of these factors illuminates the mechanisms of global population growth and change.

Figure 1: World Population

Number of people



Note: Data after 2005 are based on projections.

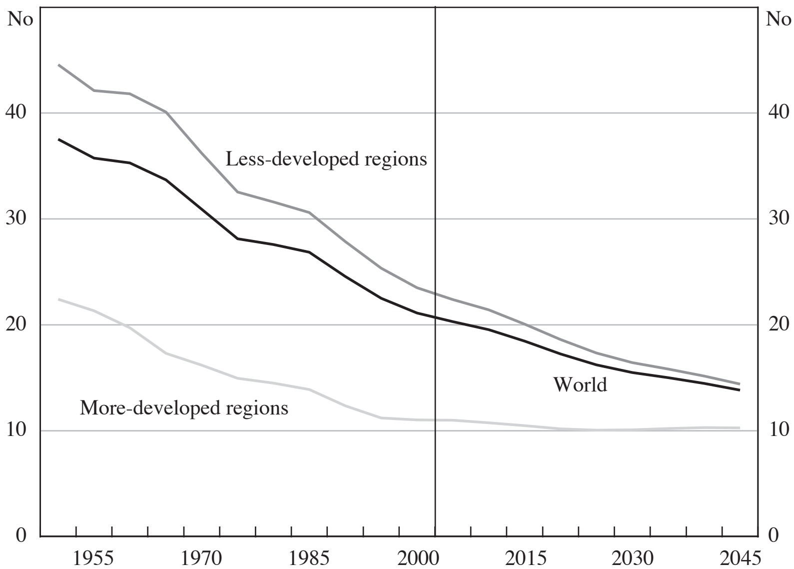
Source: UN Population Division (2005)

2.1 Crude birth and death rates

One of the simplest ways to consider population growth is through crude birth and death rates. These are the number of births and deaths per 1 000 people. On a worldwide basis, the difference between these rates is the rate of population growth. Within regions or countries, population growth is also affected by emigration and immigration. Figure 2 shows that in both developed and developing regions the crude birth rate has decreased by about half over the past 50 years. This implies a much greater absolute reduction in developing regions. The net result of these reductions is a current crude birth rate in developing regions that is similar to that of the developed regions 50 years ago.

Figure 2: Crude Birth Rate

Births per 1 000 population



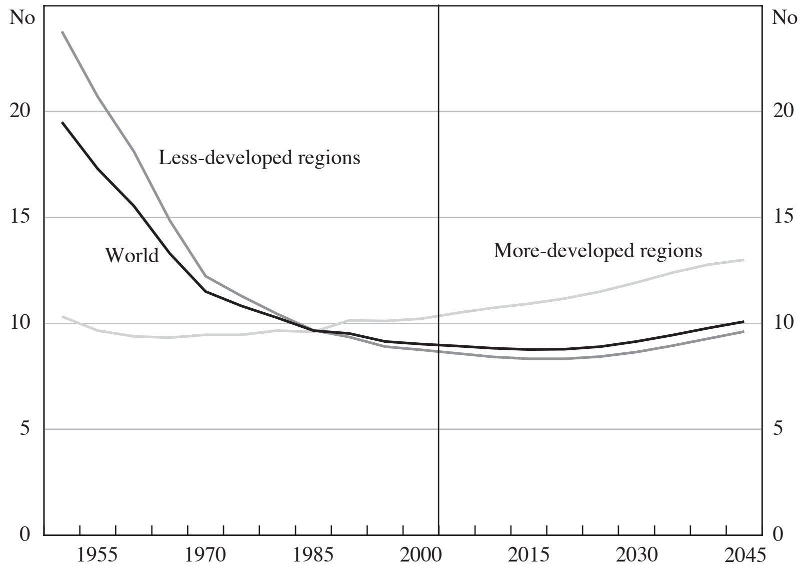
Notes: Dates refer to the beginning of the 5-year window. Data after 2005 are based on projections.

Source: UN Population Division (2005)

As Figure 3 shows, crude death rates follow a different pattern. The reduction in mortality in developing countries since 1950 has been very rapid – so rapid that the crude death rate in developing countries is now lower than in developed countries. The gradual rise in the crude death rate in developed countries results from the combination of relatively steady infant and child mortality rates and rising death rates due to an ageing population. The figure indicates that a similar rise in the death rate will begin in developing countries in a couple of decades.

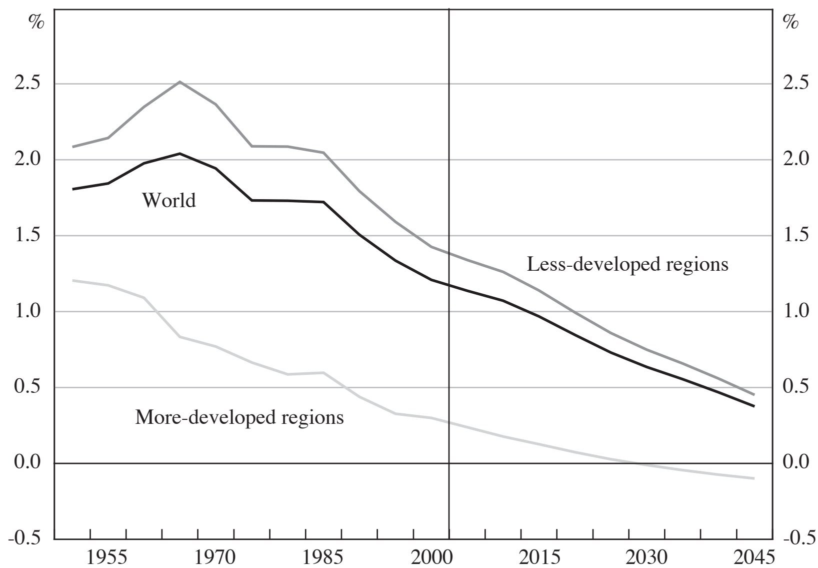
Figure 4 demonstrates the combined effect of crude birth and death rates on population growth rates, as modified by migration (primarily from developing to developed regions).

Figure 3: Crude Death Rate
Deaths per 1 000 population



Notes: Dates refer to the beginning of the 5-year window. Data after 2005 are based on projections.
Source: UN Population Division (2005)

Figure 4: Population Growth Rate
Average annual



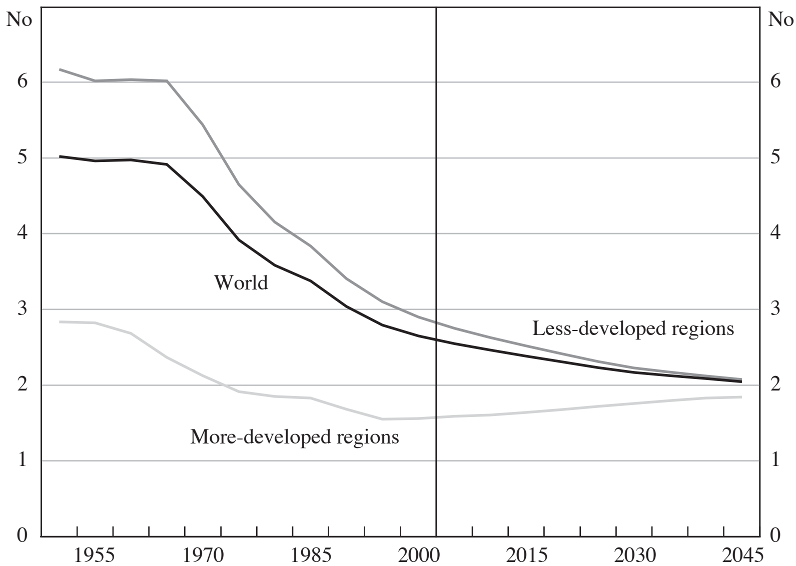
Notes: Dates refer to the beginning of the 5-year window. Data after 2005 are based on projections.
Source: UN Population Division (2005)

2.2 Total fertility rate

The total fertility rate, that is the number of children born per woman, fell from about 5 in 1950 to a little over 2.5 in 2005 (see Figure 5). This number is projected to fall to about 2 by 2050. This decrease is attributable largely to changes in fertility in the developing world. In 1950, the total fertility rate among developed countries was already below 3 children per woman; the rate among developing countries was over 6. Fertility in the latter is now below 3 children per woman. The fertility decline in low-income countries can be ascribed to a number of factors, including declines in infant mortality rates, greater levels of female education and increased labour market opportunities for women, and the provision of family planning services.

Figure 5: Total Fertility Rate

Children born per woman



Notes: Dates refer to the beginning of the 5-year window. Data after 2005 are based on projections.

Source: UN Population Division (2005)

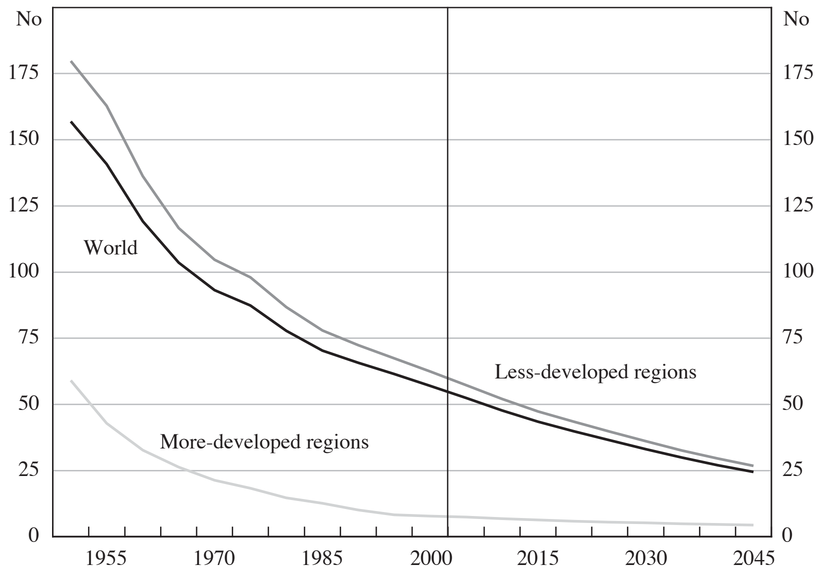
2.3 Infant and child mortality decline

The developing world has seen significant reductions in infant and child mortality over the past 50 years (see Figure 6). Infant mortality (death prior to age 1) in developing countries has dropped from 180 to about 57 deaths per 1 000 live births. It is projected to decline further to fewer than 30 deaths per 1 000 live births by 2050. The past half-century's gains resulted primarily from improved nutrition, public health interventions related to water and sanitation, and medical advances such as the use of vaccines and antibiotics. Infant mortality rates in the developed world have been, and will continue to be, significantly lower than those in the developing world. Developed countries have seen infant mortality decline from 59 to 7 deaths per 1 000 live births since 1950, and this is projected to decline further still, to 4 by 2050. Child mortality (death prior to age 5) has also fallen, in both developed and developing countries.

Figure 7 addresses a widely discussed issue relevant to infant and child mortality: 'missing women'. Perhaps because of the selective abortion of female foetuses or because of female infanticide, there is a severe exaggeration in a few countries of the usual pattern of boys aged 0–4 outnumbering young girls of the same ages.

Figure 6: Infant Mortality Rate

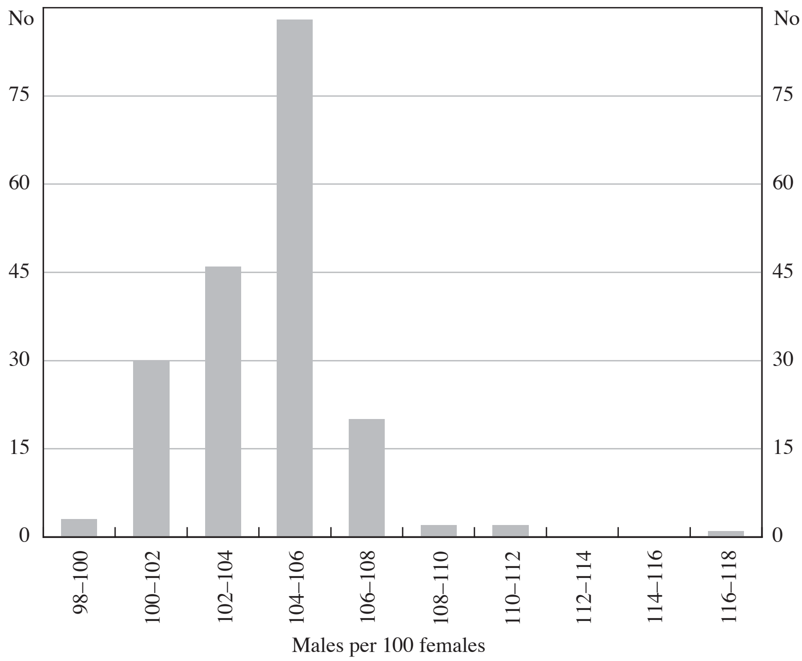
Deaths per 1 000 live births



Notes: Dates refer to the beginning of the 5-year window. Data after 2005 are based on projections.

Source: UN Population Division (2005)

Figure 7: Number of Countries in which Males per 100 Females is in a Given Range, Age 0–4
2005

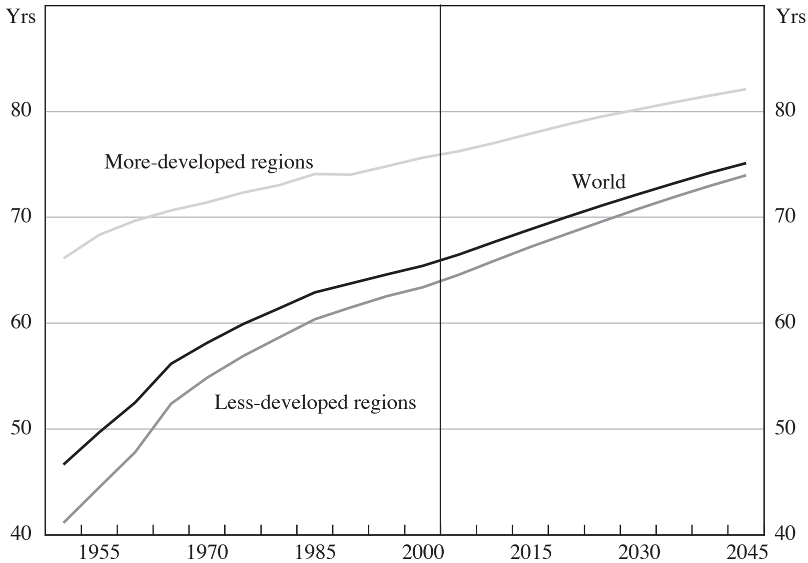


Source: UN Population Division (2005)

2.4 Life expectancy and longevity

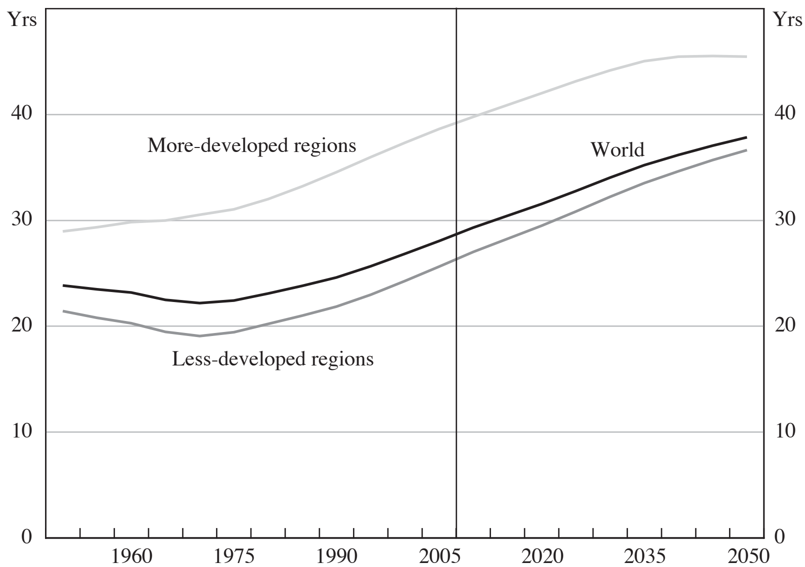
For the world as a whole, life expectancy increased from 47 years in 1950–1955 to 65 years in 2000–2005. It is projected to rise to 75 years by the middle of this century, with considerable disparities between the wealthy developed countries, at 82 years, and the less-developed countries, at 74 years (see Figure 8). As a result of the global decline in fertility, and because people are living longer, median age is rising (see Figure 9). The proportion of the elderly in the total population is rising sharply. The number of people over the age of 60, currently around half the number of those aged 15–24, is expected to reach 1 billion (overtaking the 15–24 age group) by 2020. It is projected to reach almost 2 billion by 2050. The proportion of individuals aged 80 or over is projected to rise from 1 per cent to 4 per cent of the global population by 2050. (Figure 10 shows the history and projections for the actual number of individuals aged 80 or above.) Population ageing is occurring in both developed and developing countries, although more rapidly in the former. In the developed world, the proportion of people aged 60 or over will increase from 20 to 32 per cent by 2050. In the developing world, it will rise from 8 to 20 per cent. There are gender differences in life expectancy. Figure 11 shows that life expectancy for women tends to be around 4 to 6 years longer than for men, although there is considerable variation across countries.

Figure 8: Life Expectancy



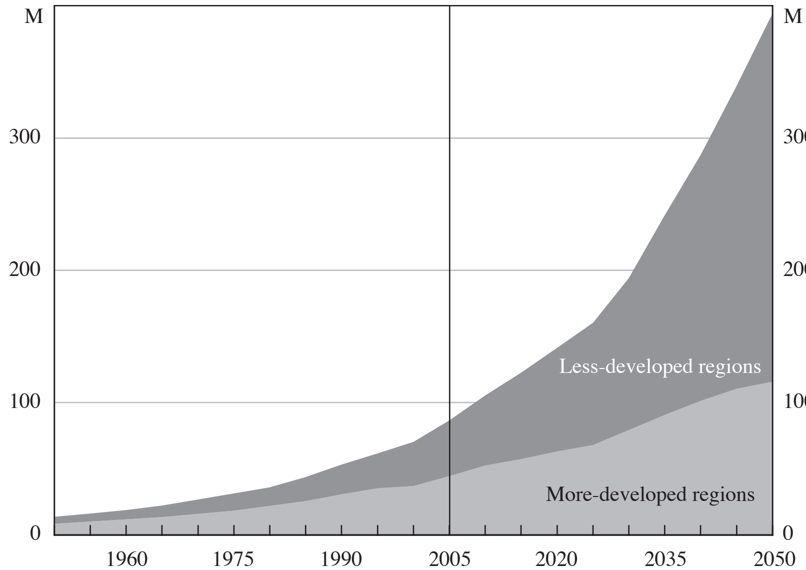
Notes: Dates refer to the beginning of the 5-year window. Data after 2005 are based on projections.
Source: UN Population Division (2005)

Figure 9: Median Age



Note: Data after 2005 are based on projections.
Source: UN Population Division (2005)

Figure 10: Number of People Aged 80 or Above

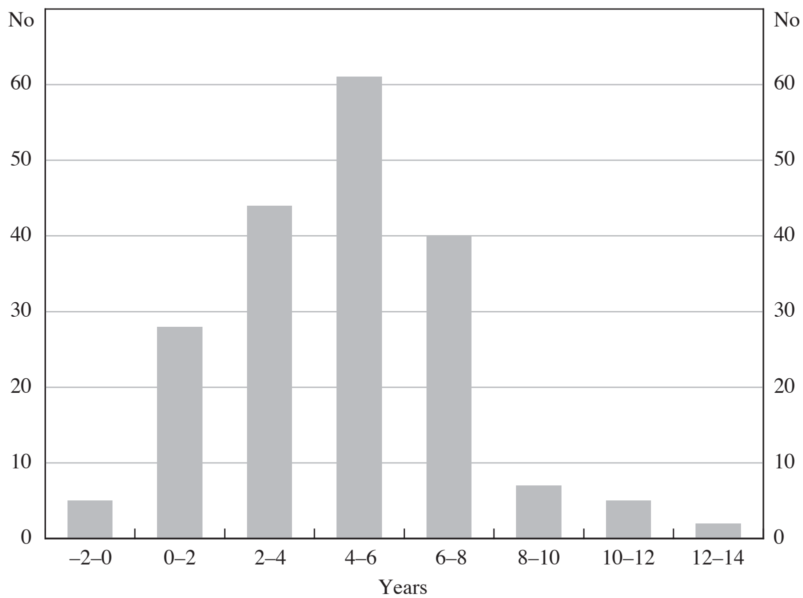


Note: Data after 2005 are based on projections.

Source: UN Population Division (2005)

Figure 11: Number of Countries in which Female Longevity Exceeds that of Males by a Given Range of Years

2000–2005



Source: UN Population Division (2005)

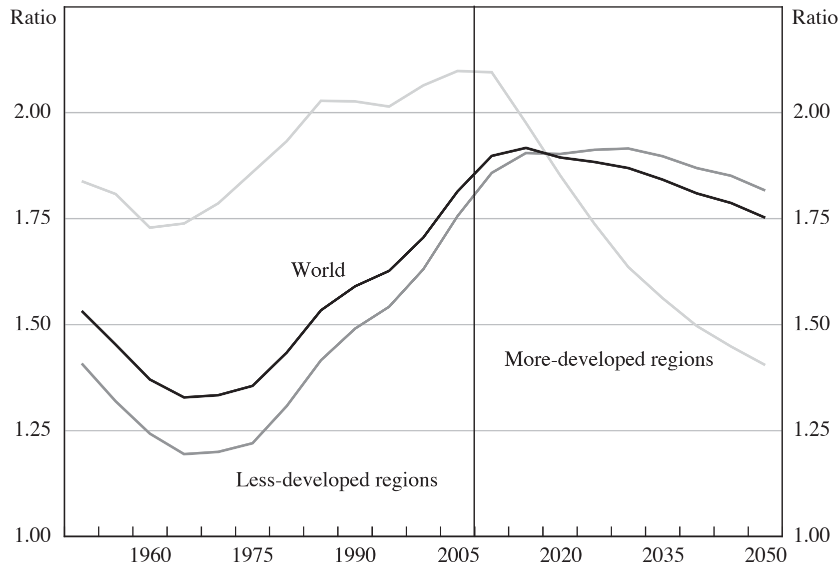
The positive correlation between life expectancy and income, which was first discussed in detail by Preston (1975), is one of the most central relationships in the fields of international health and development. Preston observed the strong, positive relationship between national income levels and life expectancy in poorer countries, though the relationship is nonlinear as life expectancy levels in richer countries are less sensitive to variations in average income. Preston also noted that life expectancy is increasing over time at all income levels. Although the basic facts set out by Preston are generally accepted, the mechanisms that lie behind the relationships and the policy implications we can draw from them are still disputed. Bloom and Canning (forthcoming) discuss Preston's paper in detail.

2.5 Age distribution: working-age population

Baby booms have altered the demographic landscape in many countries. As the experiences of several regions during the past century show, an initial fall in mortality rates creates a boom generation because high survival rates lead to more people at young ages than in earlier generations. Fertility rates fall subsequently, as parents realise they do not need to produce as many children to reach their desired family size, or as desired family size diminishes for other reasons. When fertility falls and the baby boom stops, the age structure of the population then shows a 'bulge' – the baby-boom-age cohort – created by the nonsynchronous falls in mortality and fertility. As this cohort works its way through the age structure of the population, it represents a share of the population larger than the share represented by the cohorts that precede or follow it (see Figure 12).

The baby boom creates particular challenges and opportunities for countries. In its youth, it is a large cohort to be educated. Jimenez and Murthi (2006), in addressing the challenges of a large youth cohort (ages 12–24), stress the importance for long-term economic growth of investing in education and health of the young and the need to ease entry into the labour market for this group. Once of age to enter the labour force, the baby boom generation represents an unusually large working-age (approximately ages 15–64) population, which offers the prospect of a 'demographic dividend'. Lee and Mason (2006) describe two aspects of the demographic dividend: falling fertility, leading to more workers per capita and therefore potentially more resources to devote to development and to family welfare, and extra savings generated when people expect a longer retirement period. (See also Bloom, Canning and Sevilla 2002.)

Figure 12: Ratio of Working-age to Non-working-age Population



Note: Data after 2005 are based on projections.

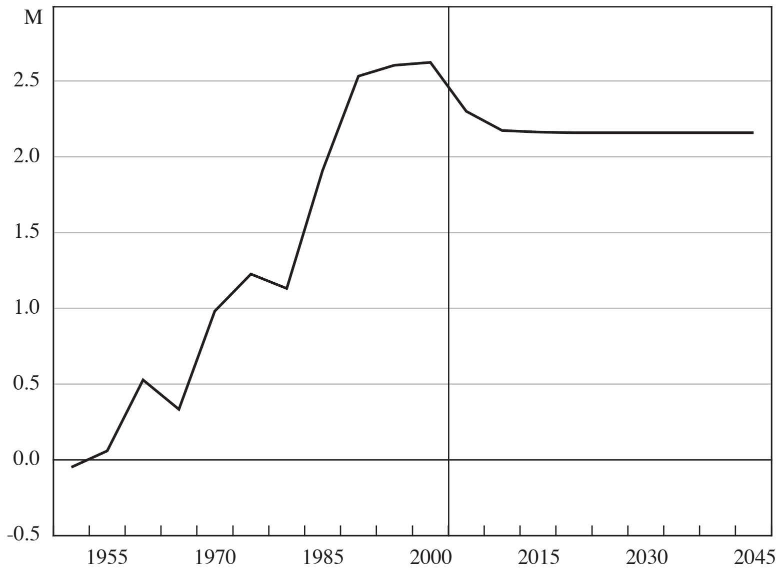
Source: UN Population Division (2005)

2.6 Migration

Migration also alters population patterns. Globally, 191 million people live in countries other than the one in which they were born. On average, during the next 45 years, the United Nations estimates that over 2.2 million individuals will migrate annually from developing to developed countries (see Figure 13). (The UN estimates regarding future migration are not very informative, a reflection of the inherent difficulty of constructing accurate projections of migration flows.) According to the UN Population Division, the United States will receive by far the highest number of immigrants (1.1 million a year), and China, Mexico, India, the Philippines and Indonesia will be the main sources of emigrants.

Several factors affect migration from developing to developed countries. A significant number of working-age people in developing countries are underemployed relative to the opportunities they perceive in developed countries. At the same time, developed countries face a declining share of working-age people and a growing number of elderly who need care, creating more opportunities for immigrants. Because migrants are disproportionately of working age, migration can affect the age distribution in both sending and receiving countries. The ratio of workers to dependents will tend to rise more slowly in sending countries and decline more slowly in receiving countries than it otherwise would. Williamson (2006) provides an economic explanation of the emigration life-cycle. First, people are too poor to emigrate; this is the 'migration poverty trap'. As wealth increases and demographic booms begin, more people are able to emigrate and more are driven to emigrate.

Figure 13: Number of Migrants from Less-developed to More-developed Countries



Notes: Dates refer to the beginning of the 5-year window. Data after 2005 are based on projections.
Source: UN Population Division (2005)

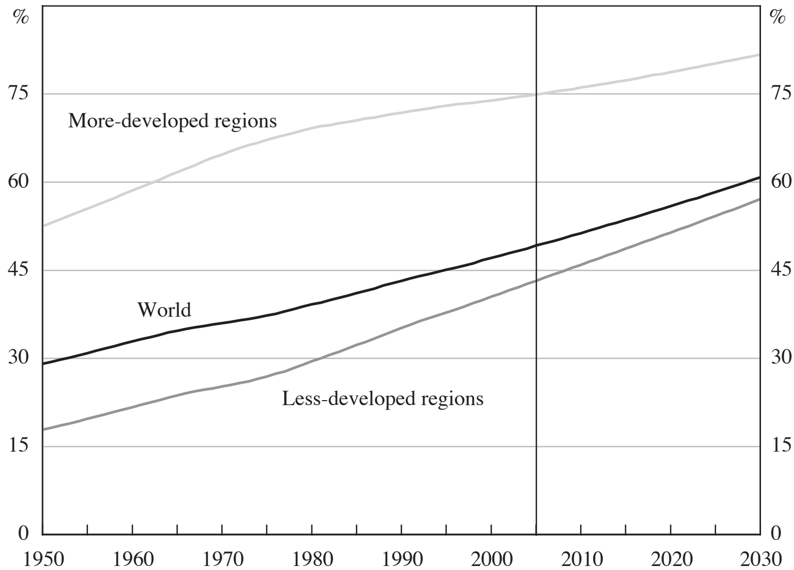
Emigration later subsides in response to remittances, industrialisation, conditions improving at home, and there being relatively fewer workers. In the case of Europe, as transport and industrialisation spread within the continent, the poorer countries joined the richer ones in sending migrants to the Americas.

2.7 Urbanisation

In both developed and developing countries, there has been a huge movement from rural to urban areas since 1950 (see Figure 14). Less-developed regions, in aggregate, have seen their population shift from 18 per cent urban in 1950 to 44 per cent in 2006, while the corresponding figures for developed countries are 52 per cent to 75 per cent. This move toward urban areas – and the concomitant urbanisation of areas that were formerly peri-urban or rural – is consistent with the shift that nearly all countries have experienced in moving from agricultural economies to industrial and service-based economies.

The existence and growth of megacities (that is, those with 10 million or more residents) is a late-20th century phenomenon that has created new problems. There were 20 such cities in 2003, 15 in developing countries. Tokyo is by far the largest, with 35 million people, followed by (in descending order) Mexico City, New York, São Paulo and Mumbai (all with 17 to 19 million residents). All cities allow for economies of scale and provide a broad mix of people and activities, making them

Figure 14: Percentage of Population Living in Urban Areas



Note: Data after 2005 are based on projections.

Source: UN Population Division (2005)

centres of economic growth and activity. These characteristics account, in some measure, for their attractiveness. However, as continued movement to urban areas leads to megacities, these factors seem to be countered in part by problems that arise in the areas of transportation, housing, air pollution and waste management. The conditions in megacities may also exacerbate socioeconomic disparities.

3. The Effect on Economies – Historical Background

Demographic change is consequential with respect to economic and social development. The economic consequences of population growth, in particular, have long been the subject of debate.

It was first believed that population growth would lead to the exhaustion of resources. In 1798, Thomas Malthus, perhaps the first of the 'population pessimists', argued that the world's resources would be unable to keep pace with population growth. Food production would expand more slowly than population, and many would lose out in the competition for food. Such thinking held sway well into the 20th century. In 1968, Paul Ehrlich predicted: 'The battle … is over. In the 1970s ... hundreds of millions of people are going to starve to death' (Ehrlich 1968, p xi). In the early 1970s, studies by the US National Academy of Sciences and the United Nations also predicted negative effects of population growth.

Not until the late 20th century did other arguments become popular. In the last 30 years of the 20th century, per capita incomes rose by two-thirds as global population doubled. This prompted some to ask whether, far from being a hindrance to growth, population expansion might in fact assist it. In the 1960s, it was proposed that population growth aided economic development by spurring technological and institutional innovation and increasing the supply of human ingenuity. Simon Kuznets (1967), Julian Simon (1981) and Ester Boserup (1981) were the leaders among the 'population optimists'. Kuznets argued that larger societies can take advantage of economies of scale and are better-equipped for trade. Simon showed that the prices of natural resources decline as growing populations, complete with a greater stock of human ingenuity, make the technological improvements necessary to respond to increasing demand. Boserup presented compelling historical evidence of the pressure that population growth puts on societies to create new solutions in the face of resource constraints. The Green Revolution, for example, where new, high-yield crops dramatically increased food production in much of the developing world, occurred in part as a response to population growth. Although the optimists did not believe population growth would automatically lead to economic advances, they saw that favourable policies could help translate increases in population into greater wealth.

Population neutralism became the predominant school of thought in the 1980s and 1990s. Advocates of this position (Bloom and Freeman 1986; Kelley 1988) took the optimists' observation that the consequences of population growth depended largely on the policy environment a step further. Population neutralism was based on empirical research showing little correlation between the growth rate of income per capita and the rate of population growth. In other words, population growth by itself has no effect on economic performance. Other factors such as openness to trade, educational attainment and the quality of institutions determine whether economic progress can keep pace with population expansion. Although fast-growing populations tend to experience slower economic growth, when these other factors are taken into account, the negative impact of population expansion disappears.

Recently, population neutralism is giving way to a more fine-grained view of the effects of population dynamics in which demographic change *does* affect economic development. Economists and demographers now point to both the accounting effects and the behavioural effects of changes in population size and structure.

4. The Effect on Economies – Some New Thinking

4.1 Accounting effects

Some of the effects of population change on economic growth result from 'accounting' effects. Accounting effects assume constant behaviour – in marriage, labour participation or other decisions – within age and other demographic groups, but allow for changes in the relative size of those groups to influence overall outcomes. For example, holding age- and sex-specific labour force participation rates constant, we can see how a change in the age structure affects total labour supply.

As a country's baby boom generation ages, for a time it constitutes a large cohort of working-age individuals and, later, a large cohort of elderly people. The span of years represented by the boom generation (which determines how quickly this cohort moves through the age structure) and the size of the population bulge vary greatly from one country to another. But in all circumstances, there are reasons to think that a very unstable age structure has economic consequences. A historically high proportion of working-age individuals in a population means that, potentially, production can increase relative to consumption, and with more workers per capita, GDP per capita can receive a boost.

Life-cycle patterns in savings also come into play as a population's age structure changes. People save more during their working-age years. If the working-age cohort is especially large compared to other age groups, savings per capita will increase.

4.2 Behavioural effects

Declining rates of adult mortality and the movement of large cohorts through the global population pyramid will lead to a massive expansion in the proportion of elderly in the world population. Some simple economic projections show catastrophic effects of this ageing. These projections tend to be based on an 'accounting' approach, which assumes that age-specific behaviour remains unchanged and ignores the potentially significant effects of behavioural change.

The ageing of the baby boom generation potentially promotes labour shortages, creating upward pressure on wages and downward pressure on the real incomes of retirees. It is likely that workers will adjust their behaviour in response to these pressures, resulting in increased labour force participation, longer working lives and possibly the immigration of workers from developing countries. In addition, Bloom, Canning and Moore (2004) find that health and longevity improvements tend, in theory, to increase individuals' desired age of retirement. In practice, however, mandatory retirement and other disincentives to work at older ages lead people to anticipate longer periods of retirement rather than longer working lives (Bloom, Canning, Moore *et al* 2006; Bloom *et al*, forthcoming). In response, national saving rates tend to rise (Bloom, Canning and Graham 2003).

Child mortality declines can also have behavioural effects, particularly for women, who are likely to be the primary caregivers for children. When fertility has fallen in response to a decrease in child mortality, more women are able to participate in the workforce, further boosting the labour supply.

5. Empirical Evidence

Demographic change is absent from many macroeconomic analyses that aim to explain cross-country differences in economic growth and poverty reduction. Yet several empirical studies show the importance of demographics in understanding economic development.

5.1 East Asia's baby boom

East Asia's remarkable economic growth in the past half-century coincided closely with demographic change in the region. As infant mortality fell from 181 to 34 per 1 000 births between 1950 and 2000, fertility fell from around 6 to 2 children per woman. The lag between falls in mortality and fertility created a baby boom generation. Between 1965 and 1990, the region's working-age population grew nearly four times faster than the dependent population. Several studies have estimated that this demographic shift was responsible for one-third of east Asia's economic growth during the period (that is, the 'demographic dividend'). (See Bloom and Williamson 1998; Bloom, Canning and Malaney 2000.)

5.2 Labour supply and the Celtic tiger

From 1960 to 1990, the growth rate of income per capita in Ireland was approximately 3.5 per cent per annum. In the 1990s, it jumped to 5.8 per cent, well in excess of any other European economy. Demographic change contributed to the country's economic surge. In the decade following the legalisation of contraceptives in 1979, Ireland saw a sharp fall in the crude birth rate. This led to decreasing youth dependency and a rise in the working-age share of the total population. By the mid 1990s, the dependency burden in Ireland had dropped to a level below that in the United Kingdom.

Two additional demography-based factors in Ireland helped fuel economic growth by increasing labour supply per capita. First, although male labour force participation rates remained fairly static, the period from 1980 to 2000 saw a substantial increase in female labour force participation rates, particularly in the 25–40 year-old age group. Although one would expect rapid economic growth to encourage female labour participation, it seems likely that some of the increase can be attributed to the availability of contraception and women's increased freedom to choose between working and rearing children. Second, Ireland historically had high levels of outward migration of young adults (around 1 per cent of the population per year), because its economy was unable to absorb the large inflows of young workers created by its high fertility rate. The loss of these young workers exacerbated the problem of a high youth-dependency rate. The decline in youth-cohort sizes and rapid economic growth of the 1990s led to a reversal of this flow, resulting in net in-migration of workers, made up partly of return migrants and also, for the first time, substantial numbers of foreign immigrants (see Bloom and Canning 2003).

5.3 Continued high fertility in sub-Saharan Africa

Demographic change of a very different type can account for slow economic development. Much of sub-Saharan Africa remains stalled at the first stage of a demographic transition.[3] Fertility rates actually increased a bit during the 1950s

3. Some African nations – notably Zimbabwe and those in southern Africa including Namibia, Botswana and South Africa – are beginning to experience faster fertility declines.

and through the 1970s and only recently have begun a slow fall. As swollen youth cohorts have entered the labour force, an inadequate economic policy environment in most countries has prevented many young people from engaging in productive employment. Large dependent populations (in this case, of children) have kept the proportion of working-age people in the total population low, making it more difficult for these economies to rise out of poverty (see Bloom and Sachs 1998).

6. Policy Implications

Rapid and significant demographic change places new demands on national and international policy-making. Transitions from high mortality and fertility to low mortality and fertility can be beneficial to economies as large baby-boom cohorts enter the workforce and save for retirement. Rising longevity also affects the incentives to save for old age, which can affect investment, international capital flows and interest rates.

The ability of countries to realise the potential benefits of the demographic transition and to mitigate the negative effects of ageing depends crucially on the policy and institutional environment. Attention to the following areas is likely to be key in developing effective policy to deal with the effects of demographic change.

6.1 Health

Recent evidence indicates that good health may be an important factor in economic development (see Bloom, Canning and Sevilla 2004). Health improvements – especially among infants and children – often lead to declines in fertility. Focusing on the diseases of childhood can therefore increase the likelihood of creating a boom generation and the positive economic effects a boom can generate (see Bloom, Canning and Weston 2005). Countries wishing to accelerate fertility declines may benefit from improving access to family planning services and education about fertility decisions.

6.2 Education

Workers are better able to contribute to economic growth if they have received an effective education. East Asia capitalised on its baby boom generation by providing high-quality education, including both general schooling and technical skills, which equipped them as workers to meet the demands of an ever-changing labour market. Ireland also gained from its baby boom by introducing free secondary schooling and expanding tertiary education.

6.3 Labour market institutions

Restrictive labour laws can limit a country's ability to benefit from demographic change, particularly where these laws make it difficult to hire and fire workers or to work part-time.[4] Restrictions on immigration are also of concern, as they hold down the labour supply. Immigration is a political hot potato in many countries, but economic incentives to lower barriers to immigration are likely to grow stronger as populations in developed countries age. International outsourcing, another controversial subject, may also be an increasingly important means of meeting the demand for labour.

6.4 Trade

One means by which east-Asian countries provided productive opportunities to their baby boom cohorts was by carefully opening up to international trade. The opportunity to export provides an outlet for the product of a large cohort. Bloom and Canning (2004) found that open economies benefit much more from demographic change than the average, and that closed economies do not derive any statistically significant benefit from changes in the age structure.

6.5 Retirement

Population ageing requires increased savings to finance longer retirements (especially if governments maintain current policies that discourage the conversion of greater longevity into longer working lives). This will affect financial markets, rates of return and investment. As more people move into old age, health care costs are likely to spiral upward, with the expansion of health care systems and growth in long-term care for the elderly. (However, Bryant and Sonerson (2006) caution that an ageing population is not the main driver of rising expenditures on health, showing that non-demographic factors are more substantial drivers of rising health expenditures than demographic ones.) As non-tradable, labour-intensive sectors with a low rate of technical progress, health care and elder care may affect the structure of the economy and potentially slow measured growth. Existing social security systems may hamper the ability of individuals to contribute to the financing of their retirement, as many of these systems penalise individuals who work beyond a fixed retirement age. As Turner (2006) explains, demographic factors play a central role in determining the potential viability of all pension systems, both fully funded and pay-as-you-go plans. Recent work in Australia by Kulish, Smith and Kent (2006) suggests that changes in fertility and longevity, functioning jointly, tend to increase the ratio of capital to labour inputs, and that, on average, people would still choose to spend a similar portion of their lives in retirement as before these changes.

4. There are also arguments on the other side of this issue that deserve consideration. For example, in many countries, labour unions have led to improved living conditions, including for non-members. The same might also be said of minimum wages even if, in some circumstances, they have constrained some aspects of economic development.

7. Thinking Far Ahead: Whither the Human Life Span?

A discussion that pertains centrally to increases in life expectancy and that touches on retirement naturally leads to the question of the human life span. How long are people likely to live in the coming decades, and are the anticipated changes likely to bring new issues to the fore?

In most of the world, life expectancy has risen sharply during the past two centuries. Children born today can expect to live for many decades longer than their ancestors born in the 19^{th} or early 20^{th} centuries. In Japan, life expectancy at birth is now 82 years, and other regions have also made great progress as medical and public health advances, improved nutrition and behavioural changes encouraged by improved education have combined to reduce the risk of death at all ages.

Fries (1983) suggests that the human life span is more or less fixed at a certain age and unlikely to change over time. According to this view, an accumulation of inherited diseases express themselves in the post-reproductive years, during which individuals' survival confers no evolutionary benefit on their descendants, effectively maintaining a ceiling on life expectancy. Ronald Lee (2003), however, proposes an evolutionary mechanism through which the human life span may increase. He argues, essentially, that the children of individuals who are genetically disposed to long life benefit from their parents' and grandparents' longevity, mainly through intergenerational transfers (for example, time spent nurturing children). This mechanism has acted against the accumulation of inherited diseases at the older ages and has tended to shape the human genome in a manner that is likely to be more responsive to the life-prolonging efforts of modern science.

Whether or not the human life span changes over time may have important implications for societies and economies. If it remains steady at around 85 years, the fraction of people living beyond that age is unlikely to grow significantly or rapidly. If it increases, on the other hand, societies may face a number of new challenges. In one plausible scenario, health care costs will rise with increasing numbers of very old individuals; pension and social security payments will come under increasing pressure; the dependency ratio will shift, leaving relatively smaller working-age populations with an increased number of elderly dependents to support; and societies will have to adapt to the social and cultural impacts of the new demographic realities. But even if life spans increase significantly, it is possible that most of these predictions will not come to pass. Fries discusses a phenomenon known as 'the compression of morbidity' – meaning that the illnesses associated with old age may come to arise sufficiently later in life so that, even with increased life spans, the elderly may have fewer years during which they are dependent on working-age people. If this is correct, the predictions above will be incorrect, particularly if people choose to retire later or save more early in life.

Continuing increases in life expectancy in low-mortality populations have led some demographers to forecast further gains. They believe that scientific advances will continue to combine with behavioural changes to yield further life expectancy gains in the future. Manton, Stallard and Tolley (1991), for example, estimate that populations with extremely healthy lifestyles – that is, with an absence or near-absence of risk factors such as smoking, alcohol and obesity, and the presence of health-promoting behaviours such as a healthy diet and exercise – could achieve a life expectancy of between 95 and 100 years. Oeppen and Vaupel (2002) found that death rates among the very old in Sweden and throughout the industrial world fell substantially in the last century, and at an accelerating pace, reflecting *bona fide* life-span improvements. They forecast that life expectancy at birth in low-mortality countries will rise to 100 years by 2060. Along the same lines, Preston (1996) observes that 60 per cent of the life expectancy increase in the United States since 1950 was due to mortality declines in people over the age of 50. Li and Lee (2005) estimate that life expectancy in the United States will rise from a 1996 figure of 76.3 to 84.9 by 2050, with that in Japan rising from 80.5 to 88.1.

Others have reached different conclusions. Olshansky and Carnes (1994) question the models used by demographers which underpin predictions that life expectancy will increase dramatically; Olshansky, Carnes and Désesquelles (2001) predict that life expectancy at birth will not surpass 85 years. Death rates, they argue, would not fall sufficiently for life expectancy to rise rapidly, and earlier increases were driven largely by dramatic reductions in infant and child mortality, which could not recur. Perhaps more importantly, they see no reason why the future should necessarily mirror the past – new threats to health such as influenza pandemics, antibiotic resistance and obesity (discussed subsequently in Preston 2005) could reverse gains made in recent decades; technological improvements could stall and the drugs needed to counter the diseases of ageing might not be found; and environmental disasters, economic collapse or war could derail health systems at the same time as weakening individuals' ability to protect their own health.

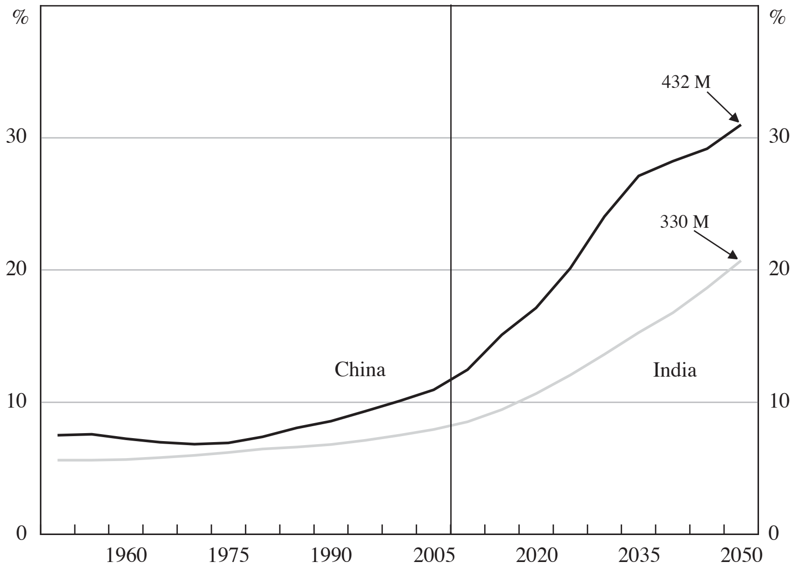
The debate continues, and many questions remain unanswered. What will be the effect on the human life span of advances in genetics? Will anti-ageing technologies emerge to make the human body more robust for longer? Will wealthy societies succumb to damaging obesity epidemics or to new infectious diseases such as avian flu? Will economic meltdown take away the wealth that has contributed so much to improvements in health? Or will wars result in massive premature mortality, and thereby render the average life span a far less compelling issue?

8. Looking to the Future

What can we expect in the next half-century? Based on the indicators that are available, we can make a few points.

- All signs suggest that there will be continued but slowing population growth. This continued growth will result in the addition of roughly 3 billion people to the world population, before it stabilises around 2050 at about 9 billion. Managing this increase will be an enormous challenge, and the economic consequences of failing to do so could be severe.
- The world's population is ageing, and the growth in the sheer number of elderly people will be huge. The United Nations predicts that 31 per cent of China's population in 2050 – 432 million people – will be aged 60 or over. The

Figure 15: Growth of Elderly Population in China and India
Percentage aged 60+



Note: Data after 2005 are based on projections.
Source: UN Population Division (2005)

corresponding figures for India are 21 per cent and 330 million (see Figure 15). No longer can ageing be thought of as a developed-world phenomenon. (Further comparison of China and India's demographic development as it has affected their economic development can be found in Bloom, Canning, Hu *et al* 2006.)

- International migration will continue, but the extent is unclear. The pressures that encourage people to migrate – above all the lure of greater economic well-being in the developed countries – will undoubtedly persist, but the strength of countervailing policy restrictions that could substantially staunch the flow of migrants is impossible to predict.
- Urbanisation will continue, but here, too, the pace is impossible to predict. Greater economic opportunities in the cities will surely continue to attract migrants from rural areas, but environmental and social problems may stymie growth.

Although demographic changes are, for the most part, easier to predict than economic changes, the big-picture outlook is nonetheless unclear. The uncertainties are similar to those we cited regarding possible changes in the human life span. Will an outbreak of avian flu or another disease become pandemic, killing many millions and decimating economies? What happens if these diseases are, or become, resistant to existing drugs? Conversely, scientific advances in areas such as genomics, contraceptive methods, or vaccines for diseases such as AIDS or malaria could save and improve millions of lives. Global warming and other environmental changes, or large-scale war, could completely alter the context of demographic and economic predictions. Millions of refugees, from any cause, could lead demographic predictions to be far off the mark, and could, of course, lead to upheavals that would dwarf the importance of the analysis offered here.

Appendix A: Notes on Source, Country Groups, Coverage Period, Definitions and Assumptions

Source

All data and charts are taken directly from, or calculated on the basis of UN Population Division (2005). See <http://www.un.org/esa/population/publications/WPP2004/2004EnglishES.pdf> for the Executive Summary of UN Population Division (2005) (including the assumptions).

Definition of country groups

The UN defines 'more-developed regions' as 'all regions of Europe plus Northern America, Australia/New Zealand and Japan'. 'Less-developed regions' means 'all regions of Africa, Asia (excluding Japan), Latin America and the Caribbean plus Melanesia, Micronesia and Polynesia'.

The list of 'more-developed' countries consists of the following: Albania, Australia, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Canada, Channel Islands, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, New Zealand, Norway, Poland, Portugal, the Republic of Moldova, Romania, the Russian Federation, Serbia and Montenegro, Slovakia, Slovenia, Spain, Sweden, Switzerland, TFYR Macedonia, Ukraine, the United Kingdom and the United States. All other countries are classified by the UN as 'less-developed'.

Coverage period

The source presents data for 1950–2050. The United Nations presents some data for exact years (1950, 1955, etc) and other data for five-year periods (1950–55, 1955–60, etc). For the former, projections are made for 2010–2050; for the latter, for 2005–2010 to 2045–2050. For urban population shares, projections extend only to 2030. In each case, 1 July is the reference date. Data presented for exact years are: population, population by any specific age group, population by sex and the urban population share. Variables presented for five-year periods are: crude birth rate, crude death rate, total fertility rate, infant mortality rate, life expectancy, population growth rate, migration rate and number of migrants.

Definitions

The source document uses the following definitions:

Total fertility: children per woman

Crude birth rate: births per thousand population

Crude death rate: deaths per thousand population

Infant mortality rate: infant deaths per thousand live births, for both sexes combined

Life expectancy: expectation of life at birth for both sexes combined (years)

Population growth rate: average annual rate of population change (per cent)

Migrant numbers: net number of migrants, both sexes combined (thousands) – defined such that a positive number of migrants means that immigrants outnumber emigrants

Migration rate: crude net migration rate (net migrants per thousand population) – defined such that a positive rate means that immigrants outnumber emigrants

Percentage urban population: there is no simple definition for 'urban' in UN data. Demographic, administrative, and economic criteria used to report figures on urbanisation differ across countries.

In addition, we have defined two age groups, as follows:

Working age: 15–64

Non-working age: 0–14 and 65+

Assumptions

Fertility

The UN uses several differing assumptions about future fertility in making its projections. For the data and figures in this paper, we have used the UN's 'medium-fertility variant' in all instances in which more than one variant is available: total fertility rate, crude birth rate, crude death rate, population (for all age groups), population growth rate, migration rate and number of migrants.

For the medium-fertility variant, the UN assumes for all countries that fertility will gradually converge to 1.85 children per woman. It does not assume that countries will necessarily reach that level by 2050. For high- and medium-fertility countries (that is, those with total fertility at or below 2.1 children per woman in 2000–2005), projections are built on the experience of all countries that experienced fertility declines during the past half-century. If a country's fertility rate is projected to fall to 1.85 before 2050, the UN model assumes it will then remain at that level. Projections are not done mechanistically; they are always checked against recent trends in a specific country. In some instances, these recent trends require an adjustment in projections for the coming five or ten years, after which time projections revert to the basic fertility projection model. For low-fertility countries whose fertility rate is currently below 1.85, the model used by the UN assumes that fertility in the coming five to ten years will follow recent trends and will then increase at a rate of 0.07 children every five years.

Mortality

The UN also makes assumptions about future mortality rates, which affect most of the data in the figures in this paper. UN projections take into account recent sex-specific trends and are based on the expectation that life expectancy will rise more slowly in countries that have already reached a fairly high level. For those indicators for which the UN provides data specific to various possible courses of the HIV/AIDS epidemic, we have used only the 'normal mortality assumption' (which uses a model that takes HIV/AIDS into consideration and, for countries with high levels of the disease, projects a 'slowdown in the reduction of general mortality risks not related to HIV/AIDS').

Migration

For migration numbers and rates, the UN assumes for most countries that migration patterns will change very slowly after the period 2010–2015, compared with the speed at which such patterns changed in the past. Projections are based on past trends and take into account countries' current policies regarding international migration.

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Discussion

1. Charan Singh

At the outset I must congratulate David Bloom on such a good paper, which presents a very comprehensive summary of the subject, explains things in a very simple way and provides up-to-date commentary on the literature relating to the links between demography and economic growth. The paper was certainly a pleasure to read and I am sure other central bankers and policy-makers would agree with me. However, being a central banker, I am trained to think differently from David on several issues. Hence, on an excellent paper presented by an exceptional expert I have some comments that I think are basic in nature, and then I will make a few points regarding our experiences in India.

First, the demographic problems of the developed world seem to be different from those of the developing countries. As an illustration, I would cite the participation rate of women in the workforce. In India, according to the census of 2001, the number of female workers per thousand males is merely 559 in rural areas and around 211 in urban areas. In addition, the ratio of women to men in the population itself is adverse, at just around 930 women per thousand men. An adverse sex ratio also prevails in China. This situation is very different from that in developed countries.

Second, the definition of 'old' needs to be dynamic. Acknowledging the considerable disparity between developing and developed countries, average global life expectancy has increased from about 46 years in the 1950s to 65 years in 2000 and is expected to increase to 75 years by 2050. I wonder whether an upward shift in the definition of 'old' is now necessary? Already there is a debate as to when old age begins, with commonly held views ranging from about 50 years in China to 56 years in India and 71 years in France. Is the onset of old age to be measured by age or by ability? And if longevity is increasing, are mandatory retirement ages desirable?

Also related to this is the issue of employer attitudes towards older workers. According to a recent survey (Munnell, Sass and Soto 2006), older workers aged over 55 years in white-collar jobs are considered useful but more costly than younger workers. Another concern is how to treat workers who earn their livelihood doing physical labour.

In many developed countries fertility has also declined below the replacement rate of 2.1 children per woman, implying (in the absence of immigration) that the number of people in successive age cohorts is declining. This phenomenon can permit the elderly to continue to hold jobs for longer as pressure from unemployed youth would not be there, unlike in countries where longevity is rising without the commensurate decline in fertility rates. Thus, there is a compelling case for extending the retirement age in some countries and properly redefining the onset of old age.

Third, most economists are interested in better understanding the determinants of economic growth. In his paper, David cautiously mentions the evidence regarding the relationship between demography and economic growth. I think that it needs to be interpreted carefully. The predicted relationships certainly find support from the experiences of many countries in east Asia, at least until the late 1990s. But they do not seem to hold in other countries, possibly because other factors were not so conducive for growth. Such factors would include the existence of suitable technology, economic openness, the composition of output, the development of the financial sector, labour laws and other associated socio-economic determinants like health, education and urbanisation. Thus, demography could be an enabling factor for growth, where the demographic dividend is appropriately exploited, but it is not a sufficient factor. India is an illustration of this.

Fourth, I observe a unique and interesting demographic trend: the churning of the world's population through large-scale flows of migrants from the developing to the developed world and an amalgamation of cultures through marriages and business practices. This trend could serve as an important complement to the significant growth in physical trade amongst countries, in which labour-intensive goods move from the developing to the developed countries and capital-intensive goods move the other way. Indeed, I would argue that, either there will be a significant increase in migration or, given the natural resistance to immigration in some countries, a significant increase in outsourcing can be expected. In either case, demographic change is likely to provide further impetus to the growth of capital and financial flows between countries. This implies greater economic integration and should alert policy-makers in both the developed and developing worlds to strengthen surveillance of capital flows. It is also especially important for developing countries to develop their financial markets (focusing particularly on equity and bond market institutions and instruments) to better absorb capital inflows and as a tool for broader economic development.

Fifth, as longevity increases in developing countries, I think that these countries could learn much by looking at the experiences of developed countries that have already undergone large demographic transitions. In Japan, for example, life expectancy at birth has already reached around 82 years. Although cultural and socio-economic factors are obviously important, I presume that its experiences could serve as a useful benchmark for insurance and pension sector reforms in developing countries. In addition, the experiences of developed countries may also provide guidance for developing countries as they attempt to enhance the financial preparedness of their populations for longer periods of retirement, including through expanded financial education programs. With regards to this, it appears likely that the issuance of long-term bonds (such as the 50-year bonds recently issued by France and the United Kingdom) and index-linked bonds (such as the 10-year inflation-linked bonds issued recently by the UK, Germany and Japan) should be considered, as well as public support for the development of annuity markets. The ageing of the population can shift investor emphasis from the accumulation of assets to the preservation, and sometimes even decumulation, of wealth. This could also affect asset prices, for which all market participants need to be prepared.

Sixth, and most importantly, the implications of population ageing for social security systems are serious and must be addressed. Population ageing affects many economic variables, including labour supply, consumption patterns, investment, cross-border capital flows, fiscal balances and private saving. Martins *et al* (2005) show that where the provision of public pensions increases, then private saving declines. The situation is particularly grim for systems that rely on intergenerational transfers from the young to the old. As Poterba (2004) observes, 'When a population ages because the existing old live longer, it is challenged to transfer resources to individuals who did not expect to outlive their savings, but did so because of mortality improvements. When a decline in birth rates is the predominant source of population aging, there is more time to prepare for the older population' (p 4). I think that the role of partnerships between the public and private sectors in areas such as health, education and caring for the elderly needs to be carefully examined. In the case of health, measures should be taken to minimise the fiscal impact of relatively expensive modern medical techniques. In education, private sector involvement could provide significant benefits. Timely action is required as, in some developed countries and many developing countries, the scope for increased public expenditure on health and education seems limited, with public finances already overstretched.

Finally, I think that the decline in birth rates across the world to low and even sub-replacement rates is an important development. Like David, however, I am uncertain about whether this trend will continue into the long-term or whether it is a temporary phenomenon.

An Indian perspective

I will now make a few points specific to India. I would like to mention that India is in the process of a demographic transition from high to low rates of fertility and mortality. The annual growth rate of its population declined from 2.1 per cent over the period 1981–1991 to 1.9 per cent during 1991–2001. According to the latest projections, the population of India will increase from 1 029 million in 2001 to 1 400 million by 2026 – representing an average annual growth rate of 1.2 per cent. The share of working-age individuals (those aged 15–59) in the total population is projected to rise from 57.7 per cent to peak at about 64.3 per cent in 2025–2026. The share of the population aged 60 years and above is projected to increase from 6.9 per cent in 2001 to 12.4 per cent by 2026. In contrast, the proportion of the population aged 0–14 is projected to decline from 35.4 to 23.4 per cent over this period.

Since 1989, India has embarked on a path of pension reforms, accompanied by an extensive process of discussion and policy debate. In 2004, the Indian Government established an independent Pension Fund Regulatory and Development Authority to regulate and develop the private pension market. However, only about 11 per cent of the working population currently participates in mandatory, formal programs designed to provide old-age security. The current coverage of life insurance is also relatively low, at around 10 per cent of the total population. Those in rural areas, who account for three-quarters of the total population, have particularly low participation rates. By global standards, insurance penetration is low in India – life insurance premiums are equivalent to 2.5 per cent of GDP in India, compared with 8.3 per cent in Japan and 4.3 per cent for the world as a whole (Swiss Re 2006). In 1999, the government established the Insurance Regulatory and Development

Authority to regulate, promote and ensure orderly growth of the insurance industry. Since then, competition has intensified, with the number of insurance providers increasing from 1 in 2001 to 15 in 2006.

From the Reserve Bank of India's (RBI) perspective, financial and regulatory issues are of special significance for India in the context of population ageing (Reddy 2001). It is important that savers can choose from a range of institutions and instruments that suit their preferences for risk and return. To facilitate the further development of financial markets, the RBI has been making an effort to maintain low and stable inflation. This should help to anchor inflation expectations and ensure a smooth term structure of interest rates. Also, recent regulatory reforms should foster greater confidence in equity markets and encourage further development of the corporate bond market in order to provide a deep and broadly based market for fixed-income instruments necessary for pension and insurance funds.

In conclusion, population ageing is taking place gradually in India. Learning from the experiences of the developed world, it should be possible for India to develop funded health and pension schemes before the full consequences of population ageing make themselves felt (Mohan 2004). Already, we have taken some measures to strengthen pension reforms and we are making extensive efforts to meet the challenges ahead.

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2. Hiroshi Watanabe

I would like to make some comments focusing on the practical policy issues arising from the demographic overview presented by David Bloom.

Demographic trends in Japan

Due to its declining fertility rate, which reached 1.25 in 2005, Japan's total population has started to decline and its dependency ratio has drastically increased. As explained by David, these demographic trends are typical of the most-developed countries, and as a front-runner Japan has already been addressing the issues raised by these demographic trends.

In Japan, the decline of the working-age population is reducing the total supply of labour and slowing economic growth. In response, it is important for policy to encourage elderly baby boomers to retire later and to increase the participation of women in the labour force. The standard retirement age, as well as the age at which individuals first become eligible for an old-age pension, has already been extended to 65. The age structure of female labour force participation rates in Japan has shown the typical 'M'-shape, with participation rates falling between ages 30–40, reflecting time spent raising children. Recently this M-shape has become milder, so that the age structure of female participation is looking more hump-shaped.

In the longer run, Japan has to consider the potential for migration. Positive efforts have been made to accept specialists and highly skilled workers as migrants. The approach regarding unskilled immigrants remains cautious, with consideration given to social tensions, in part due to the effects it would have on the domestic labour market. It is also important to differentiate between the social impact of short-term foreign workers and permanent migrants.

Impacts of the demographic change and necessary challenges

In Japan, the large post-World War II baby-boom cohort makes up the demographic peak, and the retirement of this generation will have a considerable impact on our economy, as well as our society.

First, the ageing of this generation will affect the demand for real estate. Their huge demand has boosted the prices of houses and other real estate in the era of rapid growth in Japan, while domestic migration from rural areas to urban areas may have also worked to accelerate demand in urban areas. But such demand has since declined, with adverse implications for the real estate market.

Second, with the retirement of the baby-boom cohort, the household saving rate, which had been more than 10 per cent in Japan, will decline further.

Third, as more people move into old age, medical care costs and pension payments will also increase, making present fiscal policy less sustainable. Among other things, it will be important to secure stable revenues for financing such rapidly increasing payments. The ‘Basic Policies 2006’ approved by the Cabinet in July stipulates the consideration of a value-added tax to generate revenues for this purpose.

Fourth, in order to mitigate the impacts of demographic change on economic growth, it is important to maintain and improve upon the level of productivity. Japanese authorities have actively focused on research and development expenditures in the areas of science and technology, as well as enhancing education to better develop human capital resources.

Fifth, demographic change will affect external capital flows. Facing a declining saving rate, Japan welcomes foreign direct investment as a means of boosting economic growth. Accordingly, our initiative of ‘Invest Japan’ has been announced. On the other hand, in light of a declining rate of return, domestic investors will wish to seek more profitable investment opportunities outside Japan with higher rates of return. The more than 1 400 trillion yen in financial assets held by the Japanese household sector should be channelled to better uses, including in foreign countries.

Finally, demographic change may also affect investors’ preferences for different types of financial instruments. The cash flows of pension funds are due to the insurance premiums accumulated by the young and deferred payments to those who are old. Such cash flows correspond closely to those of zero coupon-type bonds already widely used in a number of markets. Hence, I suspect that there is considerable scope for the development of new instruments of this type, which would be favoured in an aged society.

3. General Discussion

The general discussion centred on three main themes: the nature of the relationship between longevity, health and retirement; whether migration and/or fertility policies could mitigate the economic effects of population ageing; and the uncertainties surrounding demographic projections.

Several participants agreed that the relationship between increases in longevity and improvements in health was an important determinant of the effects of population ageing on the macroeconomy. Most agreed that rising longevity had been accompanied by better health of older people, allowing them to work longer. Why this had not led to an increase in retirement ages was a question raised by a number of participants. Some pointed to increases in incomes, which allowed people to take longer periods of retirement while maintaining suitable living standards; this was especially true when starting from a base of only relatively brief retirement spans. Other participants highlighted the role of retirement policies in creating incentives for early retirement, and impeding further rises in retirement age in response to rising life expectancy. For example, one participant suggested that in some countries there was evidence that people on defined contribution schemes were tending to extend their working lives in response to rising longevity, while this was less true of people with defined benefit schemes. A third argument was that labour market rigidities may impede the participation of older workers. David Bloom believed that further cross-country research comparing different retirement policies could help to shed light on whether policy or shifts in behaviour (in response to higher incomes and longer life spans) have driven observed retirement behaviour.

There was a general consensus that population policies could not substantially mitigate projected changes in the age structure of the population, although migration and fertility policies might feature in a range of policy responses to population ageing. A number of participants observed that the very large increases in immigration necessary for developed countries to leave the population age structure unchanged would be politically infeasible, and raised temporary migration as a more likely alternative. On fertility, it was noted that the literature is inconclusive on how policy might respond to very low levels of fertility, although there is a consensus that family planning initiatives and increased education of young women have been instrumental in reducing fertility rates in developing economies from very high levels. Others argued that because recent demographic trends imply considerable ongoing momentum in the ageing process, any rise in fertility was likely to have a limited effect on elderly dependency ratios in the next few decades while boosting youth dependency ratios.

Several participants were interested in the construction of demographic projections and the degree of uncertainty surrounding various components. David Bloom argued that the migration projections presented in his paper are unlikely to surprise on the upside because existing barriers to labour mobility are unlikely to be reduced in the future. More important are the uncertainties associated with fertility (given the large errors in previous forecasts) and regarding the ongoing upward trends in longevity (which have tended to be under-predicted in the past).

Optimal Private Responses to Demographic Trends: Savings, Bequests and International Mobility

Henning Bohn[1]

Abstract

This paper examines the implications of population ageing in an environment of increasingly mobile capital and labour. I first present three benchmark models for world savings, capital-output ratios and returns to capital and then examine their relevance for the world economy and their policy implications.

The mechanics of capital deepening triggered by declining birth rates are presented in a Solow-Swan model with exogenous saving. The role of retirement savings is examined in a stylised overlapping-generations model with life-cycle savers. A dynastic model with altruism towards children highlights the interaction of savings with bequests and spending on children.

All three models are calibrated to the world economy with particular attention to the G-20. The models yield different conclusions largely due to their different assumptions about bequests. While the Solow-Swan and life-cycle models suggest rising capital-labour ratios, rising capital-output ratios and a secular decline in returns to capital, the dynastic model predicts declining saving rates, a declining share of bequests in aggregate wealth and a stationary world return to capital.

A substantial share of world capital is due to bequests rather than life-cycle savings. This raises doubts about the life-cycle model as a tool for demographic projections. At the same time, the projected decline in bequests also raises questions about bequests reaching a lower bound where life-cycle reasoning would become applicable. I argue that constraints on bequests are likely to be 'soft' (non-binding) for as long as retirees can successfully lobby for growing public transfers (serving as negative bequests). Increasing capital and labour mobility are relevant in this context because increasing cross-country tax competition would impose increasingly stringent bounds on transfers and hence on aggregate bequests. While developed countries may be close to such bounds, bequests and dynastic reasoning remain important for savings in developing countries and hence for world-wide demographic projections.

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1. Department of Economics, UCSB, Santa Barbara, CA 93106. E-mail: bohn@econ.ucsb.edu. Home page: http://econ.ucsb.edu/~bohn. I would like to thank the lead discussant, Mariano Kulish, and the other conference participants for their insightful comments. The paper was previously circulated under the title 'Optimal Private Responses to Demographic Trends: What Can Theory Tell Us?'.

1. Introduction

Birth rates are declining and survival rates are increasing around the world. How will individuals respond to these trends? What are the optimal responses? What are the implications for the world economy?

This paper examines the implications of population ageing from a global perspective. I focus specifically on savings, bequests and policy expectations in an environment of increasingly mobile capital and labour. The saving responses to demographic change are central to macroeconomic analysis. Savings provide funding for capital investment and determine the future capital stock. The size of the capital stock relative to the labour force – the capital-labour ratio – determines per-capita incomes, wage rates, returns to capital and other macroeconomic variables.

Bequests matter because they are a key source of funds for savings. Bequest motives and the empirical magnitude of bequests are still the subject of controversy. As I will show, different assumptions about bequests yield very different answers about the optimal and likely private responses to demographic changes.

Expectations about economic policy deserve attention because a lack of policy credibility has destructive effects on the world economy. The spatial allocation of capital is distorted and inefficient if investors have to worry about unexpected taxes, expropriation and other capital levies. As workers become increasingly mobile, taxes on wages and on consumption will do similar damage to the global allocation of labour.

The role of savings is well-recognised in the economic literature on demographic change. Most researchers employ models with overlapping generations of life-cycle savers. The models range from stylised 2–3 period representations of the life-cycle that build on Samuelson's (1958) and Diamond's (1965) work, to detailed multi-period models that build on Auerbach and Kotlikoff's (1987) 65-period model. Noteworthy examples include Börsch-Supan, Ludwig and Winter (2002), Brooks (2003), IMF (2004), Börsch-Supan (2005), Fehr, Jokisch and Kotlikoff (2005, this volume), Attanasio, Kitao and Violante (2006), Batini, Callen and McKibbin (2006) and Bryant (this volume). Models that provide more detailed demographic and geographic coverage tend to require more specific assumptions about individual behaviour. To focus on the key conceptual issues, I model the life-cycle relatively compactly as a succession of 20-year periods – representing childhood, young and middle-aged working periods, and retirement.

A largely separate literature examines demographic change in specific countries, often treating them as closed economies. Examples include De Nardi, Imrohoroglu and Sargent (1999) for the United States, and Braun, Ikeda and Joines (2004) for Japan. In addition, there is a huge literature on long-run economic growth that compares growth performances across countries, some adopting Solow's (1956) and Swan's (1956) exogenous saving assumption, others assuming optimising infinitely-lived dynasties. Most of the literature ignores bequests; a notable exception is the dynastic approach for the US in Elmendorf and Sheiner (2000).

This paper examines optimal responses to demographic change across a range of modelling approaches. One objective is to identify critical issues and assumptions that explain why predicted responses in the literature differ substantially across models. Although I display projected values for savings, returns and other variables, they are shown to illustrate the issues and should not be interpreted as forecasts.

Economic theory offers three basic perspectives on saving and demographic change: growth models in the Solow-Swan tradition help to understand the purely mechanical ramifications of demographic change; overlapping generations models with life-cycle savers help to highlight the role of saving for retirement; and dynastic models with altruism towards children highlight the role of bequests, education and family relations.

According to the Solow-Swan model, the capital-labour ratio should increase and the return to capital fall as the birth rate declines. Life-cycle models yield similar predictions, although there are a multitude of conflicting effects that may raise or reduce the saving rate. Dynastic models, in contrast, imply an unambiguously declining saving rate, a stationary return to capital and a stationary capital-labour ratio.

The intuition for the results of the dynastic model is as follows. Optimal bequests decline as the population ages. Because bequests are bounded below (non-negative in simple models), declining bequests suggest a possible regime shift in saving behaviour. Dynastic reasoning is arguably most relevant in economies with substantial bequests, for example agrarian and industrial economies where land and business assets are mostly inherited rather than purchased. Life-cycle reasoning is more relevant when rising life expectancy requires more funds for retirement and as human capital (education spending) becomes more important. Life-cycle modelling is arguably appropriate for developed economies, at least looking forward, but probably not for less-developed countries.

Questions about retirement savings naturally involve the public sector. In life-cycle models, public pensions crowd out private saving and reduce the capital stock. In dynastic models, public pensions tend to raise bequests and relax bequest constraints. The latter gives public policy an important role in the transition from dynastic to life-cycle saving. Optimal private responses to population ageing are likely to include political efforts to increase public pensions.

The interaction between mobility and policy is important both for the allocation of capital and labour and as a constraint on public transfers. Internationally mobile capital equalises returns on capital across countries. Even if governments tried to constrain mobility, there are enough channels for factor price equalisation that the macroeconomic effects of demographic change are best examined at a global level. Policy-induced frictions (taxes, regulations, risk premiums) are crucial, however, for the spatial distribution of production and hence for the fortunes of specific countries.

An emerging issue in this context is labour mobility. Because international capital mobility does not prevent governments from taxing labour, it does not seriously threaten transfer systems financed by payroll taxes. This is different in a world with mobile capital *and* mobile labour. Because production has roughly constant returns to scale in capital and labour, the spatial allocation of production becomes essentially indeterminate. Investment decisions are then extremely sensitive to taxes and to expectations about future taxes. Decisions about where to work become similarly sensitive to redistributional wage taxes. This matters for saving and bequests because constrained taxes make it impossible for the old to avoid bequest constraints by expanding retiree transfers.

Integrated world capital and labour markets also have implications for financial markets. Taxes and public transfer systems can be interpreted as devices that help share risk (see Bohn 2001, 2003, 2006). With increased mobility, risk-sharing through *ex post* taxation becomes increasingly difficult. A better policy is to take out insurance in financial markets *before* disturbances hit, for example through state-contingent debt (Bohn 2002). Monetary policy and nominal debt may have a role in this context because they provide a flexible tool for letting the real value of debt respond to shocks.

This paper is organised as follows. Sections 2–4 examine responses to population ageing in the three benchmark models. Section 5 compares results across models and comments on the role of public institutions. Section 6 examines the interaction between global mobility and country-level policies. Section 7 summarises and concludes.

2. Solow-Swan – A Benchmark without Optimisation

Optimal responses to demographic change should be distinguished from purely mechanical responses. To provide a benchmark and macroeconomic context, this section examines population ageing in a Solow-Swan-type model. The model is not optimising and simply assumes that individuals save a fixed fraction of income.

Central to the model is the neoclassical production function. Output is produced using capital and labour. The factors of production earn incomes according to their marginal contributions to output. Individuals save a fixed fraction of their income, which determines the supply of funds to the world capital market. Firms demand funds to finance new capital investments. They promise savers a return equal to the marginal product of capital minus the depreciation rate.[2]

For now, I abstract from public sector issues and from frictions that might prevent an equalisation of factor returns across countries. Public sector variables are subsumed into the private sector: aggregate consumption includes tax-financed public goods; aggregate investment includes public infrastructure; and capital includes government-owned capital. Public sector decisions are interpreted as if they are determined by savers who are also voters and thus own and control their governments. Sufficient conditions for factor price equalisation are either capital mobility, labour mobility or both.

2. Though the return to capital is linked to various interest rates, I refer to returns because the term interest rate is commonly associated with safety, which would be misleading here. Although I will not explicitly model risk, one should keep in mind that, on aggregate, savings are invested in capital assets with uncertain returns.

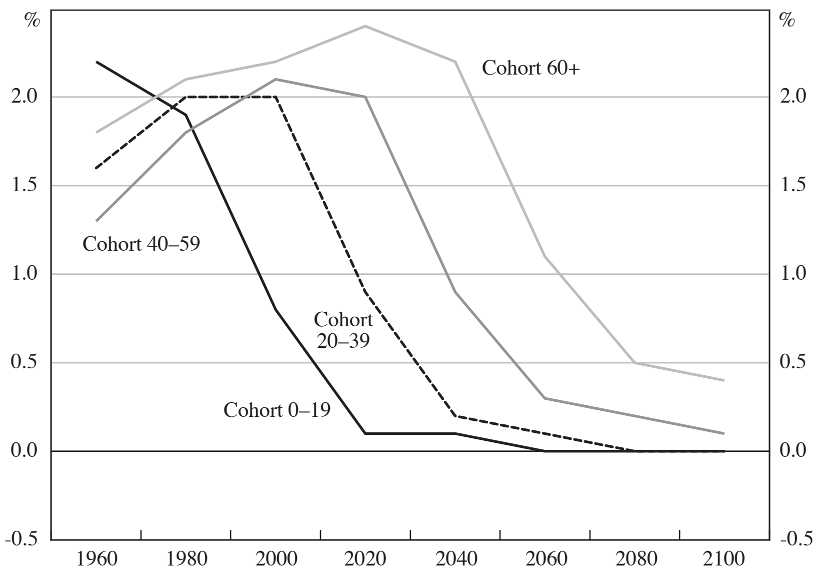
The Solow-Swan model provides a simple argument for how the demographic transition affects the world economy. Smaller working-age cohorts reduce the supply of labour relative to capital. The capital-labour ratio increases. A higher capital-labour ratio reduces the marginal product of capital while raising the marginal product of labour. Thus, the wage increases and the return to capital declines.

The application of this simple argument requires some care. Most importantly, one must account for international differences and changes in productivity. For each country, the *effective labour force* is the actual labour force weighted by the country's total factor productivity (TFP). Following the Penn World Tables (Heston, Summers and Aten 2002), productivity is measured relative to the US and adjusted for differences in purchasing power. World output is thus determined by world capital and by the effective labour force (scaled to US productivity).

To focus on the G-20, my calculations explicitly account for the 19 individual members of the G-20. Other countries are aggregated into a single Rest of the World (ROW) category. Baseline assumptions are 1.5 per cent annual US productivity growth and a gradual TFP convergence to US levels, consistent with convergence observed from 1980–2000. (An algebraic exposition and more details are provided in Appendix A; sensitivity analysis is provided below.)

Figure 1 shows projected growth rates of the world population, separated by age cohorts. The figure highlights three key features of the demographic transition. First, the rate of population growth is declining sharply. Second, the timing of the decline differs between age groups – it occurs first in young cohorts, then in older ones. Third, retirement-age cohorts will keep growing, due to increasing longevity.

Figure 1: World Demographic Projections
Population growth by cohort

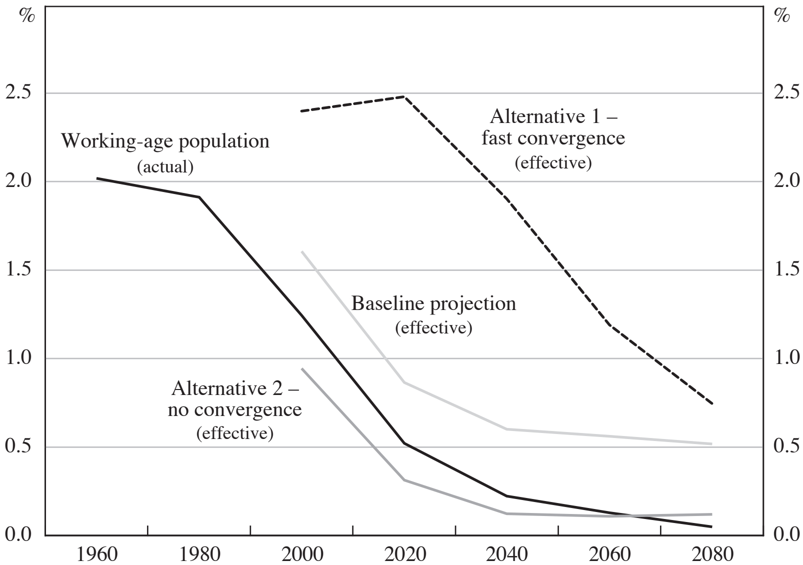


Sources: UN Population Division (2005); World Bank (2006); author's calculations

Figure 2 shows projected growth rates of the world's working-age population and three scenarios for the world's effective labour force – the baseline projection plus two alternative scenarios. The first alternative assumes fast convergence of world productivity to US levels as suggested by Lucas (2000). The second alternative assumes no convergence, that is, constant productivities relative to the US; because poorer countries tend to have faster population growth, average world productivity would decline relative to the US.

Figure 2: Actual and Effective World Labour Force

Growth rates



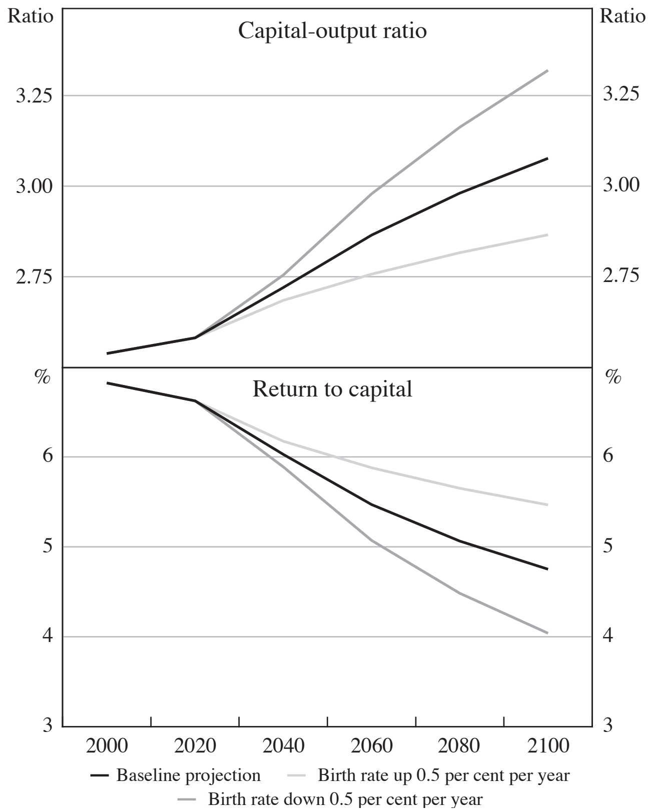
Notes: Dates refer to the beginning of the 20-year window. Author's calculations are based on demographic data from the World Bank and UN combined with productivity data from the Penn World Tables. The effective labour force weights workers by their country's total factor productivity (TFP) relative to the US. Future TFP is extrapolated across countries from 1980–2000.

Sources: Heston *et al* (2002); UN Population Division (2005); World Bank (2006); author's calculations

The alternative scenarios highlight the unavoidable fact that macroeconomic projections are conditional on productivity growth. If productivity growth were to accelerate sharply, the effective labour force could display accelerating growth despite the demographic transition. However, Figure 2 suggests that a substantial increase in productivity growth – of around one per cent per year persisting indefinitely – would be required to swamp the projected decline in population growth. Models are best compared for a common growth scenario; the figures below are conditional on the baseline growth assumptions.

Figure 3 shows the implications of declining labour force growth for the world capital-output ratio and for the world return to capital. Both panels display a

Figure 3: The Solow-Swan Model – Implications for Capital and Returns



Note: See Section 2 for an explanation of calculations used.

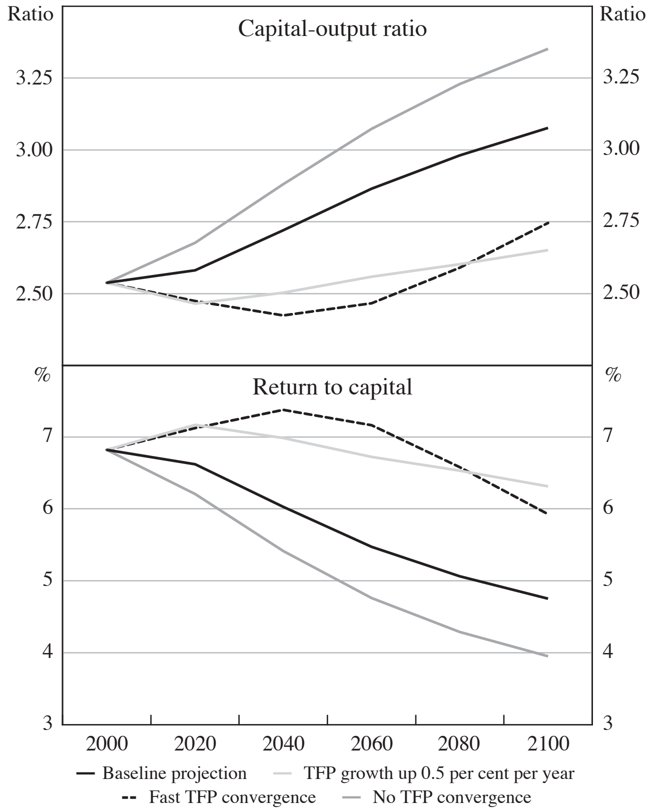
Source: author's calculations

baseline projection and two alternative demographic scenarios, one with a 0.5 per cent higher birth rate, the other with a 0.5 per cent lower birth rate. Although the economic intuition is about capital versus *labour*, I display the capital-*output* ratio for convenience. The capital-labour and capital-output ratios are one-for-one transformations of each other. The capital-output ratio is unit-free (dollars divided by dollars) and easier to display than the capital-labour ratio (which is 'dollars per efficiency units of labour').

Figure 3 (top panel) demonstrates that declining population growth implies higher capital-output and capital-labour ratios – the phenomenon of *capital deepening*. Higher capital-labour and capital-output ratios always imply higher wages and lower returns to capital. Returns are displayed in the lower panel. Capital deepening is magnified or reduced if the rate of population growth declines by more or less than the baseline.

In optimising models, comments on longevity, growth in health spending and declining youth dependency would be appropriate at this point. But because the

Figure 4: The Solow-Swan Model – Sensitivity Analysis for Productivity Growth



Notes: See Section 2 for an explanation of calculations used. The fast convergence and no convergence scenarios correspond to Alternatives 1 and 2 in Figure 2.

Source: author's calculations

saving rate is assumed to be constant, these factors are irrelevant in the Solow-Swan model.

As an illustration of how sensitive macroeconomic projections are to productivity growth, Figure 4 displays the baseline projections together with three alternative scenarios according to different TFP growth assumptions: fast convergence of world TFP to US levels (the Lucas 2000 case), no TFP convergence (slower growth), and a scenario with permanently higher US and world TFP growth. With a fixed saving rate, slower productivity growth has the same implications as a lower birth rate – capital deepening increases and the return to capital declines more sharply. Faster productivity growth has the opposite effects and may raise returns despite the reduced population growth.

The Solow-Swan model sets the stage for examining optimal saving behaviour.

3. Optimal Saving in the Life-cycle Model

The dominant framework for research on demographic change is a life-cycle model for individual saving combined with neoclassical production. Life-cycle optimisation assumes that individuals maximise preferences defined over their own consumption. Economic activity is determined by a succession of overlapping generations. The logic of capital deepening remains valid, but the saving rate may vary over time.

Any life-cycle model must address three key questions of model design: how to deal with the uncertain timing of death, how to support children and how to determine the age at which individuals start to save for retirement. Uncertain mortality raises the spectre of involuntary, 'accidental' bequests. Children's consumption does not mesh well with the premise of selfish individual optimisation. Children can only be included with altruistic add-ons, and they are often ignored. (Models commonly assume that life starts at age 20.) Finally, empirical evidence suggests that young households do not save much for retirement until about age 40 (Poterba 2001, 2004). Plausible explanations include child-rearing expenses, purchases of durable goods and an upward-sloping age-earnings profile. One must infer that aggregate saving depends importantly on the population share of the middle-aged working cohort.

In the literature, accidental bequests are sometimes avoided by the unrealistic assumption of perfect annuity markets. Bequests are empirically significant, however, and they have a major impact on saving incentives and on the resources available to savers.[3]

My version of the life-cycle model accounts for bequests by constraining retirees to leave an exogenous fraction of their resources – the *bequest share* – to the next cohort. The life-cycle is divided into four stages of 20 years: childhood (ages 0–19), young working life (ages 20–39), middle-aged working life (ages 40–59) and retirement (ages 60+). I deal with childhood by assuming that parents care about children's consumption while they are in the household. And I impose a link between age and saving by assuming that young workers are liquidity-constrained and spend their wage income on their own and their children's consumption. The assumption of liquidity-constrained young follows Constantinides, Donaldson and Mehra (2002).

The middle-aged workers are the key cohort for the macroeconomic dynamics. They divide their wage income and incoming bequests from their parents between consumption and capital accumulation. Retirees would like to consume all their wealth – principal and total returns – but are constrained to consume no more than 1 minus the bequest share.

3. Bequest motives and the quantitative role of bequests are the subject of an extensive debate. See Kopczuk and Lupton (2005) for a recent review and discussion of bequest motives. While bequest motives are still controversial, it seems clear that bequests account for a substantial fraction of aggregate wealth. Kotlikoff and Summers (1981) suggest values as high as 46 per cent for the US.

The bequest share is primarily meant to capture accidental bequests but it can be interpreted more broadly. For example, individuals may have preferences over wealth in addition to consumption, perhaps as a reduced form of preferences for the power and status associated with wealth. If preferences are homothetic over consumption and wealth, a constant bequest share would be optimal.[4] Because the public sector is not modelled separately, bequests also include the uncompensated transfer of public assets to the next generation, notably infrastructure and positive or negative fiscal transfers.

Bequest shares may depend on institutional factors that could change over time. Public policy determines the reliability of retirees' access to public transfers and the extent to which infrastructure investments are debt-financed. Accidental bequests are presumably related to market structures that determine the ability of individuals to annuitise assets. Accidental bequests may also depend on social institutions that determine the need for self-insurance, including against health risks.

The life-cycle model identifies several determinants of optimal saving and it explains their role in the context of the population ageing:

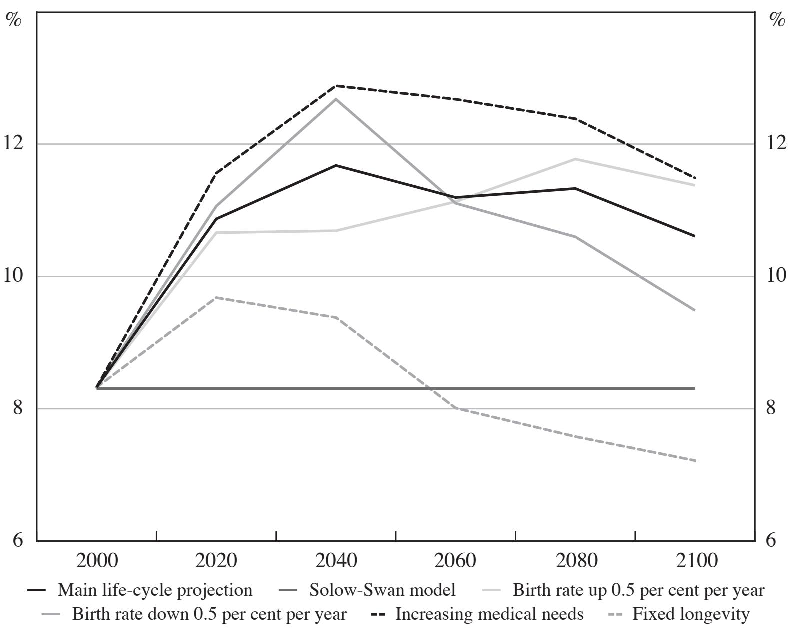
1. **Increasing longevity** – an obvious motive for increased saving. More savings implies a higher capital-labour ratio, that is, more capital deepening.
2. **Increasing medical needs**: Spending on health care is increasing around the world, a trend apparently motivated by rapid improvements in medical technology. Because medical needs increase with age, this can be interpreted as a shift in preferences towards old-age consumption. The optimal response is to save more.
3. **An increasing share of retirees**: Declining population growth implies a growing share of retirees in the population. Their attempts to consume accumulated wealth should trigger dissaving. Empirical evidence suggests, however, that dissaving by retirees is less than simple life-cycle reasoning would indicate (Poterba 2001, 2004), again suggesting a role for bequests. A greater ratio of retirees to bequest-receiving younger cohorts implies greater bequests per recipient. Because the recipients are savers, the effect of retiree dissavings is reduced.
4. **Shifts in the age distribution of wage income**: Declining population growth also implies that middle-aged workers receive a greater share of aggregate wage incomes. The effect is to increase the aggregate saving rate.
5. **Effects of a declining return to capital**: On aggregate, the return to savings is the return to world capital. Provided capital deepening takes place (as suggested by the arguments above) the return to capital will decline. This has conflicting substitution and income effects. While saving becomes less rewarding at the margin, a given wealth provides less retirement income.

4. A 'warm glow' type of altruism could also be modelled through bequest shares. Suppose individuals had homothetic preferences over their own consumption and per-recipient bequests. For constant longevity and a constant number of descendents, a constant bequest share would again be optimal. If longevity increases and the number of descendents decreases, however, the optimal bequest share would decline over time. To avoid clutter, I do not model 'warm glow' altruism separately; the implications for savings go in the same direction as the dynastic model discussed in Section 4.

The relative magnitude of the substitution and income effects is determined by the elasticity of intertemporal substitution (EIS). Empirical estimates favour a low EIS and suggest that income effects dominate (Hall 1988, Ogaki and Reinhart 1998). Demographic changes that trigger capital deepening will therefore tend to increase the saving rate. This reinforces capital deepening and magnifies the decline in returns.

Figures 5 and 6 illustrate the impact of demographic changes in the stylised life-cycle model. For the calibration, I distinguish four world regions: (1) the US; (2) seven other high-income G-20 countries;[5] (3) eleven less-developed G-20 countries (the other individual members); and (4) the ROW.[6] Regions 2 and 3 are distinguished by high versus low per-capita income and quite different demographics. The US is modelled separately because of its size and unusual demographics – a rich country with a poor-country birth rate. In the G-20 regions, population dynamics are built up from country-level data. Initial capital stocks are determined by equating 1980 values to the steady-state. Capital in 2000 is computed from 1980 values and world investment rates for 1980–2000. World wealth (ownership of capital) in 2000 is attributed to regions according to 1980 capital stocks and regional saving rates

Figure 5: The Life-cycle Model – Projected Net Saving Rates

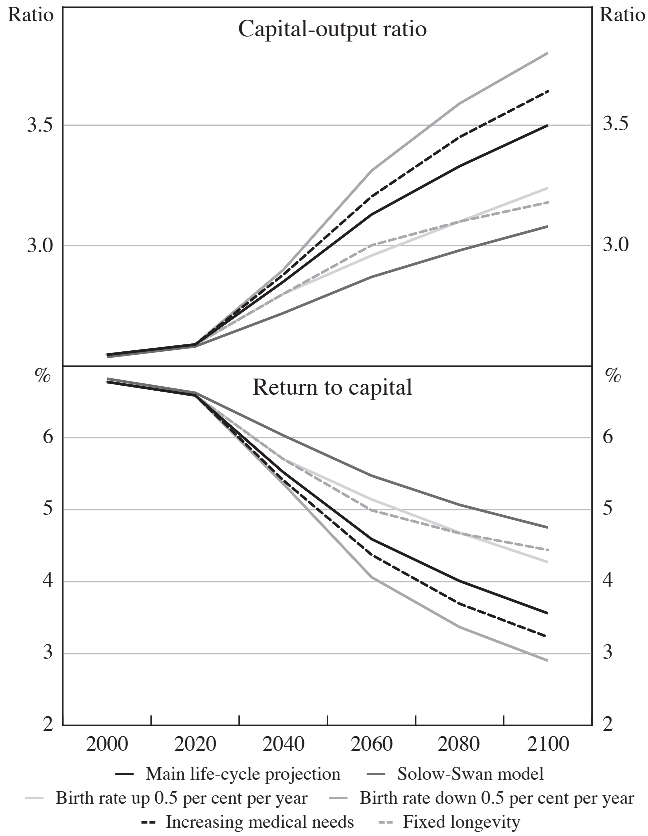


Notes: Calculations are based on the life-cycle model described in Section 3. The main projection is calibrated to match actual savings in 2000.

Source: author's calculations

5. Australia, Canada, France, Germany, Italy, Japan and the United Kingdom.
6. The disaggregation is mainly for better comparability with the multi-country literature. The model would yield similar qualitative insights if one treated the world as a single region.

Figure 6: The Life-cycle Model – Implications for Capital and Returns



Note: Calculations are based on the life-cycle model described in Section 3.

Source: author's calculations

for 1980–2000. I assume an EIS equal to 0.5 and a 1 per cent annual rate of time preference.

The bequest shares are calibrated so that each region's saving rate in 2000 matches actual saving rates. The calibrated bequest shares are 24 per cent for the US, 43 per cent for the high-income G-20 countries, 57 per cent for the less-developed G-20 and 30 per cent for the ROW. While one might quibble with these assumptions about bequests, an interpretation of bequests as exogenous is unavoidable if one wants to interpret the world as populated by life-cycle savers. The US value is broadly consistent with empirical evidence on bequests (Kopczuk and Lupton 2005). Higher bequest shares elsewhere are consistent with the notion that accidental bequests are higher when financial markets are less developed and if retirees are forced to hold substantial wealth for self-insurance purposes. (High bequest shares are of course consistent with altruism; this is pursued in the next section.)

Figure 5 presents the model's implications for saving rates under a number of assumptions about future demographic trends and consumption preferences. The main projection shows a substantial increase in net saving rates. The alternatives with higher and lower birth rates show that birth rates matter relatively little in the short run, but they influence the saving rate in the longer run, consistent with their impact on the population share of retirees. The fixed-longevity alternative highlights the key role of longevity in this model. If longevity were to remain fixed at year-2000 values, the projected increase in the saving rate would largely vanish. A final alternative projection illustrates the role of medical expenses, specifically a doubling of retiree medical consumption over 2020–2080; in this scenario, the saving rate increases more than in the main projection. Overall, saving rates increase in response to population ageing.

Figure 6 displays the implied capital-output ratios and returns to capital. For both variables, the projected higher saving rates reinforce the capital-deepening effects predicted by the Solow-Swan model. The return to capital declines sharply in all scenarios – in popular terminology, the model suggests a major global savings glut.

The prediction of a higher saving rate in response to population ageing is not a universal feature of life-cycle models. The IMF (2004), for example, projects European and Japanese saving rates to *decline* by 12 percentage points of GDP, with no substantial increases elsewhere. The IMF model assumes zero bequests and an expansion of retiree transfers as a share of GDP to finance unchanged benefits. Both assumptions clearly depress saving rates. Note that these mixed findings in the literature are limited to the saving rate. That is, *rising capital-labour ratios and declining returns on capital are robust findings in life-cycle models of world population ageing*.[7]

Finally, note that youth dependency would matter in a life-cycle model without liquidity constraints. If young families can borrow, a smaller number of children will shift optimal spending into older ages and reduce young-age borrowing. The trend towards more education spending per child goes in the other direction, however. The net effect of less spending on youth would be to further increase the aggregate saving rates. Hence youth dependency considerations are likely to strengthen the projected increase in the saving rate and the decline in returns.

4. Optimal Savings and Bequests in the Dynastic Model

The dynastic model assumes that individuals value their children's utility. Because these children care about their own children – the initial generation's grandchildren – individuals care about the welfare of all future generations.

7. Coverage of developing countries matters in this context. Declining capital-labour ratios are sometimes found in life-cycle models of developed countries, notably when one assumes rapid (and potentially unsustainable) rises in public transfers to retirees. When developing countries are included, however, declines in the capital-labour ratio turn into increases, for example when moving from developed countries in Fehr *et al* (2005) to developed countries plus China in Fehr *et al* (this volume).

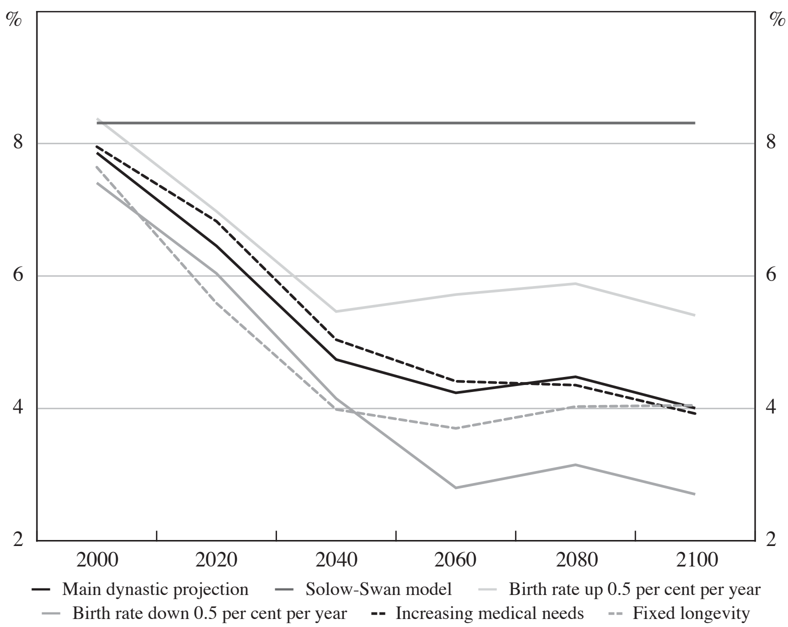
The dynastic model is interesting because it endogenises bequests and suggests very forward-looking behaviour. Future demographic developments that impact the well-being of future generations have an impact on optimal current saving and bequests. Optimal individual behaviour with altruism can also be interpreted as maximising a social welfare function. This makes the dynastic model of independent interest for policy analysis. Elmendorf and Sheiner (2000) use the dynastic model to examine the US demographic transition; this section applies similar reasoning to the world economy.

The endogeneity of bequests has striking consequences for the return to capital in the very long run. Individuals reduce bequests whenever the return falls below the discount rate on their children's utility. The resulting fall in the capital-labour ratio counteracts the initial disturbance and raises the return to capital. This endogenous return-stabilising mechanism keeps the return to capital stationary regardless of demographic changes. In response to population ageing, unchanged savings and bequests would imply lower returns. Hence the dynastic model necessarily implies a *decline* in savings and bequests.

The dynastic model does not rule out temporary changes in the return to capital. Such changes may occur as income and consumption needs vary during a demographic transition. This is best examined quantitatively.

Figures 7 and 8 display the model's implications for optimal world saving, capital-output ratios and the returns to capital. The model's structure is comparable

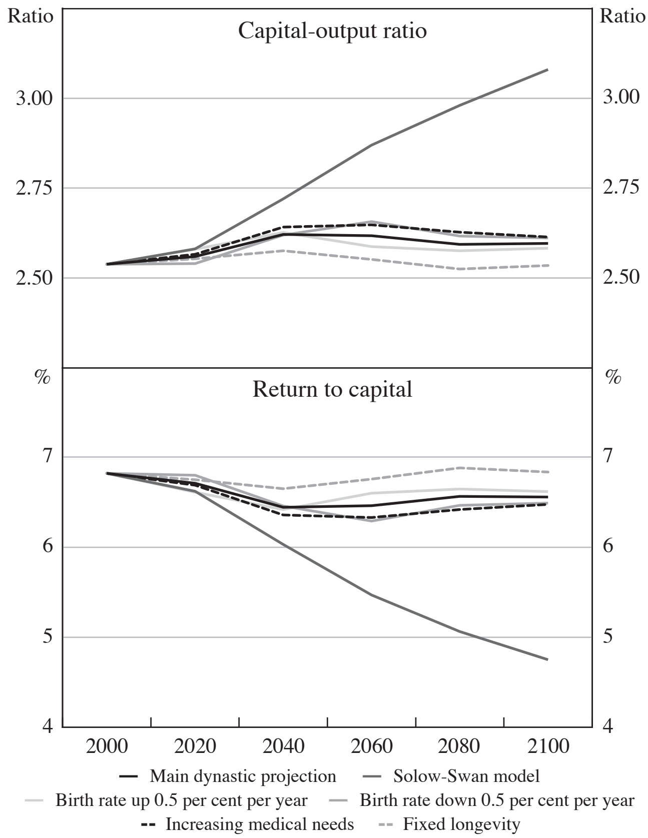
Figure 7: The Dynastic Model – Projected Net Saving Rates



Note: Calculations are based on the dynastic model described in Section 4.

Source: author's calculations

Figure 8: The Dynastic Model – Implications for Capital and Returns



Note: Calculations are based on the dynastic model described in Section 4.

Source: author's calculations

to the life-cycle model but with altruism. I assume a discount rate on children's consumption consistent with a 6 per cent steady-state return to capital. (See Appendix A for more details.)

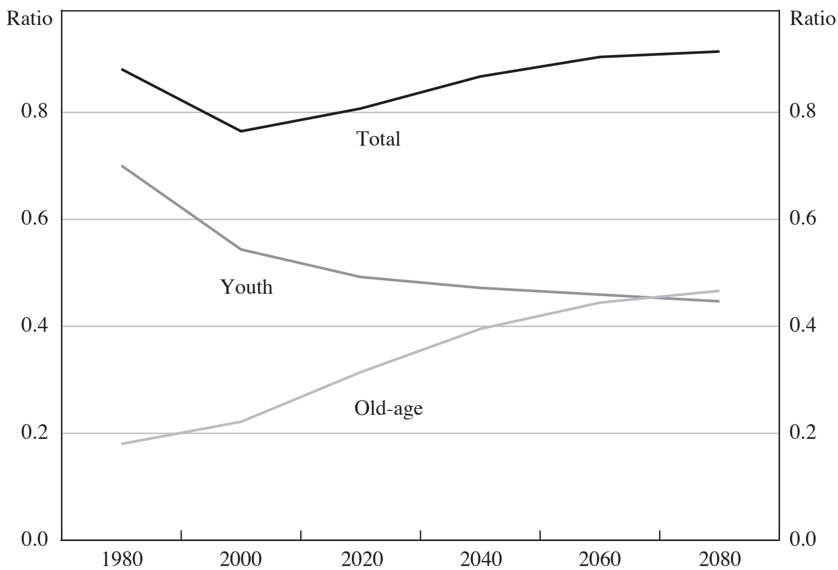
The optimal saving rates in Figure 7 show a substantial and persistent decline in the main projection and in all the alternatives. In this model, saving rates for 2000 are optimised and not calibrated to match actual saving rates, but they match quite well. The capital-output ratios in Figure 8 (top panel) increase slightly and then decline. The returns to capital in Figure 8 (lower panel) mirror the capital-output ratios, declining first and then increasing.

Three features of the calibrated findings deserve comment. First, a central finding is that in the dynastic model returns to capital are fairly stable over time and across scenarios. This stands in contrast to the secular declines projected in the Solow-Swan and life-cycle models. *In the dynastic model, population ageing does not imply capital deepening*. The economic intuition regarding this result is that fewer births implies a reduced weight on future generations in the dynastic preferences. There is no need to endow them with more capital than current cohorts. The saving rate declines sharply. The length of retirement and the level of old-age medical expenses have very little impact. At the margin, higher retirement and medical spending are financed by reductions in bequests.

Second, projected returns show a temporary decline around 2040. Figure 9 provides the economic intuition. During the demographic transition, youth dependency declines with the birth rate, whereas old-age dependency rises with longevity. Until about 2020, birth rates decline more than longevity rises. The ratio of the non-working-age population to the labour force – the total dependency ratio – declines temporarily. This means that per-capita income is high relative to per-capita demand for consumption. The optimal private response is to accumulate more capital. This raises the capital-output ratio and it reduces the return to capital into 2040, as shown in Figure 8. The slight dip in returns provides the correct incentives for individuals to shift consumption into this period.

Third, projected returns remain above the 6 per cent steady-state value towards the end of the projection period, seemingly contradicting convergence to a steady-state. The intuition is that the dynastic model's optimal forward-looking behaviour is sensitive to variations in the effective labour force far into the future. The main

Figure 9: Youth and Old-age Dependency Ratios



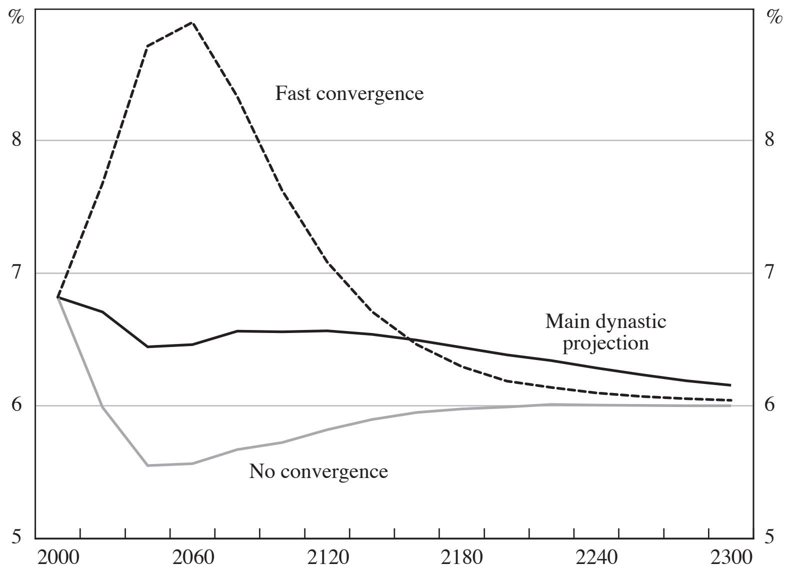
Notes: Dates refer to the beginning of the 20-year window. The youth dependency ratio is the ratio of the world population aged 0–19 to the world population aged 20–59. The old-age dependency ratio is the ratio of the world population aged 60+ to the world population aged 20–59. The total dependency ratio is the sum of the youth dependency ratio and the old-age dependency ratio.

Sources: World Bank (2006); author's calculations projection assumes a slow convergence of world productivity to the US level. Slow convergence implies a prolonged period of productivity growth above the steady-state growth rate and hence returns to capital above the steady-state level.

Figure 10 displays returns to capital over a longer horizon and for alternative growth scenarios. This is to clarify the relationship between productivity convergence and convergence of returns and as a reminder that demographic findings are conditional on growth. The scenario with fast cross-country convergence in *productivity* implies higher growth and higher returns to capital in the transition than the main scenario. As productivity convergence nears completion, world productivity growth converges down to the US rate (1.5 per cent) and the return to capital converges to the 6 per cent steady-state level. In the main projection, productivity convergence is slower. This explains why productivity growth and the return to capital remain slightly above the steady-state values for several hundred years. In the scenario without productivity convergence, growth never rises above the US level and the return to capital approaches the steady-state from below.[8]

Figure 10: The Dynastic Model – Sensitivity Analysis for Productivity Growth

Return to capital



Notes: Calculations are based on the dynastic model described in Section 4. The fast convergence and no convergence scenarios correspond to Alternatives 1 and 2 in Figure 2.

Source: author's calculations

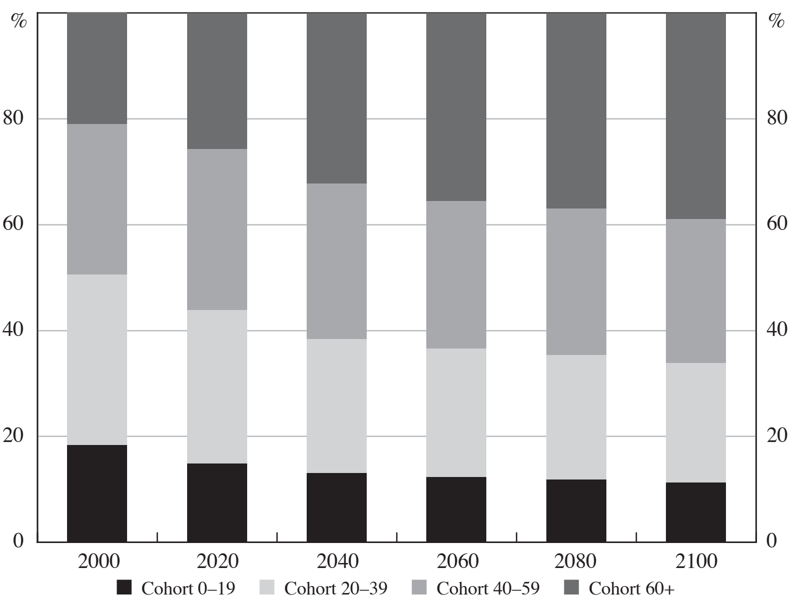
8. The below-normal growth in the 'no convergence' case is due to a composition effect. TFP relative to the US productivity remains constant. The labour force grows faster in relatively poor countries. This reduces the growth in average world productivity until the demographic transition is complete.

Note that returns would also be higher (or lower) if the labour force were to grow faster (or more slowly) for other reasons. The labour force would expand, for example, if retirement were delayed – say, due to improving old-age health – or if female labour force participation increased. On the other hand, if innovation was linked to youth, an ageing population would reduce the effective labour supply. Labour supply would also decline if households decided to substitute leisure for consumption (for example, if leisure is a superior good in the long run). One may suspect, however, that these factors are swamped by uncertainty about future productivity and birth rates. This motivates my focus on saving and bequests as the main endogenous variables and on growth comparisons for sensitivity analysis.

Returning to the main projection, the dynastic model yields a detailed account of optimal consumption and optimal intergenerational transfers. This is shown in Figure 11 and the top panel of Figure 12. The allocation of consumption in Figure 11 documents an increase in optimal retiree consumption at the expense of childhood consumption, reflecting the shift in population shares.

Figure 11: Consumption in the Dynastic Model

Optimal allocation across cohorts

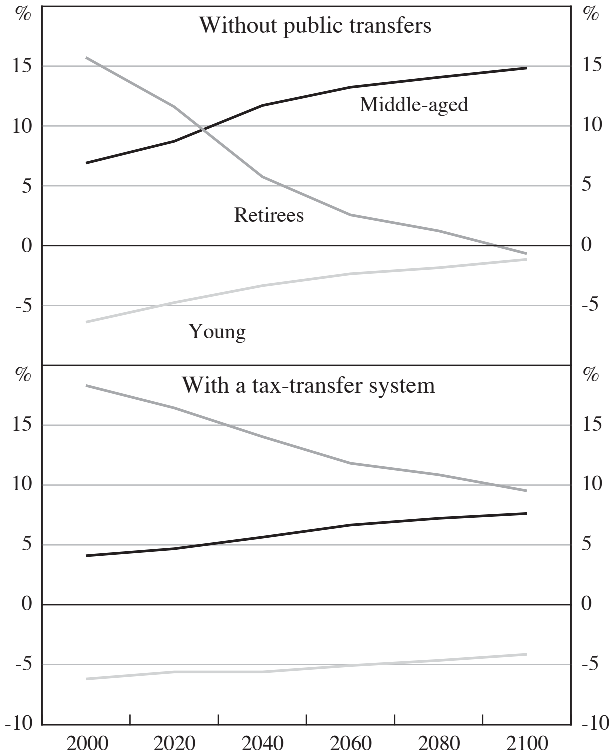


Note: Calculations based on the dynastic model described in Section 4 – main projection assumes no public transfers

Source: author's calculations

Figure 12 displays 'primary balances' of the respective cohorts, the gaps between own factor incomes and own consumption. Childhood consumption is included in the household consumption in young working-age (20–39). Capital income is attributed to retirees (60+). The sum adds up to the gross investment rate. The primary balance in old age is also the amount optimally bequeathed, gifted, or otherwise transferred

Figure 12: Primary Balances in the Dynastic Model
Per cent of aggregate income



Notes: Calculations based on the dynastic model described in Section 4 – main projection. Under the tax-transfer system, a labour income tax pays for public pensions and for all education spending. Public pensions cover 15 per cent of retiree needs in 2000 with increasing trend to 30 per cent in 2040.

Source: author's calculations

to subsequent cohorts. Figure 12 (top panel) yields two key insights. First, optimal bequests are currently positive and quite high. Second, optimal bequests are projected to decline sharply during the demographic transition.

The sharp decline in bequests raises questions about a lower bound. Individual bequests in a literal sense must be non-negative. Bequests at the macroeconomic level are more complicated. If annuity markets are imperfect – say, due to adverse selection – accidental bequests must be strictly positive. Negative bequests may be feasible through public debt that exceeds the value of public capital. Either way, the key point is that a lower bound on aggregate bequests is likely to exist. I will call an economy *bequest-constrained*, if bequests are at the lower bound.[9]

9. The definition clearly disregards heterogeneity across consumers, that is the possibility that some dynasties are constrained and others are not. This is to maintain a focus on macroeconomic issues.

Figure 12 (top panel) suggests that the world economy will eventually become bequest-constrained. At that time, dynastic reasoning would become irrelevant; a regime shift from a dynastic to life-cycle setting with exogenous bequests would take place. The key questions are then: is this likely to happen, and when?

5. Will Population Ageing Trigger a Regime Shift?

The answer is unfortunately not straightforward.

A major complication is the endogeneity of public institutions. A generation of retirees can avoid bequest constraints if it manages to create public institutions such as pensions, public debt and pay-as-you-go financed health benefits. The common effect of such institutions is to expand the resources controlled by retirees and hence to relax the bequest constraint. Political support for retiree transfers does not necessarily decline as the population ages; the share of old voters is increasing. Future generations that will have to pay for intergenerational transfers are not there to vote against them.[10]

To illustrate the impact of public transfers, Figure 12 (lower panel) shows primary balances adjusted for a stylised tax-transfer system. The calibration assumes that education is publicly funded and that public transfers cover 15 per cent of retiree spending in 2000, rising to 30 per cent by 2040, all financed through payroll taxes. Comparing the two panels of Figure 12, one finds that transfers substantially increase retirees' primary balances. The point is that, regardless of an economy's 'natural' lower bound on bequests, retirees can avoid bequest constraints by sufficiently expanding government transfers.

Rising retiree transfers would, however, create increased political risk. Hence, one may wonder if transfers are somehow bounded and a shift from a dynastic regime to a bequest-constrained regime will eventually take place. While this is difficult to resolve in theory, there are observable indicators that might help in practice.

To identify regimes, recall that the dynastic model applies when retirees have a surplus of resources to bequeath. Factors that might favour a dynastic equilibrium therefore include: (i) a low life expectancy in retirement; (ii) a resource-based economy where fixed assets (for example land, oil reserves) are often bequeathed; and (iii) stable public institutions that provides retirees with generous transfers and insurance against risks. Another important indicator is a relative stable return to capital.

10. Bohn (2005) examines voting on US Social Security and Medicare in some detail. Both provide net benefits for a majority of older voters. Benefits are negative at young ages, but affect only a minority of voters. Analogous considerations should apply elsewhere. Boldrin and Montes (2005) provide a similar, though more benign, perspective of retiree transfers. They note that education is commonly provided publicly and suggest that public pensions can be interpreted as a repayment of implicit loans for education. It is not clear why Boldrin and Montes limit their interpretation to spending on education. Total parental support for children, for consumption and education, vastly exceeds any reasonable measure of net transfers to retirees, now and in the foreseeable future. In the spirit of Boldrin and Montes, one may therefore interpret all retiree transfers as partial repayment of childhood support.

The life-cycle model applies when old-age resources are sufficiently scarce that retirees would like to dissave more than they can. Factors that tend to favour a bequest-constrained life-cycle equilibrium therefore include: (i) longevity; (ii) an economy centred on human capital, where substantial transfers take place early in life as parents finance their children's education; and (iii) an unstable political system that does not provide retirees with reliable transfers or with social insurance.

Rising longevity clearly favours a transition from a dynastic to a bequest-constrained equilibrium. Economic growth points in the same direction, because economic development typically involves a decline in agrarian and industrial activities based on fixed assets and a transition to a knowledge-based society with more spending on education.

More-developed economies tend to have more stable governments, a more stable tax base and often more generous public pension and social insurance programs, consistent with a dynastic equilibrium. Public transfers are undermined, however, by the trend towards increased international openness that exposes governments to increasing tax competition (see below). Another important consideration for more-developed economies is the increasing sophistication of financial markets (which allow for annuitisation, thereby avoiding unintended bequests). With regard to annuities, market solutions are unfortunately constrained by adverse selection.

The indicators for the US and Europe are mixed. *Prima facie*, a significant share of retirees seem to act like life-cycle savers, relying largely on annuitised public pensions and holding little or no wealth for bequests. Others leave bequests, however, and according to US evidence, a majority of people have a bequest motive (Kopczuk and Lupton 2005). More indirect indicators are the historical stability of equity returns, the pervasive lack of interest in private annuities and reverse mortgages, and the ongoing pension reform debate.

Returns to capital have been remarkably stable over the past 200 years, despite substantial demographic changes. The stability of returns is well-recognised in growth theory and has been much studied in finance (see Siegel 1994, for example). The historical stability of returns is consistent with the dynastic model and difficult to reconcile with the drifting returns commonly found in life-cycle models.

Lack of interest in private annuities and reverse mortgages also fits the dynastic model. Life-cycle savers should annuitise all their financial assets. Even if annuities are actuarially unfair, life-cycle savers should prefer unfair payouts to leaving bequests. Similarly, life-cycle savers should take out reverse mortgages on their homes even if such mortgages are actuarially unfair.

The growth in public pensions in recent decades and the reform debate suggest that the dynastic model may be on the verge of becoming less relevant in many developed economies, at least looking forward. Recent pension reforms in Europe suggest that there is not much scope for further growth in the coverage or generosity of these systems. In the US, where public pensions are smaller, the recent expansion of Medicare (Part D) suggests that politicians still see room for growth. Yet the sustainability of social security and Medicare is widely questioned. In a dynastic setting, public pensions should be politically less interesting because 'excess' pensions would be returned to children as gifts or bequests – that is, Ricardian neutrality applies. However, major disputes about pensions suggest that they do matter.

In combination, these observations are consistent with the hypothesis that US and European retirees are on the edge of being bequest-constrained, but not yet seriously constrained – that bequests and the shadow value of bequest constraints are both near zero. One may argue that this knife-edge economic scenario represents a stable situation from a political-economy perspective – an equilibrium with 'soft' bequest constraints. The US and Europe may have been in this equilibrium for some time, perhaps decades.[11] This assessment is consistent with the growth in public pensions throughout the 20th century. Similar considerations may apply to Australia, Canada, Japan and other developed countries.

Less-developed countries, in contrast, appear to be far from a life-cycle savings regime. Public pensions and other transfer systems are more rudimentary. Traded equities are much smaller relative to GDP than in developed countries. Most national wealth is concentrated in family-based firms where ownership tends to be inherited and not purchased. This suggests a prevalence of wealth accumulation through bequests.

To conclude, it seems reasonable to use life-cycle reasoning for the US, Europe and some other developed economies, at least looking forward, but not for the entire world.

Note that life-cycle models can be useful even if bequest constraints are soft. They correctly describe individual behaviour, provided bequests and other intergenerational transfers are correctly calibrated. Dynastic and life-cycle models should then yield similar results. One must be careful, however, to reconcile potentially conflicting predictions, notably about bequests and about returns to capital.

Figure 13 illustrates how life-cycle projections can be modified if one alters assumptions about bequests as suggested by the dynastic model. The figure displays projections from the life-cycle model under the assumption that retirees will find ways to avoid unintentional bequests. Specifically, I assume that by 2040, bequest shares in all countries decline to 50 per cent of the current US level. For comparison, the figure also shows the basic Solow-Swan, life-cycle and dynastic projections. The life-cycle projections with declining bequests are much closer to the dynastic scenario than to the basic life-cycle scenario. Returns to capital remain stable until bequests reach a fixed (lower bound) level.

In summary, life-cycle predictions for the world economy should be interpreted with caution if large parts of the world are not – at least not yet – bequest-constrained. A major decline in the return to capital seems unlikely until bequest constraints start binding and until individuals have economised on accidental bequests.

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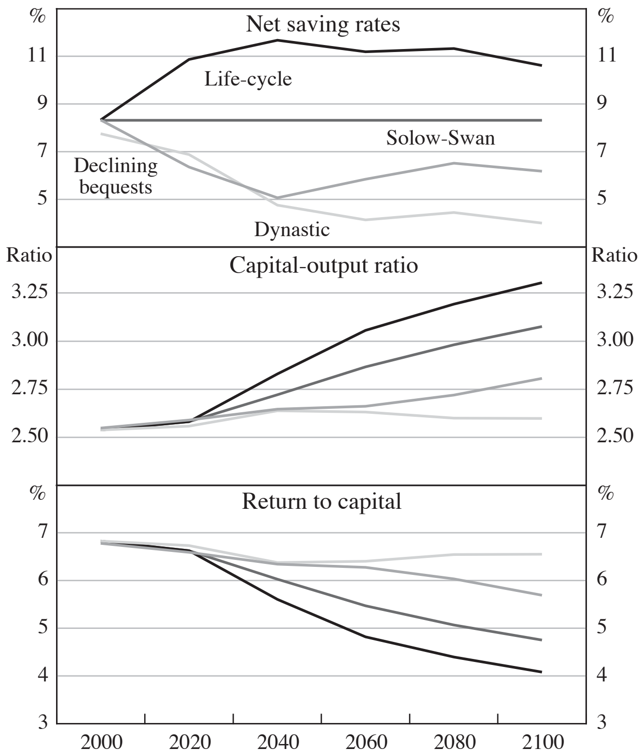
11. The argument is that no voter is interested in expanding transfers beyond the point where Ricardian neutrality applies, given the inefficiencies of a too-big government. Voters have a clear incentive, on the other hand, to create pension entitlements and public debt if necessary to avoid 'hard' bequest constraints in old age. A gradual expansion of pensions just enough to avoid hard constraints is a plausible outcome.

Figure 13: Scenario with Declining Bequests in the Life-cycle Model



Notes: Declining bequests refers to the life-cycle model with US bequests share declining 50 per cent by 2040 and other countries' bequests converging to the US level by 2040, as explained in Section 5. The other scenarios replicate the main projections from Sections 2 to 4, for comparison.

Source: author's calculations

6. Capital and Labour Mobility, Platform Competition and Risk-sharing

This section examines a set of interrelated issues regarding factor mobility, economic policy and financial markets.

The standard approach in multi-country models with capital mobility is to assume largely immobile labour. Because labour is immobile, capital must move internationally to equip labour with the efficient stock of capital. This approach has led analysts to focus on capital flows and on the implications of capital income taxes. Source-based capital income taxes – taxes on dividends, interest and capital gains – clearly distort the spatial allocation of capital. Expectations of future taxes (or more broadly, concerns about expropriation, regulation and other return-reducing measures) are also distortionary because capital investment is driven by expected returns. A perfectly efficient allocation of capital would require perfectly credible government promises not to tax returns.

Labour has become increasingly mobile around the world. While some countries have long welcomed immigrants – notably Australia, Canada and the US – declining transport costs are enabling an increasing number of people to move abroad in search of employment opportunities, with or without permission. This is important for two reasons.

First, labour mobility is a substitute for capital mobility for questions of production efficiency. If capital were immobile, capital-labour ratios could still be equalised across countries by mobile workers. A world with perfectly mobile labour would have the same world capital-labour ratio as a world with mobile capital. The returns to capital and the returns to labour (per efficiency unit) are equalised in either case. Note that workers have no incentive to move if capital is allocated efficiently. Migration is thus an indicator of inefficiency in the allocation of capital. Plausible sources of such inefficiencies are capital income taxes and concerns about capital levies in the future.

Second, labour mobility combined with capital mobility has drastic implications for fiscal policy that deserve more attention. In models with at least one immobile factor of production, the location of the fixed factor(s) determines the geography of production. But what if all factors of production become mobile? What determines where production takes place and where factor incomes can be taxed?

To a first approximation, the cross-country allocation of production becomes indeterminate without fixed factors. Given first-order indeterminacy, location decisions are determined by factors and considerations that would otherwise be considered secondary and perhaps ignored, for example geographical features such as harbours, coastlines, or soil quality. Relative to the remaining 'natural' fixed factors, public policy – taxation and the provision of public infrastructure – becomes vastly more important. It has first-order effects on the location of capital *and* labour.

A numerical example helps to illustrate the ramifications of mobility.

Example: Consider an economy that takes world factor prices as exogenous. Output is produced from capital and labour at constant returns to scale, but with a small congestion effect – say, an externality due to a fixed land area. For the illustration, let TFP depend on population density with elasticity ε, a small negative number. Domestic supplies of capital and labour may respond to returns and wages, though this will be inessential. To be specific consider $\varepsilon = -1$ per cent and $\varepsilon = -2$ per cent (for comparison), let domestic capital supply have an elasticity of 0.5 with respect to capital income and let labour supply have an elasticity of 0.5 with respect to wages.[12]

Table 1 displays elasticities of capital and labour in domestic production with respect to capital and labour income taxes under three alternative assumptions about mobility. Tax responses are expressed as elasticities with respect to $(1-\tau)$, where τ is the tax rate (on either capital or labour income). A positive value means that a tax reduction (a higher '$1-\tau$') attracts capital and/or labour. The implied capital-labour ratio and output responses are also provided.

12. Additional technical assumptions are that production is Cobb-Douglas with a capital share of 0.30, depreciation is 5 per cent and the world capital-labour ratio is 2.5.

Table 1: The Impact of Capital and Labour Mobility on Taxes – A Numerical Example

Mobility of capital:	Fixed		Mobile		Mobile	
Mobility of labour:	Fixed		Fixed		Mobile	
Externality:	1%	2%	1%	2%	1%	2%
	Elasticities with respect to (1–τ)					
Capital stock						
Capital tax	0.38	0.38	**1.64**	**1.64**	**44.30**	**22.90**
Labour tax	0.12	0.12	0.50	0.50	**100.00**	**50.00**
Labour force						
Capital tax	0.05	0.05	0.21	0.21	**42.90**	**21.30**
Labour tax	0.45	0.45	0.50	0.50	**100.00**	**50.00**
Capital-labour ratio						
Capital tax	0.33	0.33	**1.43**	**1.43**	**1.43**	**1.43**
Labour tax	–0.33	–0.33	0.00	0.00	0.00	0.00
Output						
Capital tax	0.15	0.15	0.64	0.64	**42.70**	**21.60**
Labour tax	0.35	0.34	0.49	0.49	**98.60**	**49.30**

Note: Values >1 are highlighted in bold.
Source: author's calculations

If the economy is closed, all the tax elasticities are less than 0.5, that is, less than the local factor supply elasticities (data columns 1 and 2). Capital and labour respond negatively to both taxes because they are complements in production. The congestion effect is essentially irrelevant, clearly secondary.

If capital is mobile but labour is fixed (columns 3 and 4), capital, output and the capital-labour ratio respond much more strongly to capital income taxes – confirming conventional wisdom – whereas labour income taxes have a similar impact as in the closed economy. The capital and the capital-labour ratio respond elastically to capital income taxes regardless of local capital and labour supplies.[13] Congestion effects are still secondary.

Now consider mobile capital and mobile labour (columns 5 and 6). Capital, labour and output all display huge responses to both capital and labour taxes. The responses are governed almost entirely by the congestion effect and not by the fundamentals of production and factor supplies.[14] In equilibrium, reduced taxes trigger an inflow of capital and labour until congestion has increased enough to offset the competitive

13. The elasticity of the capital-labour ratio is always 1/(1–capital share); it depends only on the capital share.

14. The labour response to a labour tax is simply $|1/\varepsilon|$ (100 for $\varepsilon = -1$ per cent, 50 for $\varepsilon = -2$ per cent). The labour response to a capital tax is $|1/\varepsilon|$ times (capital share)/(1–capital share) $\cong$ 0.43. Because the capital-labour ratio remains unchanged, output responses equal the labour responses minus the congestion effect.

advantage of lower taxes. A tax increase would trigger capital and labour outflows until congestion has decreased enough to offset the competitive disadvantage.

The example demonstrates that moving from one to two mobile factors implies a quantum leap in the responsiveness of capital, labour and domestic output to changes in tax rates. Traditional discretionary income taxation would become almost impossible. Consumption taxes would not help either, because workers could simply emigrate in response to high consumption taxes and capital would follow them.

This problem has similarities to the problem of tax competition between local authorities within a country. The literature on fiscal federalism has long recognised that mobile factors are best taxed at a 'federal' level. The difference here is not only that there is no world tax authority, but that national sovereignty precludes binding commitments. Whereas local authorities within a country can sign enforceable agreements to limit tax competition and/or to share their common tax base, such collusion is difficult across sovereign nations. As in any cartel, countries would have strong incentives to renege on agreements to limit tax competition.

Note that optimal location decisions are determined not only by taxes, but by taxes in relation to amenities such as infrastructure – again similar to local tax competition. International mobility does not restrict taxes used for productive purposes. It mainly restricts redistributional taxes. Governments that provide public services efficiently are moreover 'rewarded' with capital and labour inflows. Hence the issue is broader than tax competition. In essence, countries compete to serve as alternative 'platforms' for combining capital and labour.

Returning to population ageing, the main implication of platform competition is that countries cannot credibly promise to tax future generations for the benefit of retirees. An inherited burden of promised retirement benefits must fall on either labour or capital. Taxes on labour would trigger an exit of productive workers and their capital, leaving behind retirees and less productive workers. With regard to capital, a mere suspicion that capital might be taxed to bail out public pension will do damage. Either way, inherited fiscal obligations are a handicap in a cross-country competition for mobile factors because they raise questions about future taxes.

Policy expectations may also matter for labour if migration decisions are driven by expectations about future incomes – say, by young workers deciding where to settle down. Migration will then be influenced by fiscal burdens as signals about future taxes. Forward-looking migration will also depend on workers' expectations about the spatial allocation of capital. This is because capital and labour are complements in production. Countries that are more successful in attracting capital will offer higher wages. Migration between Mexico and the US is suggestive of this linkage. Contrary to widespread expectations that the North American Free Trade Agreement would create jobs in Mexico, the US continues to attract both capital and labour; for attracting capital, it helps to be known as the bastion of capitalism.

In summary, increasing capital and labour mobility provides an argument why transfers to retirees cannot continue to grow. If tax competition increases sharply, retiree benefits may even have to decline, at least in some countries. As retirees must save more for their own retirement, more of them will become bequest-constrained.

On financial markets, more severe bequest constraints will create a growing demand for annuity-type investment products. Eventually, when savers have exploited all means to avoid accidental bequests, world savings will be determined by life-cycle considerations.

Mobility has implications not only for inherited fiscal burdens, but also for the ability of governments to deal with macroeconomic and demographic shocks. Currently, governments can deal with disturbances on an *ex post* basis, often by bailing out the victims at the expense of taxpayers. This applies not only to natural disasters such as hurricanes, but also to costly macroeconomic disturbances, such as banking crises and cyclical unemployment and to demographic disturbances, such as the pension cost of increased longevity.

Ex post settlements will cease to work if mobile factors can exit if a government tries to charge them for a bail-out. Savers may even demand a risk premium in advance.

A more efficient way to deal with aggregate disturbances is to take out insurance *ex ante*. Increasing international integration should allow nations to lay off country-specific risks on world financial markets, just like individuals carry insurance for microeconomic risks. Such insurance would require risk premiums only to the extent that a country-specific risk is correlated with global changes. Insurance-type contracts for aggregate risks will become increasingly valuable as tax competition grows and hence a likely area for growth in financial markets. Existing examples are disaster bonds and forward contracts for natural resources. Bohn (2002) outlines how governments can use state-contingent bonds to hedge against a range of macroeconomic and demographic risks.

Monetary policy has a significant role in this context. On the downside, money creation has long been used as a shock absorber, an instrument of last resort for governments facing fiscal problems. Despite the current trend towards low inflation and central bank independence, money creation would probably be used again if governments ran out of other options. Insurance against aggregate shocks is thus a contribution to monetary stability.

On the upside, monetary policy can be welfare-improving in a setting with generally stable prices and nominal government debt. Provided general price stability is ensured – say, through a credible target for medium-term inflation – monetary policy can provide insurance against aggregate shocks by letting inflation vary in response. For example, if it were understood that inflation will be 1 per cent above normal in the year after a major disaster, a nominal bond would be equivalent to a disaster bond. Note that insurance is obtained through bond values, not through seignorage, so this is not about monetisation.

Insurance through nominal bonds and a responsive monetary policy is particularly valuable against shocks that are difficult to define in advance. Disaster bonds, for example, must include a precise definition of what constitutes a disaster. Monetary authorities have a long tradition of serving as lender of last resort, particularly in responding to unanticipated, emergency-type situations. They are generally well-positioned to manage insurance through nominal bonds in a flexible manner. It is a matter of political judgment if monetary policy in a particular country is sufficiently credible to play this role.

7. Summary and Conclusions

This paper examines population ageing in an integrated world economy. The focus is on how individuals can be expected to respond. I compare responses in three standard economic models – the Solow-Swan model with fixed savings, a life-cycle model with optimal savings, and a dynastic model with optimal savings and optimal bequests. The public sector is treated as endogenous, reflecting savers' preferences as expressed through voting.

The models yield different conclusions about the impact of population ageing on future saving rates, capital accumulation and interest rates because of their different assumptions about bequests. While the Solow-Swan and life-cycle models suggest rising capital-labour ratios, rising capital-output ratios and declining returns to capital, the dynastic model predicts declining saving rates and bequests and a more stable world return to capital.

I argue that the future of bequests depends crucially on the future of public transfer systems – particularly pensions and retiree health care. Prospects for transfers in turn depend on the strength of future cross-country tax competition, not only for capital but also for labour.

It appears that a substantial share of the world capital stock is due to bequests rather than life-cycle savings. This raises questions about the life-cycle model as a tool for economic analysis. While retirees in developed countries may be close to a bequest constraint that makes life-cycle reasoning applicable, dynastic reasoning seems appropriate for developing countries. Even for developed countries, one may argue that bequest constraints have historically been rather 'soft' and not critical for the return to capital.

As desired bequests decline, financial markets should experience sharply growing demand for annuity- and insurance-type products that economise on bequests. As tax competition increases with more capital and labour mobility, governments have increasing incentives to hedge against disturbances *ex ante* and to avoid the damaging alternative of *ex post* taxation. Monetary policy has a role in this context if fiscal authorities issue nominal bonds. Provided a credible commitment to low average inflation is maintained, an elastic response of inflation to macroeconomic shocks can provide a flexible form of insurance against a variety of disturbances.

Looking forward, dynastic reasoning suggests that the world return to capital will remain higher than life-cycle models of population ageing would imply. Returns may even rise, especially if productivity growth in developing countries raises the demand for capital. The decline in returns predicted by life-cycle models should become relevant only after individuals run out of options for minimising their bequests.

Appendix A

This appendix explains the macroeconomic framework for the calibrations. Output Y_{mt} for country m in period t is written as function of capital K_{mt}, labour L_{mt} and productivity A_{mt}:

$$Y_{mt} = K_{mt}^{\alpha} \cdot \left(A_{mt} L_{mt}\right)^{1-\alpha}$$

assuming a Cobb-Douglas functional form. The productivity index A_{mt} (TFP) can be expressed as relative productivity $\hat{A}_{mt}$ times the productivity of a reference-country productivity (here the US): $A_{mt} = \hat{A}_{mt} \cdot A_{US,t}$. Competitive wages and interest rates are obtained as marginal products

$$w_{mt} = \frac{\partial Y_{mt}}{\partial L_{mt}} = \left(1-\alpha\right) A_{mt} \left(\frac{K_{mt}}{A_{mt} L_{mt}}\right)^{\alpha} \text{ and } r_{mt} = \frac{\partial Y_{mt}}{\partial K_{mt}} - \delta = \alpha \cdot \left(\frac{K_{mt}}{A_{mt} L_{mt}}\right)^{\alpha-1} - \delta$$

where δ is a depreciation rate. The calibrations assume a 30 per cent capital share and 5 per cent annual depreciation.

Assuming capital is mobile and untaxed, returns are equalised across countries: $r_{mt} = r_t$. The return equation shows that capital-labour ratios $k_{mt} = K_{mt}/(A_{mt}L_{mt})$ are also equalised: $k_{mt} = k_t$. Wages are proportional to TFP and each country's capital stock is proportional to the effective labour force. The world capital-labour ratio is easy to compute from the world capital stock $K_t = \Sigma_m K_{mt}$ and the world effective labour force $\hat{L}_t = \sum_m \hat{A}_{mt} L_{mt}$. Note that $K_t = k_t \cdot \Sigma_m A_{mt} L_{mt} = k_t \cdot A_{US,t} \hat{L}_t$. This implies that $k_t = K_t / \left(A_{US,t} \hat{L}_t\right)$.

All other variables follow from k_t; notably returns to capital $r_{mt} - \delta = \alpha \cdot k_t^{\alpha-1} - \delta$; wages $w_{mt} = \left(1-\alpha\right) A_{mt} k_t^{\alpha}$; per-capita incomes $Y_{mt} / L_{mt} = A_{mt} k_t^{\alpha}$; and world output $Y_t = \Sigma_m Y_{mt} = A_{US,t} \hat{L}_t \cdot k_t^{\alpha}$.

The capital-labour ratio has an awkward dimensionality, dollars per effective labour unit as measured by a productivity index. The capital-output ratio, in contrast, is unit-free and can be expressed as a monotone transformation $K_t / Y_t = \left(A_{US,t} \hat{L}_t \cdot k_t\right) / \left(A_{US,t} \hat{L}_t \cdot k_t^{\alpha}\right) = k_t^{1-\alpha}$. For this reason, my figures show capital-output ratios and not capital-labour ratios.

For the projections, the capital-output ratio in each country is initialised in 1980 from Solow-Swan's steady-state condition $K_{mt} / Y_{mt} \approx s_m / \left(g_m + \delta\right)$, where s_m is the gross savings rate and g_m the GDP growth rate. For comparability with life-cycle projections, time is divided into 20-year intervals. Because depreciation is difficult to time-aggregate, my figures report results for net rather than gross savings.

Historical productivity is exactly identified in the data from output, labour forces and capital stocks. Going forward, the main projection assumes 1.5 per cent annual US productivity growth. For countries with growing relative productivity over 1980–2000, the baseline projection assumes that $\hat{A}_{mt}$ converges to 1 exponentially, starting at the 1980–2000 convergence rate; otherwise $\hat{A}_{mt}$ is held constant at the

2000 level. Alternative 1 assumes faster convergence, specifically the Lucas (2000) assumption that relative productivity growth in non-US economies will grow at a 2.5 per cent per annum. Alternative 2 (no convergence) holds $\hat{A}_{mt}$ constant at 2000 levels for all countries.

For the optimising models, I assume preferences over consumption of the form

$$U_t = \omega_0 \cdot u\left(c_{0,t-1}\right) + \pi_{1,t} \cdot \left\{u\left(c_{1,t}\right) + \omega_2 \cdot \pi_{2,t+1} \cdot \left[u\left(c_{2,t+1}\right) + \omega_3 \cdot \pi_{3,t+2} \cdot u\left(c_{3,t+2}\right)\right]\right\}$$

where $c_{i,t}$ is the consumption at age i in period t, $\pi_{i,t}$ are survival probabilities, ω_i are time-preference factors and $u(c) = c^{1-\gamma}/(1-\gamma)$ has a constant elasticity of substitution EIS=$1/\gamma$. Indexing by country is suppressed here to avoid clutter. Age $i = 0$ is childhood, $i = 1,2$ are working ages, $i = 3$ is retirement. Children's consumption is determined by their age–1 parents.

In the life-cycle model of Section 3, adults have preferences over their own consumption and over the consumption of children only while they remain in the parent's household: $V_t = U_t + \beta \cdot n_{0,t} \cdot u\left(c_{0,t}\right)$, where $n_{0,t}$ is the number of children per adult. In the dynastic model of Section 4, adults have 'Ricardian' preferences $V_t = U_t + \beta \cdot n_{0,t} V_{t+1}$ over their own consumption and over their children's utility.

Let $N_{i,t}$ be the size of cohort i at time t. Population dynamics are determined by the survival probabilities and by the number of children per young adult ($n_{0,t}$); given a birth cohort $N_{0,t}$ at time t, the same cohort in later periods has size $N_{i+1,t+1} = N_{i,t} \cdot \pi_{i,t}$, for $i = 1,2,3$. The next cohort has size

$$N_{0,t+1} = n_{0,t+1} N_{1,t+1} = n_{0,t+1} \pi_{1,t+1} \cdot N_{0,t}$$

at birth. The growth rate between successive cohorts is therefore $n_{t+1} = n_{0,t+1}\pi_{1,t+1}$. A country's effective labour force is defined by $L_t = N_{1,t} + E \cdot N_{2,t}$, where E is the productivity of middle-aged relative to young workers ($E = 1.25$ in the calibrations). Increased longevity is calibrated as an increase in $\pi_{3,t}$ over time. A decline in birth rates is calibrated as a decrease in n_t over time.

In the life-cycle model, I assume that young households are liquidity-constrained. They maximise V_t over their own and their children's consumption, given their own wage. Middle-aged households maximise V_t over current and retirement consumption, given their wage and incoming bequests. Retirement consumption is subject to an 'accidental bequests' constraint: a share q_{t+1} of resources in retirement cannot be consumed before death. The key budget constraints are $c_{2,t} + a_t = Ew_t + Q_t$ and $\pi_{3,t+1} c_{3,t+1} \leq \left(1 + q_{t+1}\right) \cdot \left(1 + r_{t+1}\right) \cdot a_t$, where a = assets, w = wage, and Q = bequests received. The bequest constraint is binding in equilibrium and implies $Q_{t+1} = q_{t+1} \cdot \left(1 + r_{t+1}\right) a_{t+1} \cdot \left(N_{3,t+1} / N_{2,t+1}\right)$.

In the dynastic model, each cohort operates under the budget constraint that the present value of income plus bequests received equals the present value of consumption plus transfers to children (in childhood or as bequests), assuming no binding constraint on bequests.

The main projections assume a 1 per cent annual rate of time preference on own consumption. ω_0 is calibrated so that children's raw per-capita consumption is half of their parents'. In addition, children consume education. The cost is based on Barro and Lee's (2001) schooling data valued at 40 per cent of per-capita consumption per student. This raises the effective value of ω_0 to about 0.63. To obtain a 6 per cent steady-state return to capital in the dynastic model, I assume $\beta = 0.54$ per 20-year generational time-unit. The preference assumptions yield a dynastic age-consumption profile similar to Elmendorf-Sheiner (2000). For the alternative scenario with higher preferences for medical spending, ω_3 is increased by 15 per cent.

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Discussion

Mariano Kulish

Let me start by saying that I am pleased to have the opportunity to discuss Henning Bohn's excellent paper and that I learnt a lot from reading it. The paper covers a lot of ground. I'll stick to just a few key points.

The world is ageing as a result of declining fertility rates and increasing longevity. Given these demographic trends, the paper asks: how will individuals respond to these trends, what are the optimal responses and what are the implications for the world economy?

The paper examines responses to population ageing from a global perspective and focuses on savings, bequests and policy expectations in a world of mobile factors of production. As we have just seen, Henning studies demographic change in three different models: the Solow-Swan growth model with a fixed saving rate; the overlapping generations (OLG) model with life-cycle optimisation; and the dynastic model in which individuals value their children's lifetime utility. To study ageing simultaneously using three competing models is a particularly interesting aspect of the paper because it allows us to better identify how different assumptions affect the predicted outcomes.

In the Solow-Swan model, population ageing increases the capital intensity of the economy. The behaviour of individuals does not result from solving any optimisation problem. Instead they save a fixed fraction of disposable income. A fall in the rate of population growth (that is, due to falling fertility) makes labour relatively more scarce and puts upward pressure on wages and downward pressure on rates of return.

In the OLG model with life-cycle optimisation, ageing increases the capital intensity of the economy. As the paper makes clear, rising capital-labour ratios and declining returns are robust findings in life-cycle models of population ageing. In his presentation, Ralph Bryant told us that falling fertility and increasing longevity can have different implications for the capital-labour ratio and consequently for factor prices. In recent work we've done at the Bank, we show that this is especially true if retirement decisions are endogenous and determined in part by the health status of individuals (Kulish, Smith and Kent 2006). Lifespan extensions that go hand-in-hand with improvements in health are likely to make longer working lives more feasible. Eventually, however, the need to save for a longer retirement period increases the capital stock and more than offsets the initial increase in the supply of labour.

In the dynastic model, households choose their bequests optimally. Recall that individuals value their children's lifetime utility in this model. The choice of bequests has very important consequences for capital accumulation. Parents care about their children and through them their grandchildren and so on. Individuals in this economy have to decide how much wealth to allocate to their own consumption and how much wealth to pass on to future generations. Parents adjust their bequests whenever the rate of return on savings (that is, the return to capital) differs from the rate at which they discount their children's utility. If, for example, the rate of return falls below this discount rate, parents will reduce bequests as they are better off consuming extra wealth themselves rather than passing it on to their children. In the life-cycle economy (without endogenous bequests), ageing leads to a rise in the capital-labour ratio, thereby pushing down the rate of return. But in a dynastic economy, any downward pressure on the rate of return would work to push down bequests (in effect, reducing the capital stock that parents pass on to their children). This response ensures that in the long run the capital-labour ratio (and hence the return to capital) is stabilised in the presence of demographic changes.

Henning argues that the dynastic model is a better approximation for developing economies. This is because public pensions and other transfer systems are more rudimentary and most national wealth is concentrated in family-based firms for which ownership tends to be inherited and not purchased. This suggests a prevalence of wealth accumulation through bequests in developing economies. On the other hand, it seems reasonable to use the life-cycle model for more developed economies, which tend to get closer to the lower bound on bequests. Convincing evidence of this comes from a popular car bumper sticker in the United States that reads '*Retired – Spending My Children's Inheritance*'. For Australia, the story seems to be similar. Researchers at the University of Canberra have found that more than half of all bequests in Australia are less than A$20 000 (Kelly and Harding, forthcoming).

As I have just mentioned, Henning argues that for developing countries the dynastic model is a better approximation. I would like to leave you with two comments. First, it seems to me that an open issue is whether the observed bequests in the developing countries are the result of intergenerational altruism or not. Instead, they could be the result of constraints brought about by low levels of financial development. For example, an individual who owns a family-based firm which is not publicly traded is simply unable to draw down wealth 'continuously' to finance consumption. Alternatively, observed bequests could perhaps be related to a relatively skewed income distribution, with most bequests accounted for by a few very wealthy households. To the extent that observed bequests are not the result of intergenerational altruism, then I suspect that ageing will stimulate the development of financial markets and financial instruments in the developing world.

My final comment is the following. Henning acknowledges an important point. Namely, that the macroeconomic effects of ageing are likely to depend on household behaviour in a fundamental way. However, a shortcoming in the literature that models the impact of ageing on macroeconomic developments is that, so far, it has largely ignored departures from fully rational and fully informed behaviour. Henning does talk about one example – a world of fixed saving rates. Other departures from these assumptions may be asymmetric information (which could contribute to market inefficiencies) or myopic behaviour, which could mean that households don't save enough for retirement.

These issues are important to consider since they lead to market failure, which is the reason why policy-makers may need to respond to population ageing. I have no doubt we'll be discussing these issues further.

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Asymmetric Demography and Macroeconomic Interactions Across National Borders[1]

Ralph C Bryant

1. Introduction

Cross-border transmissions arising from nations' differing demographic evolutions modify macroeconomic outcomes and national welfares. Asymmetric demographic transitions have particularly important effects on exchange rates, saving-investment and current account balances and, hence, net capital flows.

This survey provides an analytical overview of these increasingly important dimensions of demographic influences in the world economy. Given the purposes of this G-20-sponsored workshop, the exposition is a general survey. Amplifications, supporting technical analyses, and references to the literature are confined to footnotes or omitted altogether.

When reading the paper, remember that its purpose is to analyse the effects of asymmetric demographic transitions in isolation from other influences. At any given time, many events and shocks occur in the world economy that have little or nothing to do with demographic trends. Such events and shocks have consequences for macroeconomic interactions among countries and regions that, especially over shorter runs, are more powerful than the impacts of demographic shocks. Demographic shocks and their effects are typically slower-moving and cumulative. Over medium and long runs, however, demographic forces can exert powerful effects.

The survey draws extensively on work carried out in the past several years as part of a research project on the global dimensions of demographic change. Early papers in the project focused on alternative research strategies and on interactions among similarly structured developed economies.[2] More recent research has focused on interactions between developed and developing economies.[3]

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1. This paper is part of a joint project studying the global dimensions of demographic change coordinated by Ralph C Bryant at the Brookings Institution and Warwick J McKibbin at the Australian National University (ANU). The views expressed in this paper are those of the author alone and should not be attributed to other project researchers or the trustees and officers of the Brookings Institution. Anthony Liu provided skilful research assistance

2. Bryant and McKibbin (1998), Bryant (2004b, 2004c), Bryant *et al* (2004), Bryant and McKibbin (2004), and Bryant and de Fleurieu (2005). Bryant (2004b) gives references to related work carried out by other researchers.

3. Bryant (2005, 2006) were first efforts in the Brookings Institution's components of the project to study the interactions between developed and developing economies. McKibbin and Nguyen (2004), McKibbin (2005a, 2005b) and Batini, Callen and McKibbin (2006) have addressed these issues in the ANU components of the project.

2. A Perspective on Today's Partially Integrated World Economy

For background, it will be helpful to start with generalisations about the world economy and its evolution in recent decades. To have an analytical benchmark, moreover, it is useful to contrast today's reality with an economic system within which all economic activity is highly integrated.

2.1 Geographical flows of savings, goods and people within a highly integrated economy

In a closed (self-contained) economy, all transactions occur between residents. When any borrower has a liability on its balance sheet, a lender elsewhere in the economy has a matching asset. The savings generated in such a closed economy are like a pervasive fluid. The economy's financial system (comprising financial intermediaries and financial markets) is like a reservoir for these funds. When the current-period income of households and other economic agents exceeds their consumption, the resulting savings flow into the reservoir. Businesses and other agents, whose current-period income falls short of their spending, draw funds out of the reservoir, borrowing to finance their excess spending. The existence of the reservoir permits the saving and investment decisions of individual economic agents to be taken independently even though, when measured after all decisions have been made and inconsistencies among them have been eliminated, the flows of aggregate saving and aggregate investment are necessarily equal for the closed system as a whole.

Suppose that the economic system is highly integrated in the sense that market imperfections (such as asymmetries in the distribution of information and in access to financial institutions) do not exist; that transaction, communication and transportation costs are low; and that no restrictions exist to inhibit the geographical movements of savings, goods and people among the regions within the system. The savings fluid in the reservoir in such a system would behave much like water: following a change in underlying circumstances in some region, the fluid in all parts of the reservoir would adjust almost instantaneously to re-establish a uniform level. Savers would move funds so adeptly from lower-return to higher-return locations, and borrowers would shift so promptly from higher-cost to lower-cost sources of financing, that market interest rates and yields on investments, adjusted for risk premiums, would speedily become equalised throughout the reservoir. Similar equalising pressures would apply to the prices of goods and to wages, adjusted for skill levels.

More realistically, suppose instead that market imperfections are numerous and that transaction costs (especially for adjusting capital stocks to new desired levels) are significant. The savings fluid in the reservoir then has to be described as viscous – more like thick molasses than water. Given sufficient time to adjust to changes in underlying circumstances, a uniform level of the viscous fluid would eventually prevail. However, if in one region of the reservoir withdrawals during any particular short-run period substantially exceed or fall short of new deposits, the level in that region can be temporarily lower or higher than elsewhere in the reservoir. Suppose, for example, that investment opportunities become more favourable in a particular region. Before information about the new opportunities becomes widely available and all plans are correspondingly adjusted, that region would have an excess demand for savings and labour. Desired withdrawals from the reservoir by the residents of, or owners of assets in, the favoured region would temporarily exceed planned inflows. The region would attract funds from other parts of the reservoir as investors in projects with higher-than-average expected returns successfully bid funds away from investors in other regions whose projects were less promising. During the transitional period, there might be little relation between the investment and saving of the favoured region's residents. If one could calculate balance of payments accounts for the favoured region, one would observe a net savings inflow (a current account deficit). Eventually, risk-adjusted rates of return, skill-adjusted wage rates and the prices of goods adjusted for transportation and transaction costs would converge throughout all regions. But as long as perceived rates of return were unusually high in the favoured region, the financial reservoir would not have a uniform level. Financial funds and people themselves would flow from the rest of the reservoir to the favoured region.

The greater the heterogeneities across regions and the greater the extent to which access to financial institutions differs – more generally, the more viscous the flow of savings from one part of the reservoir to another – the more important would be geographical variations in the intensity of investment activity and its financing. Regional variations in financial activity would tend to be closely associated with regional variations in real economic activity. Sluggishness in the movements of goods and people across regional borders would likewise contribute to regional variations in real economic activity.

2.2 Flows of savings across national borders in today's world

The world economy as a whole is a closed system. Each liability position in the world is matched by a corresponding asset position. But of course huge political, economic and social differences exist among the world's regions and nation states. Restrictions inhibit many cross-border transactions, in particular the migration of people from one nation to another. Furthermore, even in the absence of border restrictions, economic transactions within nations are much more dense than transactions across national borders. Financial activity in the world economy is, rather than a single global reservoir, a collection of national reservoirs partially – but only partially – linked together.

During the years immediately following World War II, national financial reservoirs were separated nearly completely. Only limited scope existed for cross-border net capital flows and corresponding imbalances in current account positions. Even the cross-border shipments of goods and services – but especially the net ladling of savings from one national reservoir to another – were modest relative to the sizes of national outputs. The reconciliation between savings and investment necessarily proceeded largely independently, individual nation by individual nation, with little scope for aggregate national investment to differ from aggregate national saving.

The financial structure of the world economy underwent a sea change in the second half of the 20th century (in part returning the world to where it had been in the first decade of the century). The economic distances between nations' financial systems shrank markedly. National savings reservoirs that had been nearly autonomous became less so. Today, to a greater extent than before, the levels in national reservoirs tend to be pulled together toward a common level.

Even so, financial activities in many parts of the world remain segmented along national lines. The notion of a unified world financial system, implying a nearly uniform level throughout a single global reservoir, remains an inappropriate metaphor. For financial sector activity, national borders have economic influences that are large, pervasive and durable.

2.3 Cross-border integration of goods markets

Movements of goods and services across national borders, like saving flows, are still subject to numerous impediments and frictions. The density of product flows within national economies is much greater than for cross-border transactions. Yet, like financial markets, national goods markets are much more integrated today than they were in the middle of the 20th century.

The increasing cross-border integration of financial and goods markets during recent decades has two underlying causes. Many government policies that traditionally inhibited cross-border flows of goods, services and transactions were relaxed or even dismantled. And technological, social and cultural changes sharply reduced the effective economic and psychic distances between nations, reducing the costs of cross-border transactions and making domestic economic behaviour gradually more sensitive to developments abroad.[4]

2.4 Migration of people across borders

Within a fully integrated economy, geographical movements of people – especially individuals of working age – could be just as important as movements of goods and financial funds. The reality in today's world, however, is that migration is severely limited. Movements of people across national borders are, with few exceptions, much more restricted than movements of goods and financial funds.

Immigration restrictions in selected parts of the world were loosened modestly in the last decade and a half, most notably for highly-skilled workers. Traditional 'settlement' countries such as Canada, Australia, New Zealand and the United States continued to authorise further controlled immigration. Restrictions on migration for political asylum were eased in some countries during the 1990s, after

4. The points summarised so far are analysed in greater detail in Bryant (2003, 2004a).

the fall of the Iron Curtain, especially to permit flows into Europe from former Communist nations.

Nonetheless, for most nations, authorised immigration – either permanent or temporary – has remained modest. Illegal (unauthorised) immigration has been significant in a few countries, notably the United States and several countries in Southern Europe. For most nations, however, government policies successfully inhibit flows of people across their borders. Policy restrictions on immigration are far more consequential than the willingness of individuals to migrate in response to economic incentives. In particular, virtually all wealthier nations are reluctant to permit immigration of low-skilled individuals from poorer countries.[5]

Governmental policies preventing migration are the primary explanation for why almost all of international economic theory and existing multi-country empirical macroeconomic models focus on the cases where goods and financial funds move across borders in response to economic incentives but workers and people do not. The working assumption of no migration has permitted researchers to focus on the more important types of international interactions. Cross-border trade in goods and services and cross-border capital flows are certainly larger fractions of activity in goods and financial markets than the fraction of labour market activity accounted for by immigration. Similarly, the forces of international economic interdependence have not reduced wage differences among similarly skilled workers nearly as much as they have reduced differences in goods prices and differences in the cost of capital.[6]

2.5 Cross-border substitutability and macroeconomic interdependence

The greater sensitivity of domestic financial market and goods market behaviour to foreign developments that has characterised recent decades has resulted, in part, from secular increases in cross-border 'substitutability'. Households and firms have manifested a gradual increase in their willingness to substitute between home and foreign goods in response to relative price changes ('goods substitutability'). Savers and investors have shown a gradual increase in their readiness to respond across borders or across currency denominations to changes in relative expected returns among financial assets and liabilities ('financial substitutability'). Because analysts have devoted less attention to these trends than is warranted, empirical evidence

5. The OECD's *International Migration Outlook* (2006) summarises data trends and identifies policy issues related to this issue.

6. Freeman (2006) suggests that migration could become relatively more significant in the future. He argues that 'aging populations and low birth rates in advanced countries coupled with huge disparities in pay around the world and increased education in developing countries are likely to lead to increased immigration in the decades ahead, even with current immigration policies. People flows will become more important in globalization and should help reduce global inequality among workers around the world' (p 166). Even so, when analysing the macroeconomic effects of demographic transitions in the near-term, however, abstracting from the cross-border movements of people is a useful first approximation.

is still sketchy. Understanding the effects of these trends, however, is central to understanding many aspects of the evolution of the world macroeconomy.

By shrinking the economic and psychic distances between nations and enhancing sensitivities to foreign developments, behavioural changes in cross-border substitutability would have progressively knitted national economies more closely together even in the absence of reductions in the separation fences of national governments. Reductions in these separation fences would have enhanced cross-border mobility and interdependence even without the increased cross-border sensitivity and without technological innovations. Together, the two sets of evolutionary changes reinforced each other and powerfully transformed the world economy over the last half-century.

It is thus a central fact of life today that macroeconomic variables are more closely linked across national borders. Somewhat larger proportions of macroeconomic adjustments required in response to shocks originating domestically now tend to be channelled through external sector transactions. Shocks originating abroad now buffet the domestic economy more strongly. Cross-border and cross-currency adjustments have risen in importance relative to purely domestic adjustments.

These generalisations apply to all sorts of macroeconomic variables, domestic and external sector. In particular, and notably, they apply to variations in the imbalance between an economy's national savings and domestic investment – by definition also its current account balance with the rest of the world. Saving-investment imbalances have been strongly influenced by the lowering of national separation fences and by heightened goods and financial substitutabilities across borders. Typically, the sizes of, and variations in, an economy's current account balance relative to gross output are now larger and exhibit larger swings than would have occurred in the middle decades of the 20th century. Changes in exchange rates may also be a relatively more important component of macroeconomic adjustments in response to all sorts of shocks – including, not least, demographic shocks.[7]

7. Feldstein and Horioka (1980) and numerous subsequent studies showed that national saving rates and domestic investment rates exhibit a high correlation in cross-section studies of country data. More recent examinations, however, have shown that the empirical correlation has fallen somewhat as cross-border integration has continued to increase in the last several decades. Note also that some part of the observed correlation could be due to the dependence of changes in both saving and domestic investment on changes in incomes. And a variety of policy and non-policy disturbances originating within a nation's economy – and some types of disturbances originating abroad – can influence national saving and domestic investment in the same direction independently of the degree of mobility of capital across a nation's borders. Cross-border goods substitutability, despite increases in recent decades, still tends to be relatively low and in any case is typically less than cross-border financial substitutability; significant barriers remain that inhibit cross-border transactions in goods and services. Those factors prevent current account imbalances from growing as large as might otherwise be observed. Accordingly, the high correlation between domestic investment and national saving may be attributable more to goods market phenomena than to a lack of integration among financial markets or a low degree of substitutability among home and foreign assets (Frankel 1986, 1991).

3. Asymmetric Demographic Transitions

3.1 Characteristic trends

Virtually every part of the world has been gradually moving from a state of short life spans and high fertility rates to one of longer lives and lower fertility rates. These demographic transitions have been dramatically altering the age structures of populations. Eventually, the entire world is expected to be characterised by few births per woman, long life expectancies, and population structures with large proportions of elderly individuals and small proportions of children.

In the early stages of a demographic transition, infant mortality falls and overall mortality declines. Children thus become more numerous and the average age of the population becomes younger. Decreases in infant mortality are often accompanied, typically with a lag, by declines in fertility rates, as mothers choose to maintain a similar expected number of surviving offspring. In later stages of the transition, the working-age population and the labour force grow faster than the population as a whole. This development is sometimes termed a 'demographic dividend'; it is associated with a sustained rise in the 'active ratio' (the proportion of the total population accounted for by adults of working age, 20–64 years) and a marked decline in the 'youth dependency ratio' (the proportion of the total population aged 0–19).[8] In the final phases of a demographic transition, further increases in longevity and a low fertility rate slow the growth of the working-age population; the 'elderly dependency ratio' (the proportion of the total population aged 65 and over) rises sharply.

Although pervasive, the timing and speed of these demographic changes have been highly asymmetric across regions. Many western European countries began their transitions at the beginning of the 19th century. Those countries, along with many other industrial countries, are now in the later stages of their transitions with elderly dependency ratios increasing rapidly. At the other extreme, the transitions in some least-developed countries have started only in recent decades. These countries are still experiencing rising youth dependency ratios and are only now beginning to enter the period of the 'demographic dividend'.

3.2 Illustrative data for individual nations

The Population Division of the United Nations publishes bi-annual statistical volumes on world and national demographic trends.[9] The data in recent editions are presented for quinquennial averages, beginning with the period 1950–1955 for historical data and ending with 2045–2050 for forward-looking projections.

8. When using the UN Population Division demographic data, one has the choice of defining youths as either age 0–14 years or 0–19 years. Because my analytical framework presumes children pass from youth to adult age at the end of their 18th year, I choose the 0–19 year span.

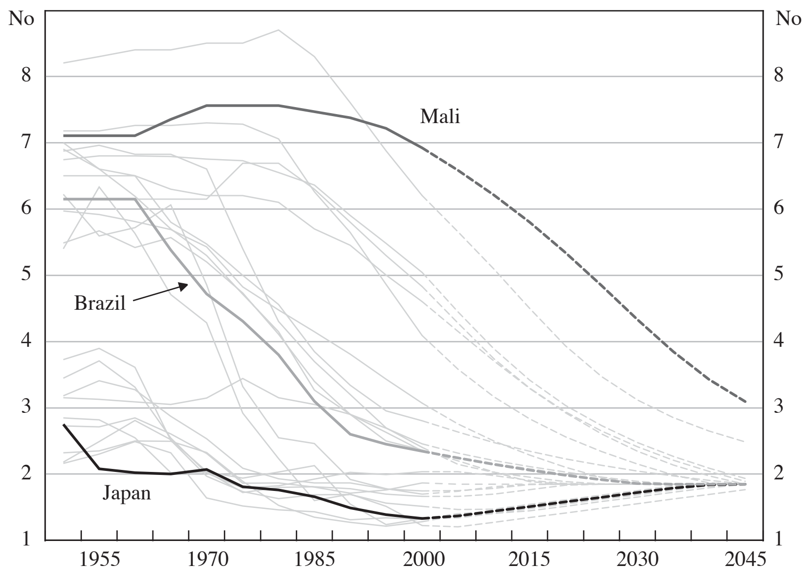
9. For example, UN Population Division (2001, 2003, 2005).

Figures 1–6 plot key demographic series from the UN data for all of the G-20 nations and several smaller developing nations. The forward-looking projections shown in the panels are the UN Population Division's 'medium' scenarios.[10] The figures immediately reveal two main facts: demographic transitions are highly heterogeneous; and common trends are pervasive. Curve labels separately identify only three of the nations – Japan, Brazil and Mali. Counterpart appendix tables at the end of the paper, however, identify the other individual countries and provide the data series (Appendix A).

Japan, Brazil and Mali exemplify the differing stages of demographic transitions. Japan is the developed country furthest along in the late stage of transitions. Other G7 nations are also in fairly late stages. Brazil is roughly representative of broad demographic trends among developing economies in the earlier to middle transition stages. Mali is an example of a smaller, least-developed country in the very early stage. (The other, earlier-stage developing nations shown in the figures are Guatemala, the Lao People's Democratic Republic, Tanzania and Yemen.)

Lifetime births per woman are much higher in developing countries than in industrialised countries (Figure 1). Yet they are falling throughout the world with

Figure 1: Fertility Rates
Births per woman



Notes: Dates refer to the beginning of the 5-year window. Data after 2005 are based on projections.
Source: UN Population Division (2005)

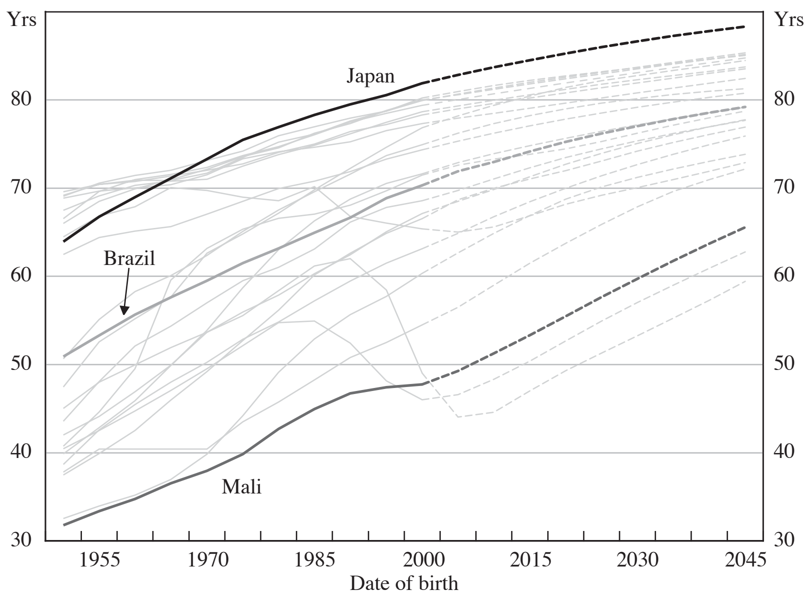
10. The UN Population Division also publishes 'low' (lower fertility and lower longevity) and 'high' (higher fertility and higher longevity) scenarios.

only a few exceptions. By the 1970s the fertility rate in Japan and several European economies had already dropped below a rate consistent with steady-state replacement of the population (about 2.1 births per woman). In contrast, in most developing countries, fertility rates today still fall into the range 3 to 5 births per woman. Countries in early transition stages, such as Mali, have even higher birth rates that have only started to decline in the last several decades.

Life expectancy is markedly higher in Northern (developed) than in Southern (developing) economies (Figure 2). The differences in levels are striking. For example, a child born today in Japan – currently the nation with highest life expectancy at birth – can expect to live on average some 34–35 years longer than a child born in Mali. No less striking, however, is the rough similarity in mortality trends throughout the world. Life expectancy has been rising persistently almost everywhere; increases are projected to continue. The sharp fall in life expectancy over the last two decades for a few nations such as South Africa, Tanzania and Russia, interrupting their trend increases, illustrates the exceptional experience of a minority of countries. South Africa and Tanzania, for example, have been hit especially hard by the HIV/AIDS epidemic.

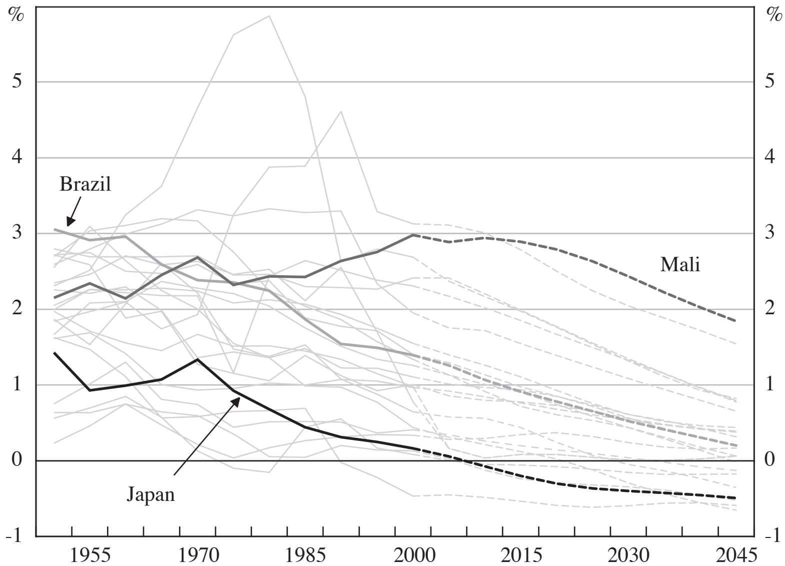
Annual growth rates of total populations have recently trended downwards (Figure 3). Broadly speaking, decreases in fertility have been quantitatively more important than increases in life expectancy; thus the net effects on population growth rates have been negative. The UN projects the trend reductions in growth rates to

Figure 2: Life Expectancy at Time of Birth



Notes: Dates refer to the beginning of the 5-year window. Data after 2005 are based on projections.
Source: UN Population Division (2005)

Figure 3: Average Annual Growth Rate of Total Population



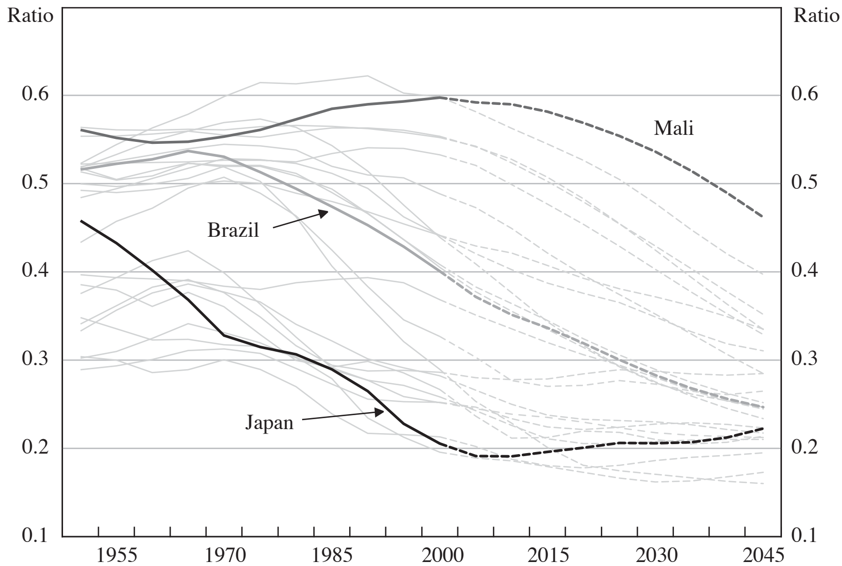
Notes: Dates refer to the beginning of the 5-year window. Data after 2005 are based on projections.
Source: UN Population Division (2005)

continue. Cross-country differences in birth rates and life expectancies, however, can continue to cause major differences in the levels of population growth rates. For developed nations such as Japan, the total population is now beginning to contract. In contrast, many developing countries still have population growth rates in the neighbourhood of 1½ per cent or higher. At the extreme, the growth rate in least-developed countries such as Mali is very high and is projected to remain high for several more decades before eventually falling.

Youth dependency ratios have fallen fastest and furthest in those Northern economies whose demographic transitions are the most advanced (Figure 4). Conversely, youth dependency ratios in early-stage developing countries are still very high; well over half of the population in many of those countries is under the age of 20. On average in middle-stage developing economies, some two-fifths of the total population are youths.

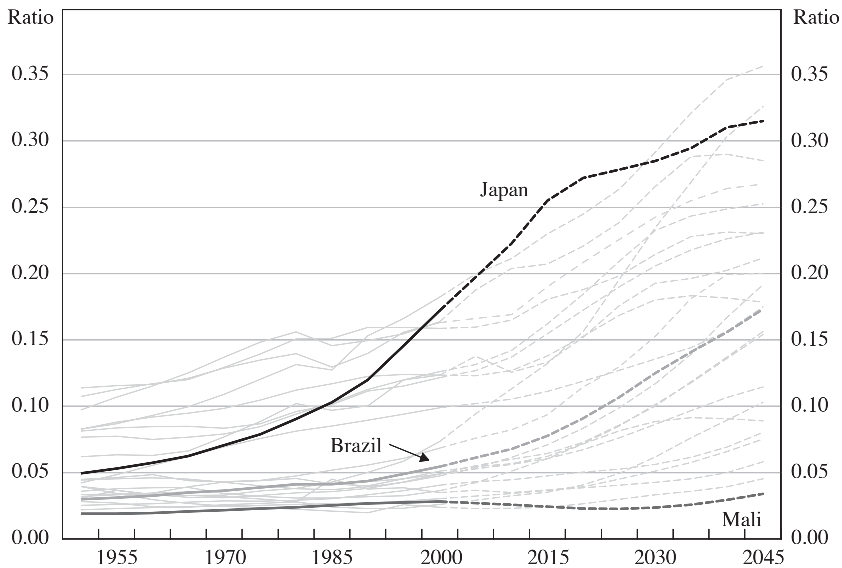
Because of their more advanced transitions, Northern economies have also experienced the greatest increases in the share of the elderly in their populations (Figure 5). In Japan, for example, already one-fifth of the population is elderly (65 years and older), with large further increases projected between now and 2050. The elderly dependency ratio is projected eventually to rise significantly throughout the South, albeit from levels today that are much lower than in Northern economies. Indeed, for early-stage developing countries, the elderly ratio may not rise at all for several more decades.

Figure 4: Ratio of Youths (Ages 0–19) to Total Population



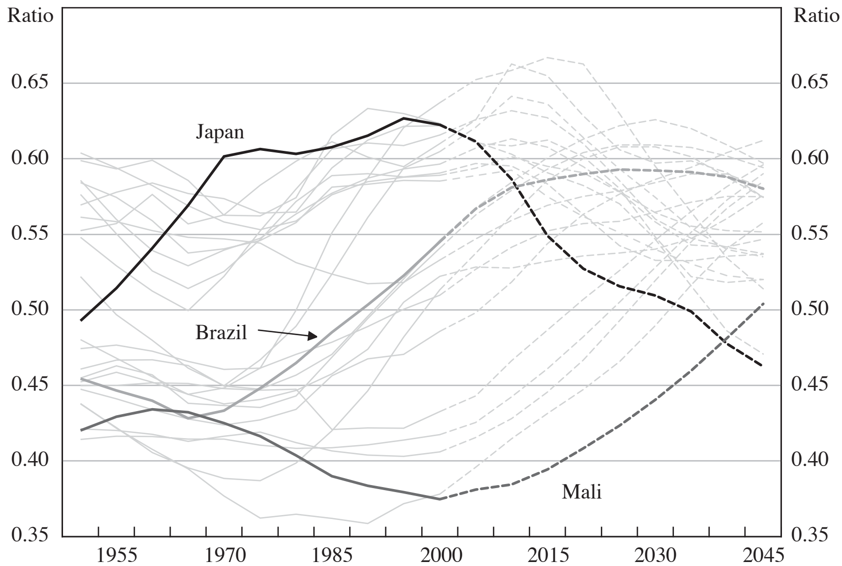
Notes: Dates refer to the beginning of the 5-year window. Data after 2005 are based on projections.
Source: UN Population Division (2005)

Figure 5: Ratio of Elderly (Ages 65+) to Total Population



Notes: Dates refer to the beginning of the 5-year window. Data after 2005 are based on projections.
Source: UN Population Division (2005)

Figure 6: Ratio of Active Adults (Ages 20–64) to Total Population



Notes: Dates refer to the beginning of the 5-year window. Data after 2005 are based on projections.

Source: UN Population Division (2005)

Active ratios are strongly influenced by the stage of demographic transition (Figure 6). Differences among nations are dramatic, both for levels at any point in time and for changes through time. In the second half of the 20th century most developing economies had significantly lower active ratios than those in industrialised economies (for example, compare Brazil and Japan). Early-stage transition economies have had especially low, and often even falling, active ratios. In contrast, the active ratios of Japan and several European economies reached their maximum values in the 1990s; the United States is currently near the peak of its active ratio. During the first half of the 21st century, broad trends in the active ratios of Northern and Southern economies will continue to be contrary, but in the opposite directions from the 1990s. The North is moving into a stage in which active ratios will persistently decline. Most Southern economies are entering decades in which active ratios will continue to rise, a period that will enable them to reap the demographic bonus associated with a plentiful supply of workers relative to dependents.

4. Basic Macroeconomic Effects of Demographic Transitions

Effects on labour markets and the production sectors and production technologies of economies are the fundamental determinants of the macroeconomic outcomes resulting from demographic transitions. The rudiments of these basic forces are summarised in this section. Important open-economy modifications are not discussed until the following section.[11]

Declines in birth rates (reductions in 'fertility') and increases in adult life expectancy (declines in adult 'mortality' rates) both alter the composition of national populations: the average age of individuals in the population rises; the ratio of elderly individuals to working adults increases; the ratio of youths to working adults declines; and the ratio of the effective labour force to the entire adult population falls.[12] The effective labour force declines relative to the output and capital stock of the economy. The marginal product of labour rises. With the effective labour force lower relative to the capital stock, the marginal product of capital falls and the capital-output and capital-labour ratios rise. Real interest rates decline over the medium run in association with declines in the marginal product of capital.

To gain intuition about the effects of demographics on macroeconomic variables such as saving, remember that when individuals first enter the labour force, they have relatively low productivity, relatively low labour incomes, and relatively low savings. Younger adults on average have lower savings in their early working years in part because of children and child-support expenses. Then as workers gain experience and seniority and have higher productivity, their effective labour input increases over time; in effect, they ascend the left side of the hump of the economy's age-earning profile. Individuals tend to reach their peak earning and high-saving years when they are in their forties, fifties and early sixties. Saving is high in these years not only because of higher labour incomes but also because of the need to save in anticipation of retirement and because older adults typically face lower payments for child support. Eventually, workers start to descend the right side of the humped age-earning profile so that their labour incomes and saving decline. During retirement, their consumption must be increasingly financed out of their privately accumulated financial wealth as supplemented by pension transfers from the government.[13]

Changes in the age composition of the population, together with the hump-shaped profile of earnings by age, influence both the supply side and the demand

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11. The generalisations summarised here and in following sections are based on the research cited in the papers in footnotes 2 and 3 above. The two-region analytical models used in the research are general equilibrium models simultaneously determining all the main macroeconomic variables in each region. The model structures are described in detail in the research papers. The treatments of household consumption, saving and wealth accumulation build on the simplified overlapping generations framework of Yaari (1965), Blanchard (1985) and Weil (1989) as extended by, among others, Faruqee, Laxton and Symansky (1997) and Faruqee (2002). That framework is in the tradition of modified life-cycle models. Bequests (voluntary or involuntary) are not taken into account.

12. The effective labour force is the labour force adjusted for labour-augmenting technical change (so-called efficiency units of labour).

13. The hump shape of an economy's aggregate age-earnings profile reflects both of two types of effects: changes over time in the relative productivities of age cohorts (initially, increases due to rising seniority and experience and then subsequently decreases towards the end of working life as workers become less productive); and changes in the rates of participation in the labour force of different age cohorts.

side of macroeconomic behaviour. On the supply side, the age-earnings profile is an indicator of changes in a cohort's relative productivity and its supply of labour over its lifetime. The number of workers in each cohort, weighted by productivities across working cohorts, directly influences the aggregate supply of output. On the demand side, the anticipated path of labour income determines the saving plans of consumers over their lifetimes.

Incentives for investment also change in response to changes in demographics and labour productivity. As the effective labour force adjusts and the relative scarcity of labour and capital are altered, the previous relationship between the capital stock and output becomes economically inappropriate. Variables such as real interest rates are pressured to adjust to reflect the new conditions. Investment flows, occurring promptly or sluggishly depending on the size of the changed incentives and the adjustment costs to be paid, alter the capital stock and key macroeconomic variables such as the capital-output and the capital-labour ratios.

Historical demographic transitions have been a mixture of declines in fertility and increases in life expectancy, with the mixtures varying heterogeneously across countries (Figures 1–6). For most countries, fertility declines have been quantitatively more important as a driver of current and prospective population ageing. As the 21st century progresses, increases in life expectancy due to further advances in medical science may become relatively more significant.[14]

The specific cause of demographic changes, or the combination of causes, matters greatly. Notably, the macroeconomic effects of demographic change differ importantly depending on whether ageing of the population occurs predominantly because of fertility declines and hence fewer children or, alternatively, because of lower death rates and hence longer survival spans.

For fertility declines where the birth rate falls from an initial to a lower level and remains thereafter at the lower level, a fall in the effective labour force relative to the adult population and an eventual rise in the elderly dependency ratio are associated with a *fall* in the aggregate sizes of the total and adult working populations. The growth rate of population and its components *declines*. *Less* output is produced than would otherwise have been generated in the absence of the demographic changes. Other major macroeconomic aggregates – specifically including the capital stock and the aggregate consumption of the economy's residents – are also *lower*.

As with fertility declines, increases in adult life expectancy (with, for example, the adult mortality rate declining from an initial to a lower level and remaining at the lower level thereafter) lead to rises in the elderly dependency ratio, declines in the youth dependency ratio and falls in the ratio of the effective labour force to the adult population. But those similarities are overshadowed by qualitative differences. With increases in life expectancy, the total and adult working populations *increase*

14. The two categories of underlying demographic causes are interrelated in complex ways. Declines in birth rates, for example, are probably in part an endogenous response to actual and expected declines in mortality rates at all ages (especially reductions in mortality for infants and young children). A helpful recent overview of demographic behaviour is provided by Lee (2003).

and the ultimate growth rate of the population and its components moves *higher*. *More* aggregate output is produced, the economy's capital stock is *larger*, and the economy's residents have *higher* aggregate consumption than would have been the case in the absence of the demographic changes.[15]

Other similarities and differences are significant. With both fertility declines and increases in life expectancy, for example, *per-adult* human wealth rises, the ratio of savings to output rises, and the marginal propensity to consume out of lifetime wealth and per-adult consumption fall as forward-looking consumers adjust the intertemporal paths of their consumption. In contrast, absent the open-economy effects, per-adult financial wealth *declines* over the longer run with fertility declines but *rises* in the longer run with increases in life expectancy.[16]

When analysing macroeconomic effects, it is essential to carefully incorporate the implications of youth dependency and elderly dependency. The key point about youth dependency is that the consumption-saving behaviour of individual adults who provide *in vivo* transfers to children is dramatically different, in theory and in practice, from the behaviour of otherwise identical individuals without financial responsibilities for child support. If a demographic shock lowers the number of children, for example, the financial burden on child-supporting adults is reduced and resources are freed for additional adult consumption or saving. That reallocation of resources radically changes the transitional dynamics and the ultimate position of the economy compared to what it would otherwise be in an analysis that disregards children and child support. Analogously, because elderly individuals tend to be supported by pension benefits, some portion of which is provided through government-administered programs, ignoring elderly dependency suppresses the major source of macroeconomic effects stemming from the operation and financing of public pension systems.

5. Open-economy Effects of Asymmetric Demography

Open-economy interactions can critically modify the macroeconomic effects of demographic change when one part of the world economy experiences a different demographic evolution from those occurring elsewhere.

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15. Even for demographic variables such as elderly ratios and labour-force-to-adult-population ratios that move qualitatively in the same direction, the quantitative size of changes tends to be significantly different. For example, an increase in adult life expectancy that is 'comparably sized' to a reduction in the birth rate – where comparably sized has the specific meaning that both types of shock have equivalent effects on the absolute values of changes in the ultimate steady-state growth rate of population and its components – tends to cause significantly smaller increases in elderly ratios and markedly smaller falls in the ratios of the effective labour forces to adult populations.

16. Numerous individual economies and, on average, the world as a whole have in recent years experienced an extended secular decline in real interest rates. It is interesting to speculate whether this decline is attributable partly to demographic factors. The common trends in demographic transitions, fertility declines and increases in life expectancies, both lead to reductions in the marginal product of capital and hence to declines in real interest rates.

The simplest analytical case, one that brings out key generalisations with the fewest complexities, is a world composed of two equal-sized economies (referred to hereafter as the home economy and the rest of the world, ROW) with identical domestic structures that are linked by cross-border flows of goods and capital but that have no cross-border migration.[17] The exchange rate linking the two economies adjusts to ensure that the current account balance and the net foreign asset position for the world as a whole (the algebraic sum of both economies) are always zero. Within each economy, optimising firms produce a single composite good. The goods from each country are imperfect substitutes; some production in each country is exported; import demands are a function of national incomes and relative prices. Suppose that, in the past, the two countries have had identical demographic and economic histories. For analytical shorthand, refer to an extrapolation of these identical histories as a benchmark 'baseline'.

5.1 Asymmetric fertility declines

Now imagine that the home economy is subject over an extended period to a demographic shock (departure from the past experience) that is larger or occurs sooner than demographic changes in the ROW. Fertility declines must be analysed separately from increases in life expectancy. Hence consider first the case in which the home economy experiences a rapid and large decline in its birth rate relative to baseline while the ROW has a slower, more gradual decline.[18]

In the home economy, aggregate human wealth, financial wealth, output, consumption and the capital stock all eventually decline to levels that are lower relative to baseline. Because the effective labour force declines relative to the capital stock, the marginal product of capital falls and the home real interest rate declines. Since the ROW also experiences a decline in fertility, albeit at a slower pace than in the home economy, the ROW real interest rate will also decline, but by less than in the home economy. The home capital-output ratio rises substantially in the medium and longer runs and remains at the higher level forever. The ROW experiences a smaller rise in its capital-output ratio. These different interest rate, capital stock and output evolutions in the two parts of the world are associated with major differences in saving and external sector behaviours.

Saving and financial wealth per adult in the home economy rise sharply relative to baseline in the shorter and early medium run; part of the increase is gradually

17. In this section and the ones that follow it is assumed throughout that workers, and people generally, are prohibited from moving across national borders. Neither I, nor others, have so far developed a satisfactory general equilibrium modelling of the world economy that appropriately and systematically adds cross-border migration of people to the cross-border movements of goods and financial funds. As discussed earlier, movements of people across borders are relatively less important so that the omission of migration is a defensible first approximation to a comprehensive analysis.

18. For analytical clarity, it is assumed that both the home and ROW economies ultimately reach new steady-state evolutions that, as with their past histories, are identical in rates of growth. The home economy, however, reaches its new steady-state evolution much sooner and, of course, experiences a permanent change in the size of its economy relative to the ROW economy.

reversed in the longer run. In contrast, ROW saving and financial wealth per adult rise less. The relatively higher increases in home financial wealth are explained partly by higher disposable incomes and savings reflecting the reduced support of consumption of the smaller numbers of children. The differences in saving behaviour, and hence in financial wealth, between the home and ROW economies are attributable not merely to their different-sized demographic shocks but also to modifying effects working through the exchange rate and external sector transactions.

As the interest rate falls more in the home economy than in the ROW, an interest differential in favour of the ROW opens up. That interest differential needs to be offset by an expected depreciation of the ROW currency. So as fertility continues to decline faster in the home economy, the home currency begins a sustained appreciation, first in nominal then with a lag in real terms. In the medium and long runs, the nominal and the real exchange value of the home currency settle at appreciated levels significantly higher relative to baseline.

To understand why the asymmetric demography results in a permanent appreciation of the home currency, it is necessary to focus on changes in the *relative* size of home and ROW outputs, which in turn depend on changes in the *relative* sizes of the populations and effective labour forces. The asymmetric fertility declines cause transitory differences between the home and ROW demographic rates of growth but permanently change the relative levels of demographic and macroeconomic variables. The home effective labour force falls substantially relative to the ROW's by the time both parts of the world eventually settle down to identical long-run rates of growth. Correspondingly, home macroeconomic aggregates such as the capital stock and goods output become smaller relative to the ROW. The quantity of home-produced goods available for sale and consumption in the world thus falls relative to the quantity of ROW-produced goods. In the absence of changes in the preferences of each region's consumers for the two types of goods, relative prices in the world economy have to change to reflect the now relatively less abundant home-produced goods. A permanent real appreciation of the home currency, representing an improvement in the home economy's real terms of trade, is an integral part of the required change in relative prices. The size of the required appreciation depends – as will be discussed further below – on the degree of price sensitivities in the home and ROW economies, in particular on the price elasticities of import demands.

Changes in the exchange rate create incentives for expenditure switching between the two economies. Thus the home economy begins to import substantially more of the now relatively cheaper goods produced in the ROW. Home exports to the ROW are inhibited. These expenditure-switching effects eventually cause the home economy to run a progressively larger *deficit* on its real trade account. This net import of real resources from abroad provides a cushion of support to the home economy that permits it to sustain a significantly higher level of consumption than would otherwise be possible. The ROW economy experiences the opposite effect: it must make net exports of real resources and correspondingly curtail its consumption.

The home trade deficit is *not* associated with a deficit on current account. The home economy not only imports more from abroad. It also saves more and its financial wealth *rises*. A fraction of the higher home financial wealth is invested abroad at the relatively higher interest rates available abroad. Hence the home economy over the medium and long runs earns a higher flow of investment income from abroad. The net investment income received is more than enough to offset the deficit on trade account so that the home economy experiences a significant current account *surplus*. The home net foreign asset position, the integral over time of its current account imbalances, becomes increasingly positive.

It is instructive to analyse the outcome from the perspective of the home and ROW saving-investment balances. Saving rises relative to investment in the home economy. In the ROW, saving falls relative to investment. The opposite side of the coin of the home current account surplus is a *net outflow* of financial capital. Thus, the home economy – despite its relatively larger demographic shock, which causes sizable declines in home output and aggregate consumption relative to output and consumption abroad – nonetheless becomes a net capital exporter. The sizable net positive return earned on the home net foreign asset position helps to cushion the home economy from its larger demographic changes. Conversely, the ROW economy is adversely buffeted; it must, in effect, share some of the consequences of the larger demographic shock occurring abroad.

Careful analysis should differentiate between *aggregate* levels of macroeconomic variables and their *per-capita* and *per-adult* values. Home aggregate real consumption falls further below baseline than does ROW aggregate real consumption. Yet the path for home aggregate real consumption is significantly *above* the path that would be experienced in the hypothetical case in which the home economy is unable to cushion its larger shock through transactions with the ROW. When the per-adult or per-capita values of consumption in the home economy are considered, the cushioning effects of openness appear even more consequential. Notwithstanding the fact that the home demographic shock is larger than the ROW's shock, home per-adult consumption is *higher* than ROW per-adult consumption. The difference between the two economies is sizable in the initial decades of the asymmetric shocks and is even more marked in the long run. The cushioning effects are so substantial when measured in per-adult terms that home adults can be better off *not only relative to ROW adults*, *but also better off absolutely relative to the no-shock baseline*. Conversely, ROW per-adult consumption is *lower* than in the no-shock baseline even though the ROW's population, aggregate real GDP and aggregate consumption are all at higher-than-baseline levels.

5.2 Asymmetric increases in life expectancy

Continue to posit a world composed of two equal-sized economies having identical domestic structures and linked by cross-border flows of goods and capital. But now assume that the home economy experiences a larger and faster increase in life expectancy than the ROW. The capital stock, aggregate output and aggregate consumption of the home economy will *expand* relative to the counterpart ROW aggregate variables (instead of shrinking as with an asymmetrically larger home fertility decline). Increased longevity, however, also leads to a relatively larger increase in the size of the home labour force. In both economies the capital-labour ratios decline and the capital-output ratios rise over the long run. But the decline in the home capital-labour ratio is relatively larger and the rise in the home capital-output ratio is relatively smaller. Declines in home real and nominal interest rates will thus be *smaller* than the declines abroad. The resulting interest differential in favour of the home economy, which other things equal needs to be offset by an expected incipient depreciation of the home currency, encourages an actual depreciation. Because the aggregate supply of home-produced goods is *increasing* relative to the aggregate supply of goods produced in the ROW, a medium- and long-run depreciation of the home currency – a deterioration in the home economy's real terms of trade – is needed as a component of the required change in the relative prices of goods and services produced in the two economies. The size of the required depreciation depends, in part, on the price sensitivities of home and ROW import demands.

The consequences of asymmetric increases in life expectancy for the home economy's net external sector transactions – the balances on trade, investment income, the current account and net capital flows – differ in important ways from, but also have similarities with, the effects of asymmetric fertility declines. Shorter-run effects from increased longevity also differ from the long-run effects. The home real trade balance in the shorter run is in deficit; yet over the longer run, reflecting the expenditure switching associated with the depreciation of the home currency, the trade balance moves toward a surplus. The home investment-output ratio rises fairly sharply over the short and medium runs, but the saving-output ratio rises even more. The ratio of the home current account to nominal GDP thus changes positively. The home economy is a net exporter of capital. Net investment income rises enough to more than offset the trade deficit. The home net foreign asset position modestly and gradually becomes more positive over the short and medium runs.

Over the longer run, however, the home saving-investment balance changes sign, the current account moves into deficit, and the net foreign asset position begins a protracted decline. After the medium run, the home economy's real terms of trade continue to deteriorate gradually. In the longest of runs, the home net foreign asset position actually turns into a net liability position.

The evolution of external sector transactions in the shorter and medium runs might at first seem paradoxical. Why do the home current account and net foreign asset positions improve for the asymmetric increase in life expectancy as well as for an asymmetric decline in fertility even though the exchange rate in the two cases moves in opposite directions? The apparent paradox is explained when it is seen that improvements in the current account and net foreign asset positions of the home economy occur sooner and faster for the asymmetrically larger home increases in life expectancy but then begin to be reversed sooner and faster. The evolutions of external sector outcomes over time become progressively different when asymmetric increases in life expectancy are compared with asymmetric declines in fertility.

Welfare comparisons between parts of the world economy also depend sensitively on whether the demographic changes take the form of increases in life expectancy or declines in fertility. When life expectancy in the home economy increases faster than in the ROW, home per-adult and per-capita consumption fall below the no-shock baseline even though the home population, aggregate home real GDP and aggregate home consumption are all above their baseline levels. ROW per-adult and per-capita consumption also fall below baseline, but proportionately *less* than in the home economy. The effects on individuals at home stemming from the openness of the economy can be adverse – 'exacerbating' rather than 'cushioning' the impact of demographic change – if the dominant cause of a faster and larger home demographic transition is an increase in life expectancy instead of a fertility decline.

5.3 Qualifications

The preceding cases abstract from several relevant considerations. The underlying analytical framework uses simplifying assumptions. The generalisations are a sound place to begin the analysis of demographic and macroeconomic interactions across borders. Nonetheless, one should be cautious when applying that analysis to actual economies.

One question to ask is whether the generalisations are significantly affected by the assumption of equal-sized economies. For example, would the qualitative conclusions differ much if the home population and economy were assumed to be much smaller than the population and economy of the ROW? Limited explorations in varying the relative sizes of the economies in my analytical framework suggest some expected differences in results, but typically only of second-order importance. One presumes that a small open economy will be substantially influenced by shocks originating in the rest of the world and, correspondingly, that shocks originating in a small economy will have relatively modest effects abroad. But by itself, the relative size of regions that experience asymmetric demographic evolutions does not appear to overturn the qualitative conclusions summarised above.

To illustrate, consider a smaller home economy experiencing a faster fertility decline relative to the ROW. The home currency will appreciate somewhat less than when the home economy is large relative to the ROW. Given the smallness of the economy relative to the ROW, home per-adult and per-capita consumption will perform somewhat more favourably as the asymmetric demographic evolutions occur. But the qualitative outcomes do not show a first-order difference.

Possible qualifications are more significant when nations or regions of the world vary greatly in structure and initial conditions, as of course they do in real life. The next section discusses the case of demographic differences between two regions representing developing and developed economies. The focus is on how such differences influence the regions' aggregate saving-investment imbalances and the resulting net capital flows between the regions. That example assumes large differences in the structures and sizes of the two regions and allows for quite different initial conditions (the configuration of the economies at the start of the analysis). As shown in the example, the underlying analytical framework described above can be successfully applied in circumstances where regional or country differences are more realistically taken into account.

Much further research, however, remains to be done before one can generalise with confidence about individual countries and regions. Analytical frameworks differ in the details of their structures and simplifications (as can be seen by a comparison of several papers for this workshop). What is most needed is further refinement of multi-country models that provide for a general equilibrium determination of interest rates, exchange rates, saving-investment imbalances and external sector transactions.

My inferences about the effects of asymmetric changes in life expectancy may be especially subject to modification. It is a strength of my modelling framework that it delivers an endogenous determination of interest rates and exchange rates that keeps careful track of general equilibrium interactions across borders. But the tractability of my general equilibrium approach comes with a cost: the model uses a theoretical shortcut that assumes adult mortality rates are age-invariant across all adults and youth mortality rates are age-invariant across all children. The assumption that mortality rates (the inverse of life expectancies) are age-invariant rather than age-specific departs seriously from reality.[19]

6. North-South Capital Flows

The largest demographic asymmetries in the world today, dramatically evident in Figures 1–6, exist between lower-income, less-developed countries (the 'South') and higher-income developed countries (the 'North'). Although many factors other than demography influence net capital flows between the North and South, asymmetric demographic transitions are important in determining whether and how transfers of savings take place. Focusing on North-South capital flows is thus another revealing way to study the issues on this workshop's agenda.

In principle, demographic influences can have either facilitating or restraining effects on net transfers of savings. Toward one end of the range of views, the presumption is that asymmetric demographic evolutions will increase the extent to which the South collectively runs a current account deficit, thus importing a fraction of Northern savings into Southern economies. This view is relatively optimistic:

19. The theoretical shortcut is attributable to Yaari (1965), Blanchard (1985) and Weil (1989). Advantages and disadvantages are discussed in Bryant and McKibbin (2004), Bryant (2004c) and Bryant *et al* (2004). Blanchard himself pointed out that the evidence on mortality rates suggests low and approximately constant probabilities of death from, say, ages 20 through 40; thereafter mortality rates rise with age (sometimes modelled by 'Gompertz's Law' suggesting that mortality rates after puberty rise in geometric progression as in Wetterstrand 1981), reaching (annual) rates in the United States in the neighbourhood of 16 per cent by age 80 and 67 per cent by age 100. The generalisations about changes in life expectancies in the text stem from analytical experiments that asymmetrically change the average (age-invariant) life expectancies for adults in the model's regions. In real life, macroeconomic effects presumably depend sensitively on the specific age cohorts for which life expectancy increases. Declines in mortality rates for elderly adults, for example, presumably have different macroeconomic effects than declines in mortality rates for young adults or for children. When simulation experiments in my underlying model for reductions in youth mortality are contrasted with the results for reductions in adult mortality, notable differences are evident.

it presumes North-South macroeconomic interactions will be mutually beneficial, permitting asset owners in the North to earn higher returns on their savings than would otherwise be possible and simultaneously permitting investment within the South to be higher, thereby promoting Southern economic development. Views toward the opposite end of the range are sceptical. Demographic influences could, according to those views, move saving-investment imbalances in the North and the South in the 'wrong' direction, *reducing* the degree to which Southern economies can run a current account deficit and sustain a higher level of domestic investment relative to Southern savings.

Quite apart from demographic trends, impediments and frictions in Southern economies and politics suggest a non-optimistic view about their ability to absorb saving from the rest of the world. Southern economies can provide substantially larger investment opportunities at the margin for Northern investors only if the constraints that inhibit faster Southern growth can be eased. In practice, the South might not be able to absorb enough Northern savings to alter significantly the saving-investment balance for the North. Most analysts agree that investments in the South by Northern owners of financial capital, if feasible, could bring advantages to both the North and South through enhanced diversification of risk and higher rates of return. For Southern economies to capture those potential gains, however, the economic, political and legal impediments that inhibit Northern investment in the South must not be too severe.[20]

To isolate the effects of asymmetric North-South demography from other influences, I use an analytical framework similar to that underlying the analysis above. Developing and developed economies are aggregated into a two-region world – a Southern economy and a Northern economy – and the demographic and macroeconomic interactions between them are simulated. The analysis, however, differentiates many aspects of the behaviour of the regions, trying to capture some of the salient differences between developing and developed economies. The calibration of the regions' structures, for example, reflects the facts that the South has some 80–85 per cent of the world's population but only about one-fifth to one-quarter of world GDP measured at market prices and at market exchange rates. The regions have very different levels and growth rates of total factor productivity. The investment climate in the South is less favourable than in the North (adjustment costs for changing capital stocks and risk-premium wedges are higher). A smaller fraction of Southern than of Northern households is assumed to be able to smooth consumption intertemporally in a manner consistent with the life-cycle hypothesis. At the outset of the analysis, the South is running a sizable current account deficit in relation to its GDP and has a large net foreign *liability* position. Because of the global identities enforced in the model, the North has a correspondingly large net foreign asset position *vis-à-vis* the South. In the 1950 initial conditions with which

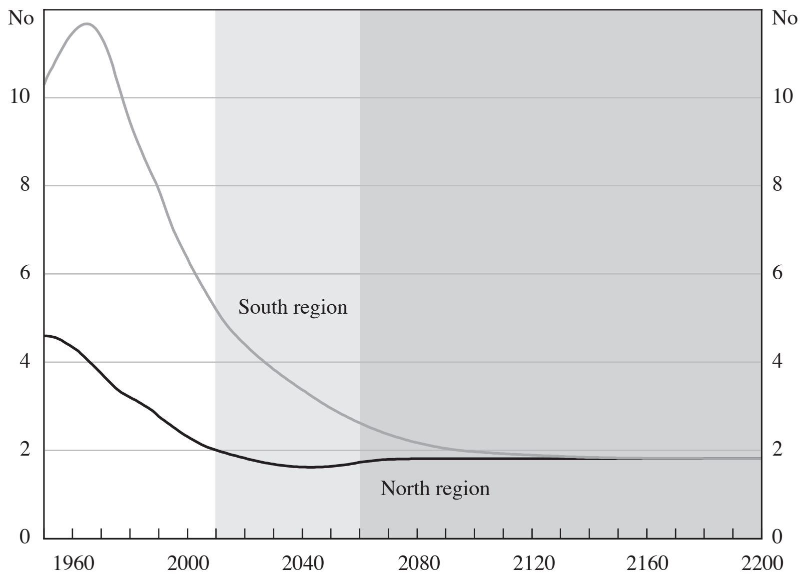
20. Discussion of the issues can be found in, for example, the World Bank's (2002, 2004) *World Development Report* for the years 2002 and 2005, Gertler and Rogoff (1990), Temple (1999), Hall and Jones (1999), Holzmann (2000) and Bosworth and Collins (2003). See also the early pages of Bryant (2006).

simulations begin, therefore, the South has domestic investment that is higher than national saving while national saving in the North is higher than domestic investment, with a part of Northern gross saving exported to the South through net capital outflows.[21]

Figure 7 shows aggregated birth-rate series for the Southern and Northern regions that are derived from the UN Population Division's data for life expectancies and the growth rates of adult populations. Figure 8 plots the related series of the active ratios of working-age adults to the total population. Each of these charts (as well as the others that follow) begins with the historical data for 1950–2005; the UN projection data for 2005–2050 are lightly shaded; the darkly shaded parts for years after 2050 indicate how the UN projections can be analytically extended to produce eventual convergence to a steady state with stationary populations in all parts of the world.

The changes over time in birth rates shown in Figure 7 and counterpart series for changes in life expectancies indicate that, from today until the middle of the 21st century, demographic transitions on average in Northern economies are beginning to slow down while transitions in Southern economies are picking up speed. The effects of asymmetric demography depend not only on differences across

Figure 7: Fertility Rates
Births per woman

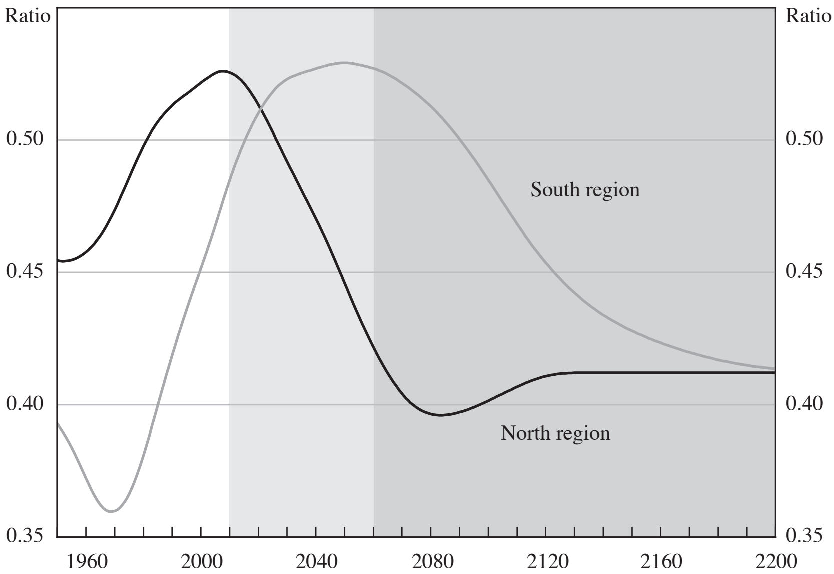


Note: Data from 2005 to 2050 are based on UN Population Division projections and thereafter analytical extensions to produce eventual convergence to a stationary population steady state.

Sources: Bryant (2006); UN Population Division (2005)

21. Details are given in Bryant (2006).

Figure 8: Ratio of Active Adults (Ages 20–64) to Total Population



Note: Data from 2005 to 2050 are based on UN Population Division projections and thereafter analytical extensions to produce eventual convergence to a stationary population steady state.

Sources: Bryant (2006); UN Population Division (2005)

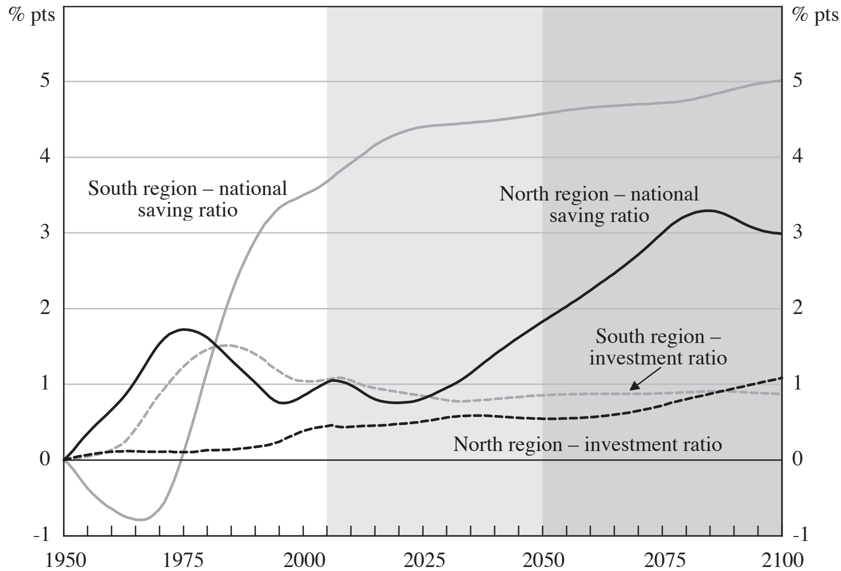
regions in the *levels* of birth rates, life expectancies and dependency ratios but also on differences in the sizes of incremental *changes* in rates and ratios. The gap in levels between Southern and Northern demographic variables will diminish through time. Alternatively stated, especially because of faster declines in Southern fertility rates, Southern economies will prospectively experience demographic change *more rapidly* – not less rapidly – than Northern economies. The very different prospective changes in active ratios (Figure 8) provide another clue about the macroeconomic interactions that lie ahead between developing and developed regions.

To illustrate the macroeconomic effects on saving, investment and saving-investment balances, Figures 9 and 10 summarise the results of a benchmark model simulation incorporating the demographic inputs shown in Figures 7 and 8. Figure 9 plots the evolutions of saving and investment relative to economic activity in the Southern and Northern regions. Each region's external imbalance in the benchmark simulation, measured as a ratio to the region's nominal GDP, is plotted in Figure 10. These current account balance ratios are implicit in Figure 9, but Figure 10 makes it easier to focus on how dramatically the saving-investment balances change over time. The variables are measured as changes from the initial-conditions values of the ratios prevailing in 1950.[22]

22. The denominators of the ratios in Figures 9 and 10 are Southern nominal GDP for the Southern ratios and Northern nominal GDP for the Northern ratios. Saving is nominal national saving, the sum of nominal private saving and nominal government saving or dissaving.

Figure 9: Ratios of Domestic Investment and National Savings to Nominal GDP

Benchmark simulation – change from 1950 value of ratios

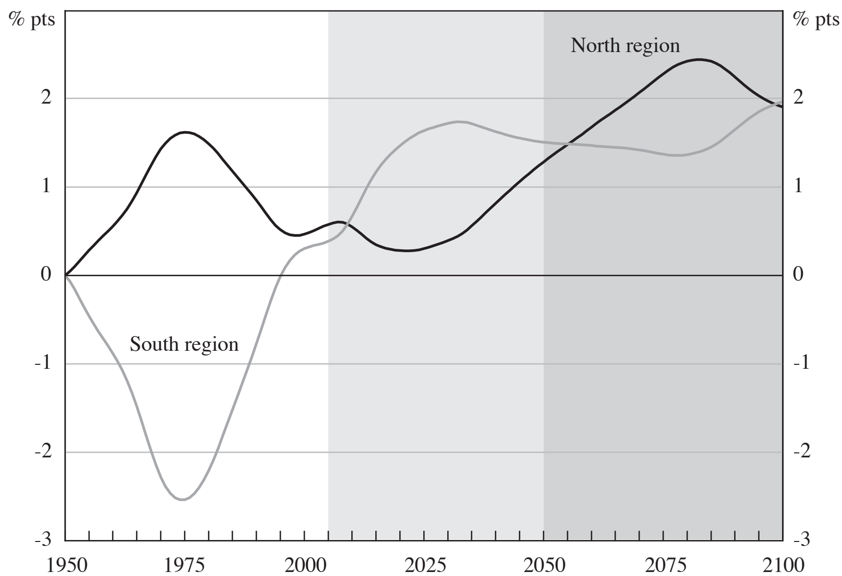


Notes: Data from 2005 to 2050 are based on UN Population Division projections and thereafter analytical extensions to produce eventual convergence to a stationary population steady state.

Source: Bryant (2006)

Figure 10: Ratio of Current Account Balance to Nominal GDP

Benchmark simulation – change from 1950 value of ratios



Notes: Data from 2005 to 2050 are based on UN Population Division projections and thereafter analytical extensions to produce eventual convergence to a stationary population steady state.

Source: Bryant (2006)

For the first few decades after 1950, the level of the active ratio is much lower in the South than the North and declines markedly (Figure 8). The decline in the Southern active ratio reflects the large number of children entering the South population in those years and the lower productivity relative to older workers of the increasingly numerous youths just entering the labour force. In association with these demographic changes, the saving-GDP ratio in the South declines significantly (by close to a percentage point of GDP) and does not begin to increase strongly until the active ratio begins rising several decades later. In contrast, the Southern investment-GDP ratio rises from the outset but then begins a gradual deceleration after the 1970s; the investment ratio falls after the mid 1980s for several decades.

Demographic influences on saving and investment in the North during the first decades after 1950 are roughly the opposite of those in the South. The North has a high and initially rising active ratio. Northern saving is buoyant and Northern investment is relatively weak during the early decades when the North active ratio is rising strongly.

The saving-investment balances move dramatically in the reverse direction, however, once the Northern active ratio peaks and begins to decline and as the Southern active ratio begins to increase strongly. The gap between the Southern and the Northern active ratios is already narrowing by the 1980s. The Southern active ratio exceeds the Northern ratio after 2020 and does not peak until 2050. The Northern active ratio continues its sharp fall. The saving ratio in the South, now influenced by the demographic bonus of a fast-increasing effective labour force, begins a persistent upsurge that continues into the middle of the 21st century. In contrast, net demographic influences in the North contribute to a peaking of its saving ratio and then a subsequent decline. The demographic evolutions of the two regions thus contribute to a progressive strengthening of Southern saving and a relative weakening of Northern saving.

As part of the adjustment to the asymmetric demographics in the benchmark simulation, the Southern currency depreciates gradually for several decades after 1950 and then depreciates more strongly over a period that continues for more than 100 years. In the very long run, the real value of the Southern currency settles at a depreciated level far below its original (initial-conditions) value. As in the earlier analyses, the changes in the real exchange rate are due to changes in the relative size of the regions' outputs, which in turn depend on changes in the relative sizes of the regions' populations and effective labour forces. The South's effective labour force is much larger than the North's by the time both regions settle down to the same rates of growth in the long run. Correspondingly, macroeconomic aggregates such as the capital stock and output become larger in the South relative to the North. The quantity of goods produced in the South available for sale and consumption in the world thus increases relative to the quantity of goods produced in the North. In the absence of changes in the preferences of each region's consumers for the two types of goods, relative prices in the world economy have to adjust to reflect the now relatively more abundant Southern-produced goods. A real depreciation of the South's currency, representing an improvement in the Northern economy's real terms of trade, facilitates the required change in relative prices.

Recall that in the benchmark initial conditions, the South in 1950 starts out as a debtor region, running a current account deficit. Thus at the outset some part of Northern saving flows to the South. This pattern of sizable capital inflows to the South in proportion to the Southern economy continues in the benchmark simulation for two and a half decades after 1950. Hence the shifts in relative demographics contribute to a major increase in the gap between the South's domestic investment and national savings ratios, and hence to a further widening in the current account deficit (Figure 10).

However, the gaps in the regional saving-investment balance ratios – the current account deficit ratio in the South and the North's current account surplus ratio – begin to move in the opposite direction around the mid 1970s. Thereafter, for the final two decades of the 20th century and the first four decades of the 21st century, the South's current account deficit as a proportion of GDP narrows steadily and persistently. By the decade of the 2030s, the South's current account deficit ratio is more than 1.5 percentage points of GDP less negative than in 1950.

The analysis summarised here thus identifies a dramatic reversal after the 1970s of saving-investment balances in relation to the sizes of the regional economies. Prior to the mid 1970s, demographic asymmetries between the Southern and Northern regions increase the net flow of capital from the North to the South. Beginning in the mid 1970s, however, the relative demographics operate in the reverse direction. As a percentage of their regional economies, Northern saving falls relative to Northern investment while Southern saving increasingly rises relative to Southern investment. Demographic influences considered by themselves progressively operate to *reduce* rather than increase the net flow of capital from the North to the South measured relative to the size of the Southern economy.[23]

The fundamental explanation for these effects is, to repeat, the shift in *relative* demographics between regions. Relative shifts in the age compositions of populations, and in particular relative shifts in the numbers of active workers in the labour forces and their efficiencies, differentially affect regions' flows of saving and investment. Aggregate savings, determined in a modified life-cycle framework, are relatively high (low) in a region in which the active labour force rises (declines) in relation to the total population. Investment relative to saving is high (low) when youth and elderly dependents constitute a large (small) fraction of the population. Both saving and investment are of course higher (lower) in a region growing strongly (sluggishly). But the balance between saving and investment for a single region – and even

23. The ratios in Figures 9 and 10 measure savings, investment, and current account balances in relation to the sizes of the regional economies and in relation to the initial conditions of 1950. In the benchmark simulation, the South – even by the 2030s – is still running a current account deficit in absolute terms; the North is still exporting a (smaller) fraction of its savings to the South. Thus the direction of net capital flows in absolute terms is still from the North to the South. The more important point analytically, stressed in the text, is that the net capital flows occurring after the mid 1970s are progressively *diminished* as a proportion of the Southern economy.

more so net changes through time in the saving-investment imbalances of regions interacting with each other – depend critically on the relative demographics.[24]

7. Cross-border Goods Substitutability

Goods substitutability and financial substitutability in the world economy have both increased over time, linking macroeconomic variables more closely across national borders. The prevailing degrees of cross-border substitutability between goods produced in different parts of the world critically determine the quantitative sizes of macroeconomic responses to policy and non-policy shocks. That point is relevant for all cross-border transmissions. It warrants emphasis here because it applies strongly to the cross-border effects of asymmetric demography.[25]

The substitutability between home-produced and foreign-produced goods – the degree of imperfect substitutability – is captured in analytical models partly by the values of the price-elasticity parameters governing each region's demand for imports. Suppose goods production in a region accounts for a rising share of world output over time. Given traditional assumptions about the determinants of imports, that region will experience a faster increase in its imports than its exports. The incipient trade imbalance will, other things equal, give rise to a real depreciation of the region's currency. With unchanged preferences for the imperfectly substitutable home-produced and foreign-produced goods, such depreciation is required to induce the world's consumers and firms to buy the now relatively less scarce output of the faster-growing region and to prevent the region's actual trade deficit from growing larger and larger. The size of the required depreciation will depend on the degree of the imperfect goods substitutability. Most other macroeconomic variables will in turn be influenced by the changes in real and nominal exchange rates.

An example drawn from the analysis of asymmetric North-South demography will establish the empirical importance of the point. The benchmark simulation whose effects on saving-investment imbalances was shown in Figures 9 and 10 above was conducted with typically estimated values for substitutability parameters. Specifically, in the import equations of both regions the price elasticities had values of –1.10 (values near negative unity are commonly estimated in aggregate import demand equations) and values of zero were assigned to the so-called 'varieties

24. Bryant (2006) discusses a variety of sensitivity experiments that test the robustness of the conclusions about the likely future direction of North-South capital flows. For example, alternative assumptions were examined about the speed of the demographic transition and the evolution of total factor productivity in the South. Although the sensitivity experiments with alternative assumptions revealed quantitative differences in the simulation results, the differences were not large enough to overturn the qualitative conclusions summarised in the text.

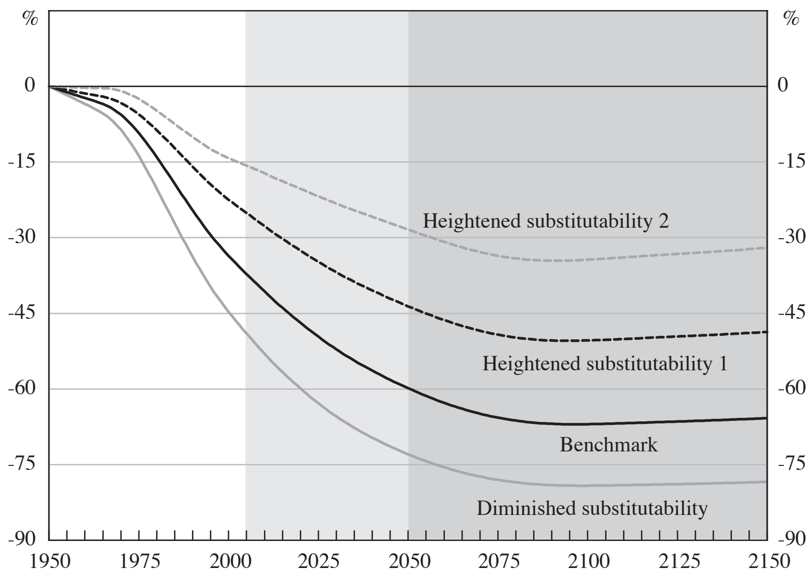
25. Bryant and de Fleurieu (2005) provide background for, and empirical illustrations of, this basic point. The degree of imperfect cross-border *financial* substitutability is probably an even more important influence on macroeconomic interactions than the degree of imperfect goods substitutability. But financial substitutability is more difficult to study empirically. Unfortunately, multi-country general equilibrium models are not yet sufficiently advanced to successfully treat assets denominated in different currencies and issued in different nations as imperfect substitutes.

effects'. For comparison, three additional simulations were prepared that were identical except for the assumed values of the substitutability parameters. For a 'diminished-substitutability' simulation, the import price elasticities were lowered by 25 per cent (to values of –0.82). A 'heightened-substitutability-1' simulation raised the import price elasticities to values two-thirds larger than the benchmark case (to –1.65) but kept varieties effects set at zero. A 'heightened-substitutability-2' simulation raised the import price elasticities by two-thirds and also assigned a positive value of 0.50 to the varieties-effect coefficient.[26]

Figure 11 contrasts the effects of the four simulations on the depreciation of the real value of the South's currency. Figure 12 contrasts the effects on the South's current account balance expressed as a proportion of nominal GDP. As the figures show, altering the substitutability parameters has major effects. Heightened substitutability dramatically cuts the size of the currency depreciation. Adding non-zero varieties effects in the heightened-substitutability-2 simulation reduces the size of the depreciation still further. Raising the substitutability parameters increases the South's current account deficit relative to GDP up until the decade of the 2030s

Figure 11: Real Exchange Value of South's Currency – Alternative Substitutability Parameters

Percentage change from 1950 value



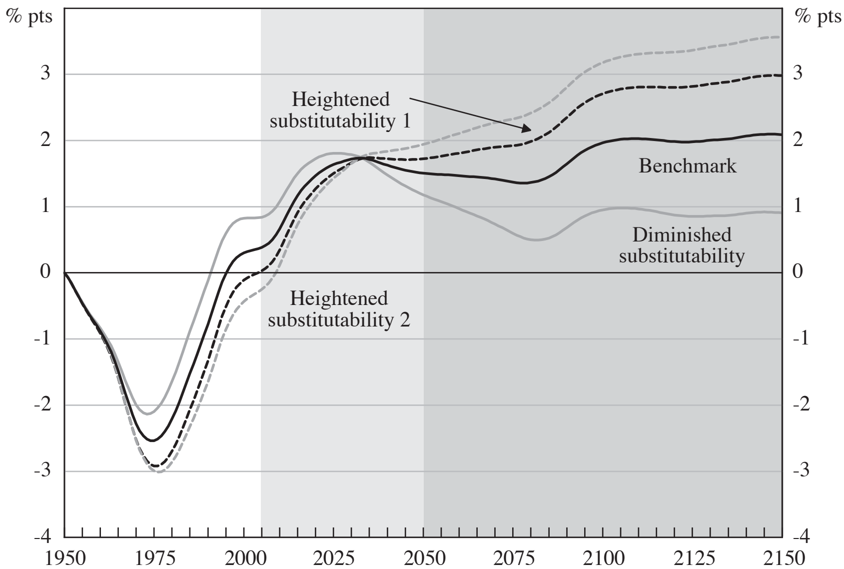
Notes: Negative values indicate a depreciation of currency. Data from 2005 to 2050 are based on UN Population Division projections and thereafter analytical extensions to produce eventual convergence to a stationary population steady state.

Source: Bryant (2006)

26. The rationale for 'varieties effects' in trade equations and the way they are incorporated in the analytical model are explained in Bryant and de Fleurieu (2005).

Figure 12: Ratio of South's Current Account Balance to Nominal GDP – Alternative Substitutability Parameters

Change from 1950 value of ratios



Notes: Data from 2005 to 2050 are based on UN Population Division projections and thereafter analytical extensions to produce eventual convergence to a stationary population steady state.

Source: Bryant (2006)

(Figure 12). If cross-border goods substitutability is diminished, the effects on the real value of the South's currency and its current account ratio go in the opposite direction. The differences in outcomes associated with different substitutability parameters have first-order importance.

The key to understanding the differences between the scenarios is to realise that changes in the degree of goods substitutability influence the relative importance of *quantity* adjustments relative to adjustments in *prices* and *price-like variables*. Heightening cross-border substitutability increases the importance of quantity adjustments relative to price adjustments. Diminishing substitutability has opposite effects: it puts even greater pressure for adjustment on prices and price-like variables. When any exogenous shocks – such as changes in fertility rates or life expectancies – are put into an analytical macroeconomic system, real quantity variables (for example, incomes, wealths, outputs and consumptions) must adjust so that regional economies and the world economy as a whole can attain a new real equilibrium. The necessary adjustments in quantity variables, although not independent of what happens to price variables, depend most crucially on the evolution of other endogenous quantity variables (with all endogenous variables ultimately driven by the exogenous shocks). If shocks are asymmetric across regions, major adjustments are typically required in both the real and the nominal values of cross-border transactions. The greater is cross-border goods substitutability in response to changes in relative prices, the less will price variables have to adjust to achieve the necessary adjustments in real quantity variables. Greater sensitivity of behaviour to prices means that quantities, both cross-border and domestic, adjust faster and possibly more smoothly to the required new equilibrium. Conversely, if cross-border goods substitutability is weak, then price and price-like variables must adjust by much larger amounts to achieve the adjustments to quantities that are ultimately necessary. Price variables in these generalisations include of course goods prices – domestic prices as well as import and export prices. But the relevant price-like variables also include interest rates and exchange rates (both real and nominal).

Thus in the diminished-substitutability simulation shown in Figures 11 and 12, price adjustments – including, dramatically, the real exchange rate but also the real interest rate – are larger than in the benchmark case. In particular, diminished goods substitutability increases the size of the depreciation of the South's currency needed to adjust the global economy to the greater relative abundance of goods produced in the South. The lower value of the import price elasticity simultaneously *raises* the South's current account ratio (relative to the benchmark case) through the decade of the 2030s.

The opposite effects occur when the substitutability parameters are larger in absolute value. The real exchange rate and real interest rate need to change *less* relative to the benchmark case to achieve the required adjustment to the altered demographic conditions. The higher values of the substitutability parameters thus permit a *smaller* depreciation of the South's currency and produce a *deterioration* (larger negative value) of its current account ratio through the decade of the 2030s. If a non-zero varieties effect is combined with a higher value for the import price elasticities (as in the heightened-substitutability-2 simulation), the size of the necessary depreciation is still smaller and the South runs a still more negative current account ratio in the short and medium run.

The example from asymmetric North-South demography highlights another general point: the degree of cross-border goods substitutability can dramatically influence regional welfares. Heightened (diminished) cross-border substitutability with its augmented (reduced) Southern use of Northern savings improves (worsens) per-adult and per-capita consumption in the South but lowers (raises) per-adult and per-capita consumption in the North. Those effects on per-adult and per-capita consumptions stem from changes in the terms of trade of the regions. When a region experiences a real depreciation of its currency, it suffers a deterioration of its real terms of trade with the rest of the world. Other things equal, the deterioration of the terms of trade causes an adverse change in the welfare of the region's residents. In the example here, Southern residents in the benchmark simulation, because of the very large currency depreciation, experience a large deterioration in the relative prices at which South-produced goods can be traded for imported goods. With heightened substitutability parameters, the adverse changes from deterioration of the terms of trade are significantly mitigated. What is gained by the South when substitutability parameters are higher, however, is plainly an adverse development for Northern residents. The Northern real terms of trade is less favourable than in the benchmark case and hence negatively impacts Northern per-adult and per-capita consumption.

Welfare inferences for particular nations or regions must focus on the possibility that outcomes beneficial for one part of the world economy may well be adverse for other parts. What is favourable cushioning for a region where a shock originates can turn out abroad to be unwelcome buffeting. Increases in cross-border substitutability augment the international transmission of shocks. But whether the consequences of heightened transmission are beneficial or adverse for a particular region depends on the type of shocks that occur and where the shocks originate. Heightened transmission can thus be a double-edged sword, cutting helpfully for some but unhelpfully for others.

Even the brief discussion here should suffice to establish the need for paying greater attention to the degree of cross-border goods substitutability when analysing macroeconomic interactions among different parts of the world economy. In particular, analysts and policy-makers require more reliable empirical estimates of the determinants of cross-border goods substitutability than the inadequate estimates currently available.

8. Concluding Observations

The overview in this paper in some places is, inescapably, preliminary. The overall conclusions are nonetheless robust. And such a survey provides a helpful place to start when initially familiarising oneself with existing knowledge.

To conclude, I recapitulate some main themes of the survey and highlight some points that most deserve emphasis from a policy perspective. I also suggest a few guidelines that should shape further analysis and research.

The importance of open-economy dimensions. The openness of economies decisively influences the macroeconomic consequences of asymmetric demographic transitions. The 'domestic' effects of demographic change are strongly influenced by cross-border transactions. Failure to take into account the powerful macroeconomic effects working through exchange rates and cross-border transactions can lead to a seriously inaccurate assessment of the net impacts of demographic change.

Alternative drivers of demographic change. Population ageing can result from different demographic causes. Macroeconomic consequences depend sensitively on the specific cause, or combination of causes. Most notably, the effects differ depending on whether the ageing occurs because of reductions in fertility (lower birth rates and hence fewer children) or, alternatively, increases in life expectancy (lower death rates and hence longer survival spans).

Aggregate versus per-capita outcomes. Analysis of the macroeconomic effects of demographic transitions should differentiate between aggregate effects for an economy as a whole versus effects on the economy's residents expressed in per-capita or per-adult terms. For several types of demographic shocks, the paths for aggregate levels of variables – for example the total output, consumption, and savings of all the economy's residents – can move in the opposite direction from the paths of the same variables when measured in per-capita or per-adult terms. Differentiating between aggregate and per-capita variables would be important for the interpretation of outcomes even in a completely closed economy. For open economies experiencing different speeds and intensities of demographic change, the distinction is especially consequential and has great relevance for policy debates about population ageing.

Favourable or adverse welfare consequences? Depending on the specific nature of asymmetric demographic trends, nations and regions can be either favourably cushioned or adversely buffeted by the effects of resulting changes in exchange rates, trade flows and net flows of capital. Alternative assumptions about parameter values embodying the degree of cross-border substitutabilities can significantly change inferences about the consequences and the geographical distribution of effects. To form judgments about whether the welfare consequences will be favourable or adverse, analysis should carefully focus on the type of demographic shocks and the extent of cross-region asymmetry. It would also be desirable to conduct sensitivity tests of such judgments using alternative values of substitutability parameters.

Relative sizes of countries, demography and macroeconomics. Macroeconomic interactions in response to asymmetric demography can alter the relative sizes of economic activity in nations and regions. In effect, outputs, capital stocks and consumptions can be 'redistributed' across borders. Such redistributions can have major consequences for the relative welfares of nations, not only in economic but also in political and security terms.

When considering these redistributions, one has to bear in mind the cross-border mobility of labour. In the analysis underlying this paper, as is largely true in reality, workers cannot move across borders. In a world economy where cross-border movements of labour are prohibited, the effects of a country-specific demographic shock fall on the population, workers and effective labour forces *within* the nation where the demographic shock occurs. There can be no secondary or feedback effects, via emigration or immigration, on the sizes of the population, workers and effective labour forces outside that nation. Asymmetric demographic shocks do not have cross-border *demographic* effects.

In contrast, cross-border *macroeconomic* interactions can be powerful when goods, services and financial funds are relatively free to move internationally. Outputs, capital stocks and consumptions can be redistributed across borders with the passage of time. Within-border evolutions of effective labour forces play critical roles in determining economic activity, but the cross-border transactions can modify and redistribute the impacts of these changes. The relative sizes of economies measured by people and labour forces can thus evolve quite differently from the relative sizes measured by macroeconomic aggregates.

Will cross-border migration become more important in the future? In principle, flows of workers across borders could diminish cross-national differences in returns to capital and labour. For the destination nations where inward migration is now significant, migrants tend to be of working-age; thus they raise the ratio of workers to non-workers, augment labour supply, and dampen changes in the capital-labour ratio that would otherwise result from demographic forces. Migration could raise saving relative to investment in destination countries and thereby improve those countries' current account balances (though remittances sent home are an offset to such effects).

As noted earlier, however, government policies severely limit or altogether restrict the flows of workers across borders. Inward and outward migration for most nations is still only of second-order importance and, in the shorter run, probably will not expand greatly. All things considered, large movements of people across borders in the next few decades are unlikely to significantly undermine the generalisations about the macroeconomic effects of demographic change summarised in this paper. Nor can one plausibly expect large-scale emigration to be a primary remedy for the economic problems of developing economies, regardless of demographic trends.

Accordingly, this paper treats the omission of migration as a defensible first approximation to a comprehensive analysis of asymmetric demography. Migration of people was an important feature of the world economy in the late 19th and early 20th centuries, however, and could become more important again in the future. Eventually, analysts of the partially integrated global economy must develop full-blown general equilibrium models that include cross-border movements of people as well as movements of goods, services and financial funds.

Guidelines for further analysis and research. The analysis summarised here is abstract and qualitative. One cannot confidently apply the generalisations to individual nations or regions. As further policy analysis and basic research are carried out prior to the successful inclusion of migration, the following points can serve as useful guidelines to shape that work.

First, analysis should focus on *relative* demographics and their likely consequences as insights are sought about interactions between a particular country or region and the rest of the world. Dependency ratios and active ratios, for example, can provide clues about saving, investment and saving-investment balances, and hence about the probable evolution of current account balances and net capital flows.

Second (a guideline related to the first), analysis should examine the relative sizes of effective labour forces and outputs for a country or region *vis-à-vis* the parts of the world with which it primarily has external transactions. The labour force and output relativities will diverge through time, but those divergences will themselves provide useful clues. The evolution of relative outputs is especially useful for generating insights about the likely direction of movements of real exchange rates and hence changes in the real terms of trade.

Third, future analysis should be conditioned by the facts that empirical estimates of relative price elasticities for trade flows, varieties effects on trade flows, and other parameters reflecting cross-border substitutability play critical roles in determining the projected global consequences of asymmetric demography, indeed of all types of shocks. And it merits emphasising again that it should be a high priority for future research to obtain more robust empirical estimates of those key parameters than the estimates currently available.

Finally, analysis should continue to study cross-border macroeconomic interactions in general equilibrium analytical frameworks. Only the least consequential economies in the world can be usefully studied with 'small, open-economy' models in which the remainder of the world is assumed exogenous, unaffected by developments in the nation or region of interest. Interactions between large individual nations – such as the United States, those of the European Union, Japan, China, India and Brazil – or between major regions of the world (for example, aggregations of developed and developing countries; North America, Europe and Japan) must be studied in frameworks that are capable of endogenously determining interest rates, exchange rates and external imbalances together with domestic macroeconomic variables in all nations or regions. Developing such frameworks is a formidable analytical task but merits the efforts that will be entailed.

Appendix A

Table A1: Fertility Rates

G7 countries, other G-20 countries and selected least-developed countries; births per woman

												UN medium projection								
	1950–1955	1955–1960	1960–1965	1965–1970	1970–1975	1975–1980	1980–1985	1985–1990	1990–1995	1995–2000	2000–2005	2005–2010	2010–2015	2015–2020	2020–2025	2025–2030	2030–2035	2035–2040	2040–2045	2045–2050
Canada	3.73	3.90	3.61	2.51	1.97	1.74	1.63	1.69	1.69	1.56	1.51	1.47	1.47	1.54	1.61	1.68	1.75	1.82	1.85	1.85
France	2.73	2.71	2.85	2.61	2.31	1.86	1.87	1.81	1.71	1.76	1.87	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85
Germany	2.16	2.30	2.49	2.32	1.64	1.52	1.46	1.43	1.31	1.34	1.32	1.34	1.41	1.48	1.55	1.62	1.69	1.76	1.83	1.85
Italy	2.32	2.35	2.50	2.49	2.33	1.89	1.53	1.35	1.28	1.21	1.28	1.38	1.41	1.45	1.52	1.59	1.66	1.73	1.80	1.85
Japan	2.75	2.08	2.02	2.00	2.07	1.81	1.76	1.66	1.49	1.36	1.33	1.37	1.44	1.51	1.58	1.65	1.72	1.79	1.84	1.85
UK	2.18	2.49	2.81	2.52	2.04	1.72	1.80	1.81	1.78	1.70	1.66	1.66	1.70	1.77	1.83	1.85	1.85	1.85	1.85	1.85
US	3.45	3.71	3.31	2.55	2.02	1.79	1.83	1.92	2.03	1.99	2.04	2.04	1.98	1.91	1.86	1.85	1.85	1.85	1.85	1.85
Argentina	3.15	3.13	3.09	3.05	3.15	3.44	3.15	3.05	2.90	2.63	2.35	2.25	2.16	2.08	2.00	1.92	1.85	1.85	1.85	1.85
Australia	3.18	3.41	3.27	2.87	2.54	2.09	1.93	1.87	1.87	1.77	1.75	1.75	1.79	1.84	1.85	1.85	1.85	1.85	1.85	1.85
Brazil	6.15	6.15	6.15	5.38	4.72	4.31	3.80	3.10	2.60	2.45	2.35	2.25	2.15	2.06	1.98	1.92	1.86	1.85	1.85	1.85
China	6.22	5.59	5.72	6.06	4.86	3.32	2.55	2.46	1.92	1.78	1.70	1.74	1.81	1.85	1.85	1.85	1.85	1.85	1.85	1.85
India	5.97	5.92	5.81	5.69	5.43	4.83	4.48	4.15	3.81	3.43	3.07	2.76	2.50	2.29	2.11	1.95	1.85	1.85	1.85	1.85
Indonesia	5.49	5.67	5.42	5.57	5.20	4.73	4.11	3.40	2.90	2.50	2.37	2.20	2.03	1.89	1.85	1.85	1.85	1.85	1.85	1.85
Mexico	6.87	6.96	6.82	6.82	6.60	5.40	4.30	3.70	3.20	2.70	2.40	2.15	2.03	1.95	1.89	1.85	1.85	1.85	1.85	1.85
Russia	2.85	2.82	2.55	2.02	2.03	1.94	2.03	2.13	1.55	1.24	1.33	1.40	1.44	1.51	1.58	1.65	1.72	1.79	1.85	1.85
Saudi Arabia	7.18	7.18	7.26	7.26	7.30	7.28	7.05	6.26	5.65	4.86	4.09	3.58	3.17	2.84	2.57	2.34	2.15	1.99	1.87	1.85
South Africa	6.50	6.50	6.50	5.80	5.47	5.00	4.56	3.85	3.34	2.95	2.80	2.64	2.48	2.34	2.23	2.13	2.05	1.97	1.90	1.85
South Korea	5.40	6.33	5.63	4.71	4.28	2.92	2.23	1.60	1.70	1.51	1.23	1.21	1.28	1.35	1.42	1.49	1.56	1.63	1.70	1.77
Turkey	6.90	6.60	6.19	5.70	5.30	4.72	4.15	3.27	2.90	2.69	2.46	2.31	2.21	2.11	2.03	1.96	1.89	1.85	1.85	1.85
Guatemala	7.00	6.60	6.50	6.30	6.20	6.20	6.10	5.70	5.45	5.00	4.60	4.15	3.71	3.29	2.92	2.61	2.35	2.14	1.97	1.85
Laos	6.15	6.15	6.15	6.15	6.15	6.69	6.69	6.30	5.80	5.30	4.83	4.28	3.74	3.30	2.94	2.65	2.41	2.21	2.04	1.89
Mali	7.11	7.11	7.11	7.35	7.56	7.56	7.56	7.47	7.38	7.22	6.92	6.58	6.21	5.80	5.34	4.85	4.33	3.85	3.43	3.10
Tanzania	6.74	6.80	6.80	6.79	6.75	6.73	6.55	6.36	5.90	5.48	5.04	4.45	3.89	3.42	3.04	2.73	2.48	2.27	2.09	1.93
Yemen	8.20	8.30	8.40	8.40	8.50	8.50	8.70	8.30	7.60	6.88	6.20	5.65	5.10	4.50	3.94	3.47	3.12	2.85	2.65	2.49

Source: UN Population Division (2005)

Table A2: Life Expectancy at Time of Birth

G7 countries, other G-20 countries and selected least-developed countries; years

											UN medium projection									
	1950–1955	1955–1960	1960–1965	1965–1970	1970–1975	1975–1980	1980–1985	1985–1990	1990–1995	1995–2000	2000–2005	2005–2010	2010–2015	2015–2020	2020–2025	2025–2030	2030–2035	2035–2040	2040–2045	2045–2050
Canada	69.08	70.55	71.44	72.01	73.15	74.19	75.94	76.96	77.92	78.72	79.91	80.66	81.35	81.99	82.57	83.14	83.70	84.25	84.79	85.32
France	66.52	69.61	70.96	71.55	72.35	73.70	74.72	76.03	77.48	78.48	79.39	80.03	80.68	81.30	81.91	82.50	83.08	83.65	84.21	84.75
Germany	67.50	69.10	70.30	70.80	71.00	72.50	73.80	74.85	76.16	77.45	78.65	79.32	79.96	80.59	81.21	81.77	82.27	82.76	83.24	83.72
Italy	66.00	68.48	69.92	70.97	72.11	73.59	74.54	76.24	77.31	78.81	79.99	80.58	81.20	81.80	82.38	82.95	83.51	84.06	84.60	85.14
Japan	63.94	66.75	68.96	71.11	73.30	75.47	76.91	78.30	79.50	80.53	81.90	82.82	83.69	84.50	85.26	85.98	86.64	87.25	87.80	88.29
UK	69.18	70.42	70.76	71.36	72.01	72.76	74.04	75.01	76.42	77.22	78.30	78.97	79.60	80.22	80.81	81.38	81.93	82.47	83.00	83.51
US	68.87	69.67	70.03	70.38	71.52	73.32	74.12	74.65	75.25	76.53	77.31	77.92	78.48	79.07	79.65	80.22	80.79	81.35	81.90	82.45
Argentina	62.49	64.40	65.14	65.63	67.07	68.48	69.94	70.77	71.87	73.28	74.34	75.32	76.22	77.06	77.83	78.53	79.18	79.75	80.28	80.75
Australia	69.57	70.41	70.91	70.85	71.70	73.45	75.21	76.10	77.60	78.73	80.21	80.96	81.64	82.22	82.71	83.20	83.68	84.14	84.60	85.04
Brazil	50.92	53.29	55.67	57.63	59.50	61.49	63.15	64.94	66.63	68.85	70.30	71.91	72.94	74.16	75.24	76.18	77.03	77.82	78.54	79.20
China	40.76	44.61	49.53	59.58	63.18	65.33	66.56	67.06	68.07	69.70	71.49	72.59	73.30	73.84	74.45	75.27	76.21	77.12	77.96	78.73
India	38.69	42.60	45.45	48.01	50.27	52.87	54.82	57.20	59.46	61.50	63.12	64.87	66.75	68.47	70.00	71.39	72.66	73.83	74.90	75.91
Indonesia	37.47	39.92	42.52	45.96	49.20	52.70	56.16	60.14	62.64	64.88	66.53	68.70	70.00	71.04	71.99	73.08	74.18	75.19	76.09	76.90
Mexico	50.64	55.11	58.25	60.08	62.36	65.09	67.51	69.59	71.58	73.69	74.92	76.21	77.30	78.21	78.98	79.63	80.16	80.60	80.97	81.25
Russia	64.48	66.85	67.87	70.07	69.72	68.96	68.58	70.18	66.78	66.04	65.37	65.03	65.60	66.87	68.18	69.20	70.08	70.97	71.92	72.88
Saudi Arabia	39.87	42.86	45.91	49.90	53.88	58.69	63.01	66.29	68.76	70.54	71.62	72.87	73.90	74.82	75.65	76.43	77.15	77.86	78.53	79.18
South Africa	45.01	47.99	49.95	51.93	53.67	55.54	58.36	61.18	62.02	58.44	49.02	44.06	44.59	47.00	49.29	51.32	53.26	55.25	57.30	59.43
South Korea	47.46	52.57	55.20	57.64	62.61	64.79	67.17	69.81	72.22	74.65	76.85	78.20	79.38	80.45	81.42	82.19	82.77	83.34	83.90	84.44
Turkey	43.59	48.08	52.10	54.34	57.01	59.51	61.04	63.11	66.15	67.82	68.57	69.75	71.03	72.31	73.45	74.46	75.36	76.19	76.96	77.67
Guatemala	42.01	44.11	46.90	49.94	53.65	55.94	57.86	60.32	62.43	65.04	67.11	68.50	69.85	71.31	72.71	73.95	75.05	76.05	76.94	77.75
Laos	37.82	40.42	40.42	40.42	40.42	43.51	45.75	48.27	50.78	52.49	54.50	56.50	59.00	61.50	63.74	65.88	67.88	69.61	70.96	72.15
Mali	31.80	33.38	34.76	36.52	37.97	39.83	42.72	44.95	46.72	47.42	47.76	49.28	51.27	53.33	55.48	57.64	59.73	61.76	63.71	65.55
Tanzania	40.46	42.53	44.73	47.05	49.51	52.12	54.75	54.93	52.44	48.16	46.02	46.57	48.33	50.39	52.68	54.94	57.03	59.01	60.91	62.76
Yemen	32.55	33.97	35.18	36.98	39.85	44.17	49.11	52.92	55.66	57.71	60.33	62.67	64.87	66.91	68.74	70.14	71.21	72.17	73.04	73.84

Source: UN Population Division (2005)

Table A3: Average Annual Growth Rate of Total Population

G7 countries, other G-20 countries and selected least-developed countries; per cent

												UN medium projection								
	1950–1955	1955–1960	1960–1965	1965–1970	1970–1975	1975–1980	1980–1985	1985–1990	1990–1995	1995–2000	2000–2005	2005–2010	2010–2015	2015–2020	2020–2025	2025–2030	2030–2035	2035–2040	2040–2045	2045–2050
Canada	2.7	2.6	1.9	2.0	1.3	1.2	1.1	1.4	1.1	0.9	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.5	0.4	0.4
France	0.8	1.0	1.3	0.8	0.7	0.4	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.1	0.1	0.0	0.0	–0.1	–0.1
Germany	0.6	0.7	0.8	0.6	0.1	–0.1	–0.2	0.4	0.6	0.2	0.1	0.0	0.0	–0.1	–0.1	–0.1	–0.2	–0.2	–0.2	–0.2
Italy	0.6	0.6	0.7	0.6	0.6	0.4	0.1	0.0	0.2	0.1	0.1	0.0	–0.1	–0.2	–0.3	–0.3	–0.3	–0.4	–0.4	–0.5
Japan	1.4	0.9	1.0	1.1	1.3	0.9	0.7	0.4	0.3	0.2	0.2	0.1	–0.1	–0.2	–0.3	–0.4	–0.4	–0.4	–0.5	–0.5
UK	0.2	0.5	0.8	0.5	0.2	0.0	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.2	0.2	0.2	0.2
US	1.6	1.7	1.4	1.0	0.9	1.0	1.0	1.0	1.1	1.1	1.0	0.9	0.8	0.8	0.7	0.6	0.5	0.5	0.4	0.4
Argentina	2.0	1.7	1.6	1.5	1.7	1.5	1.5	1.4	1.3	1.2	1.0	0.2	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.1
Australia	2.3	2.2	2.3	2.0	1.4	1.4	1.4	1.5	1.2	1.2	1.1	1.0	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4
Brazil	3.1	2.9	3.0	2.6	2.4	2.4	2.2	1.9	1.5	1.5	1.4	1.3	1.1	0.9	0.8	0.7	0.5	0.4	0.3	0.2
China	1.9	1.5	2.1	2.6	2.2	1.5	1.4	1.5	1.1	0.9	0.6	0.6	0.6	0.4	0.2	0.1	0.0	–0.1	–0.2	–0.4
India	2.0	2.3	2.3	2.3	2.2	2.1	2.1	2.1	1.9	1.7	1.6	1.4	1.3	1.1	0.9	0.8	0.6	0.5	0.4	0.3
Indonesia	1.7	2.1	2.1	2.4	2.3	2.2	2.0	1.8	1.5	1.3	1.3	1.1	0.9	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Mexico	2.7	3.0	3.1	3.2	3.2	2.8	2.2	2.0	1.9	1.6	1.3	1.1	1.0	0.9	0.7	0.6	0.4	0.3	0.1	0.0
Russia	1.6	1.5	1.1	0.6	0.6	0.6	0.7	0.7	0.0	–0.2	–0.5	–0.4	–0.5	–0.5	–0.6	–0.6	–0.6	–0.6	-0.6	–0.6
Saudi Arabia	2.3	2.5	3.2	3.6	4.7	5.6	5.9	4.8	2.6	2.8	2.7	2.4	2.2	2.0	1.8	1.5	1.3	1.1	0.9	0.8
South Africa	2.3	2.5	2.7	2.6	2.6	2.5	2.5	2.1	2.6	1.7	0.8	0.2	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.1
South Korea	2.5	3.1	2.6	2.0	2.0	1.6	1.4	1.0	1.0	0.8	0.4	0.3	0.2	0.1	0.0	–0.1	–0.3	–0.4	-0.6	–0.7
Turkey	2.7	2.7	2.5	2.6	2.6	2.3	2.4	1.9	1.8	1.7	1.4	1.3	1.1	1.0	0.9	0.7	0.6	0.4	0.3	0.2
Guatemala	2.8	2.7	2.7	2.7	2.7	2.5	2.5	2.3	2.3	2.3	2.4	2.4	2.2	2.0	1.8	1.6	1.3	1 .2	1.0	0.8
Laos	2.0	2.3	2.2	2.2	2.2	1.2	2.4	2.6	2.5	2.4	2.3	2.2	2.0	1.9	1.7	1.5	1.3	1.1	1.0	0.8
Mali	2.2	2.3	2.1	2.4	2.7	2.3	2.4	2.4	2.6	2.8	3.0	2.9	2.9	2.9	2.8	2.6	2.4	2.2	2.0	1.8
Tanzania	2.6	2.8	3.0	3.1	3.3	3.2	3.3	3.3	3.3	2.3	2.0	1.8	1.7	1.5	1.4	1.2	1.1	0.9	0.8	0.7
Yemen	1.8	2.0	2.1	1.7	1.9	3.2	3.9	3.9	4.6	3.3	3.1	3.1	3.0	2.8	2.5	2.2	2.0	1.9	1.7	1.5

Source: UN Population Division (2005)

Table A4: Youth Dependency Ratio

G7 countries, other G-20 countries and selected least-developed countries; ratio of population between the ages of 0 and 19 to the total population

												UN medium projection								
	1950–1955	1955–1960	1960–1965	1965–1970	1970–1975	1975–1980	1980–1985	1985–1990	1990–1995	1995–2000	2000–2005	2005–2010	2010–2015	2015–2020	2020–2025	2025–2030	2030–2035	2035–2040	2040–2045	2045–2050
Canada	0.375	0.393	0.413	0.424	0.399	0.363	0.326	0.291	0.277	0.271	0.258	0.243	0.226	0.211	0.206	0.205	0.207	0.209	0.210	0.210
France	0.302	0.310	0.325	0.341	0.331	0.319	0.303	0.289	0.277	0.259	0.252	0.245	0.239	0.235	0.230	0.223	0.218	0.215	0.213	0.212
Germany	0.304	0.300	0.286	0.289	0.300	0.289	0.270	0.239	0.217	0.215	0.213	0.202	0.188	0.180	0.178	0.181	0.186	0.190	0.192	0.195
Italy	0.348	0.335	0.323	0.323	0.317	0.316	0.304	0.279	0.234	0.212	0.196	0.189	0.186	0.179	0.173	0.166	0.162	0.163	0.168	0.173
Japan	0.458	0.433	0.402	0.368	0.328	0.315	0.306	0.289	0.265	0.228	0.205	0.191	0.191	0.196	0.201	0.206	0.206	0.207	0.212	0.222
UK	0.289	0.293	0.301	0.311	0.312	0.307	0.291	0.273	0.256	0.253	0.252	0.247	0.234	0.224	0.221	0.224	0.227	0.229	0.227	0.223
US	0.341	0.362	0.382	0.391	0.376	0.349	0.316	0.294	0.287	0.288	0.286	0.280	0.278	0.279	0.284	0.289	0.287	0.284	0.283	0.285
Argentina	0.397	0.393	0.392	0.390	0.384	0.380	0.388	0.391	0.393	0.388	0.368	0.351	0.335	0.320	0.306	0.294	0.280	0.266	0.254	0.244
Australia	0.333	0.356	0.376	0.386	0.377	0.366	0.341	0.322	0.301	0.291	0.282	0.266	0.250	0.238	0.233	0.232	0.230	0.227	0.221	0.217
Brazil	0.516	0.522	0.527	0.537	0.530	0.513	0.494	0.474	0.453	0.429	0.401	0.372	0.351	0.336	0.319	0.300	0.283	0.268	0.256	0.246
China	0.433	0.457	0.472	0.495	0.507	0.489	0.463	0.424	0.383	0.346	0.327	0.303	0.277	0.270	0.271	0.277	0.273	0.265	0.261	0.265
India	0.492	0.490	0.493	0.499	0.503	0.500	0.489	0.479	0.468	0.454	0.441	0.420	0.402	0.387	0.376	0.365	0.349	0.332	0.318	0.311
Indonesia	0.500	0.497	0.499	0.506	0.519	0.520	0.509	0.494	0.466	0.437	0.405	0.378	0.355	0.335	0.314	0.292	0.274	0.262	0.254	0.247
Mexico	0.518	0.533	0.548	0.559	0.569	0.573	0.564	0.543	0.514	0.476	0.439	0.409	0.376	0.343	0.316	0.293	0.275	0.259	0.245	0.234
Russia	0.386	0.379	0.361	0.377	0.360	0.329	0.299	0.292	0.298	0.286	0.267	0.237	0.212	0.212	0.220	0.218	0.210	0.205	0.207	0.214
Saudi Arabia	0.519	0.525	0.532	0.539	0.544	0.543	0.538	0.519	0.510	0.506	0.488	0.473	0.449	0.421	0.396	0.374	0.352	0.330	0.307	0.285
South Africa	0.484	0.494	0.506	0.517	0.528	0.527	0.523	0.511	0.494	0.462	0.441	0.429	0.421	0.407	0.393	0.381	0.371	0.361	0.349	0.335
South Korea	0.517	0.505	0.515	0.523	0.519	0.503	0.462	0.406	0.363	0.321	0.289	0.253	0.229	0.201	0.181	0.175	0.171	0.166	0.163	0.160
Turkey	0.513	0.504	0.509	0.523	0.520	0.521	0.511	0.490	0.466	0.437	0.408	0.383	0.364	0.345	0.324	0.306	0.289	0.275	0.262	0.252
Guatemala	0.554	0.554	0.556	0.559	0.555	0.552	0.559	0.563	0.563	0.560	0.553	0.541	0.527	0.507	0.483	0.455	0.424	0.394	0.363	0.335
Laos	0.522	0.523	0.524	0.525	0.526	0.526	0.524	0.534	0.541	0.540	0.532	0.520	0.499	0.477	0.454	0.429	0.403	0.377	0.353	0.329
Mali	0.561	0.552	0.546	0.547	0.553	0.561	0.573	0.585	0.590	0.593	0.597	0.592	0.590	0.581	0.569	0.554	0.536	0.514	0.489	0.462
Tanzania	0.564	0.561	0.560	0.561	0.561	0.564	0.566	0.565	0.562	0.558	0.552	0.542	0.523	0.502	0.479	0.454	0.429	0.403	0.377	0.352
Yemen	0.523	0.544	0.563	0.579	0.598	0.614	0.613	0.617	0.622	0.602	0.598	0.581	0.562	0.545	0.526	0.504	0.477	0.448	0.420	0.397

Source: UN Population Division (2005)

Table A5: Elderly Ratio

G7 countries, other G-20 countries and selected least-developed countries; ratio of population at age 65 and older to the total population

	1950–1955	1955–1960	1960–1965	1965–1970	1970–1975	1975–1980	1980–1985	1985–1990	1990–1995	1995–2000	2000–2005	UN medium projection 2005–2010	2010–2015	2015–2020	2020–2025	2025–2030	2030–2035	2035–2040	2040–2045	2045–2050
Canada	0.077	0.077	0.075	0.077	0.079	0.085	0.094	0.103	0.113	0.120	0.126	0.131	0.142	0.162	0.184	0.209	0.233	0.243	0.249	0.253
France	0.114	0.116	0.116	0.121	0.129	0.135	0.140	0.130	0.140	0.156	0.163	0.166	0.169	0.190	0.208	0.226	0.242	0.255	0.264	0.267
Germany	0.097	0.107	0.115	0.125	0.137	0.148	0.156	0.146	0.150	0.155	0.164	0.188	0.204	0.207	0.221	0.239	0.266	0.288	0.290	0.285
Italy	0.083	0.087	0.093	0.100	0.109	0.120	0.131	0.127	0.153	0.166	0.182	0.200	0.211	0.230	0.245	0.264	0.291	0.321	0.346	0.356
Japan	0.049	0.053	0.057	0.062	0.071	0.079	0.090	0.103	0.120	0.146	0.172	0.197	0.223	0.255	0.272	0.278	0.285	0.294	0.310	0.315
UK	0.107	0.113	0.117	0.120	0.129	0.140	0.151	0.151	0.159	0.159	0.159	0.160	0.165	0.181	0.188	0.198	0.214	0.228	0.231	0.230
US	0.083	0.088	0.092	0.095	0.098	0.105	0.112	0.117	0.122	0.124	0.123	0.123	0.127	0.138	0.153	0.168	0.180	0.183	0.182	0.178
Argentina	0.042	0.048	0.055	0.062	0.070	0.076	0.081	0.085	0.089	0.094	0.099	0.102	0.105	0.111	0.119	0.127	0.135	0.144	0.156	0.175
Australia	0.081	0.084	0.085	0.085	0.083	0.087	0.096	0.101	0.112	0.115	0.121	0.127	0.137	0.155	0.172	0.190	0.206	0.218	0.226	0.231
Brazil	0.030	0.031	0.033	0.035	0.036	0.039	0.041	0.041	0.044	0.049	0.054	0.061	0.068	0.078	0.091	0.107	0.125	0.141	0.156	0.173
China	0.045	0.046	0.048	0.044	0.043	0.044	0.047	0.052	0.056	0.061	0.068	0.076	0.082	0.094	0.114	0.130	0.153	0.181	0.199	0.200
India	0.033	0.034	0.034	0.035	0.037	0.038	0.040	0.042	0.043	0.045	0.049	0.053	0.056	0.061	0.067	0.076	0.086	0.097	0.107	0.115
Indonesia	0.040	0.037	0.034	0.031	0.031	0.033	0.035	0.036	0.038	0.043	0.049	0.055	0.060	0.064	0.073	0.086	0.100	0.118	0.137	0.156
Mexico	0.044	0.045	0.046	0.045	0.043	0.040	0.038	0.037	0.039	0.043	0.048	0.053	0.061	0.071	0.083	0.099	0.117	0.139	0.167	0.192
Russia	0.062	0.063	0.063	0.066	0.077	0.089	0.102	0.097	0.100	0.120	0.123	0.138	0.126	0.133	0.152	0.176	0.193	0.196	0.202	0.212
Saudi Arabia	0.033	0.033	0.033	0.033	0.032	0.030	0.028	0.024	0.023	0.023	0.026	0.029	0.032	0.035	0.041	0.049	0.062	0.076	0.089	0.103
South Africa	0.036	0.038	0.039	0.039	0.034	0.032	0.031	0.031	0.032	0.033	0.036	0.042	0.051	0.061	0.072	0.081	0.088	0.091	0.091	0.089
South Korea	0.030	0.037	0.033	0.033	0.033	0.036	0.038	0.043	0.050	0.058	0.074	0.094	0.113	0.132	0.156	0.196	0.234	0.269	0.303	0.326
Turkey	0.032	0.033	0.034	0.039	0.043.	0.044	0.046	0.042	0.040	0.045	0.051	0.054	0.057	0.062	0.072	0.085	0.101	0.118	0.136	0.154
Guatemala	0.025	0.026	0.026	0.028	0.029	0.028	0.029	0.030	0.033	0.036	0.040	0.043	0.045	0.047	0.050	0.053	0.056	0.061	0.069	0.080
Laos	0.028	0.027	0.024	0.024	0.026	0.027	0.028	0.045	0.038	0.039	0.035	0.037	0.035	0.037	0.039	0.045	0.051	0.058	0.066	0.075
Mali	0.019	0.019	0.020	0.021	0.022	0.023	0.024	0.025	0.027	0.028	0.028	0.027	0.026	0.024	0.023	0.023	0.023	0.026	0.029	0.034
Tanzania	0.022	0.023	0.023	0.024	0.025	0.025	0.026	0.027	0.027	0.028	0.030	0.032	0.034	0.037	0.038	0.040	0.043	0.045	0.050	0.058
Yemen	0.039	0.034	0.030	0.027	0.025	0.024	0.022	0.021	0.020	0.026	0.024	0.023	0.023	0.024	0.026	0.030	0.033	0.036	0.039	0.045

Source: UN Population Division (2005)

Table A6: Active Ratio

G7 countries, other G-20 countries and selected least-developed countries; ratio of population between the ages of 20 and 64 to the total population

												UN medium projection								
	1950–1955	1955–1960	1960–1965	1965–1970	1970–1975	1975–1980	1980–1985	1985–1990	1990–1995	1995–2000	2000–2005	2005–2010	2010–2015	2015–2020	2020–2025	2025–2030	2030–2035	2035–2040	2040–2045	2045–2050
Canada	0.548	0.529	0.512	0.500	0.522	0.552	0.580	0.606	0.610	0.609	0.616	0.626	0.632	0.627	0.610	0.585	0.560	0.547	0.541	0.537
France	0.584	0.575	0.559	0.538	0.540	0.546	0.558	0.581	0.583	0.586	0.585	0.589	0.592	0.575	0.562	0.551	0.540	0.530	0.523	0.520
Germany	0.599	0.593	0.599	0.586	0.563	0.562	0.574	0.615	0.633	0.630	0.623	0.610	0.608	0.612	0.602	0.580	0.548	0.522	0.518	0.520
Italy	0.569	0.578	0.584	0.577	0.574	0.564	0.565	0.594	0.612	0.621	0.622	0.611	0.603	0.591	0.582	0.570	0.547	0.516	0.486	0.471
Japan	0.493	0.514	0.541	0.569	0.601	0.606	0.603	0.608	0.615	0.627	0.622	0.611	0.587	0.549	0.527	0.516	0.509	0.499	0.477	0.463
UK	0.604	0.594	0.582	0.569	0.558	0.553	0.559	0.576	0.585	0.588	0.589	0.594	0.601	0.595	0.591	0.578	0.558	0.543	0.542	0.547
US	0.576	0.550	0.526	0.514	0.525	0.547	0.572	0.589	0.590	0.588	0.590	0.597	0.595	0.583	0.563	0.543	0.533	0.532	0.536	0.537
Argentina	0.561	0.558	0.552	0.548	0.547	0.544	0.531	0.524	0.517	0.518	0.533	0.547	0.559	0.569	0.575	0.579	0.584	0.590	0.590	0.581
Australia	0.586	0.560	0.539	0.529	0.540	0.547	0.564	0.577	0.587	0.593	0.596	0.607	0.613	0.608	0.595	0.578	0.564	0.555	0.552	0.552
Brazil	0.455	0.447	0.440	0.428	0.433	0.448	0.465	0.485	0.503	0.523	0.545	0.567	0.581	0.586	0.590	0.593	0.592	0.591	0.588	0.580
China	0.522	0.497	0.480	0.461	0.450	0.467	0.489	0.524	0.561	0.594	0.605	0.621	0.641	0.636	0.614	0.593	0.575	0.554	0.540	0.535
India	0.474	0.477	0.473	0.466	0.461	0.461	0.471	0.479	0.489	0.500	0.510	0.527	0.542	0.552	0.557	0.559	0.565	0.571	0.575	0.575
Indonesia	0.461	0.467	0.467	0.463	0.450	0.448	0.457	0.471	0.496	0.521	0.546	0.567	0.584	0.601	0.613	0.622	0.626	0.620	0.609	0.597
Mexico	0.438	0.422	0.406	0.395	0.388	0.387	0.399	0.420	0.446	0.482	0.513	0.537	0.562	0.586	0.600	0.608	0.608	0.601	0.588	0.575
Russia	0.553	0.557	0.576	0.557	0.563	0.582	0.598	0.611	0.601	0.595	0.610	0.626	0.663	0.655	0.629	0.606	0.597	0.599	0.591	0.574
Saudi Arabia	0.447	0.441	0.434	0.428	0.424	0.427	0.434	0.456	0.468	0.470	0.486	0.498	0.518	0.544	0.563	0.577	0.586	0.594	0.604	0.612
South Africa	0.480	0.468	0.456	0.444	0.438	0.441	0.447	0.458	0.474	0.505	0.522	0.528	0.528	0.532	0.536	0.538	0.540	0.547	0.560	0.576
South Korea	0.452	0.459	0.452	0.444	0.448	0.461	0.500	0.551	0.587	0.621	0.637	0.652	0.658	0.667	0.663	0.630	0.595	0.565	0.534	0.514
Turkey	0.455	0.463	0.457	0.438	0.437	0.435	0.443	0.469	0.494	0.518	0.541	0.563	0.579	0.593	0.604	0.609	0.609	0.607	0.602	0.594
Guatemala	0.421	0.420	0.418	0.413	0.416	0.419	0.412	0..407	0.404	0.403	0.406	0.416	0.428	0.446	0.467	0.493	0.519	0.545	0.567	0.585
Laos	0.450	0.450	0.452	0.451	0.448	0.447	0.448	0.421	0.422	0.422	0.433	0.443	0.466	0.487	0.507	0.536	0.546	0.565	0.582	0.596
Mali	0.420	0.429	0.434	0.432	0.425	0.416	0.404	0.390	0.383	0.379	0.375	0.381	0.384	0.394	0.408	0.423	0.440	0.460	0.481	0.504
Tanzania	0.414	0.416	0.416	0.415	0.414	0.410	0.408	0.409	0.411	0.414	0.418	0.425	0.442	0.461	0.482	0.505	0.528	0.551	0.573	0.590
Yemen	0.438	0.422	0.408	0.395	0.377	0.362	0.365	0.362	0.359	0.372	0.378	0.396	0.415	0.431	0.447	0.466	0.490	0.517	0.541	0.558

Source: UN Population Division (2005)

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Discussion

Alain Duchâteau

My discussion today will focus on four issues: the main lessons of Ralph Bryant's paper, implications of the paper for G-20 policy-makers, some questions about the assumptions in the paper, and possible extensions of the paper.

Main lessons of the paper

I drew three main lessons from this paper. First, demographic change is likely to lead to a shrinking of the excess of saving over investment in developed economies (which Ralph labels the 'North'). This is particularly true in the rapidly ageing regions of Europe and Japan, so that, in the future, the capital account surpluses of these regions will decline. Second, in developing countries (the 'South') the demographic effect will work in the opposite direction: saving will increase relative to investment and the current account balances of these countries will increase. Third, the degree of cross-border substitutability has important implications for future evolutions of real exchange rates, as I will discuss further below.

Starting with current account issues, Ralph highlights the striking differences in active ratios as population ageing causes the proportion of the population of prime working age in the North to decline and, in the South, to increase. In Ralph's model, these demographic trends cause the South region's current account to GDP ratio to increase until around 2030 and then to decline as an increasing proportion of its population enters their asset-decumulating retirement years.

Another interesting result is the magnitude of the future real exchange rate adjustments projected in Ralph's paper. In the benchmark case, the South's real exchange rate is projected to depreciate by as much as 70 per cent in order for the North to absorb the South's output (which increases strongly as its active ratio rises). This represents a striking deterioration in the South's terms of trade and points to the important consequences of cross-border goods substitutability in determining welfare outcomes. Indeed, Ralph shows in his paper that increased goods substitutability enhances the welfare of the South.

A caveat to this discussion, however, is that what we have here are mainly accounting reactions as saving and investment rates adjust mechanically to demographic change. Of course, at this workshop we are also concerned with behavioural reactions, of which there may be many. For example, if governments reduce the generosity of public pension systems, households may save more. And lower pension payments may also increase public saving. Presumably, these behavioural reactions will also affect the current account and exchange rate projections in Ralph's paper.

Relevance for G-20 policy-makers

One interesting conclusion that I draw from the paper is that its projections are rather reassuring in terms of financial stability. For many developing countries, relying too much on foreign borrowing, especially when it is denominated in foreign currencies, has often been described as the 'original sin'. Sudden reversals of capital and financial flows have frequently been the cause of great economic hardship. Ralph's paper, however, offers the long-term prospect of current account surpluses in the South helping to rebalance the net foreign asset positions of the North and the South. Hopefully, this rebalancing will help to reduce the likelihood of the type of financial crises we have experienced so far.

Another conclusion that may be of interest to G-20 policy-makers relates to the question of cross-border substitutability. If greater cross-border substitutability increases the welfare of those in the South, then this may provide a rationale for promoting greater trade flows by reducing barriers such as subsidies and tariffs. This could provide additional motivation to revisit the current round of World Trade Organisation negotiations, despite disappointments of late.

Questions

My first question is whether the division of the world into two regions, the North and the South, is perhaps too arbitrary? While there are large differences in demographic characteristics between the North and South regions in Ralph's paper, there are also considerable differences within each region and these differences are projected to continue. When we look at active ratios, it strikes me that, by around 2050 the populations of some countries in the North region, such as the United Kingdom and the United States, will closely resemble that of China, with active ratios of around 55 per cent. In contrast, some other countries in the North region, such as Japan and Italy, will have active ratios of close to 45 per cent. Potentially, these differences in demographic characteristics could translate into large variations in economic outcomes. One could also think of some cases, for example if Turkey were to join the European Union, where the potential for rapid economic development could make it sensible for a country currently in the South to be reclassified as being part of the North.

Another question relates to the 'no migration' hypothesis. We have already talked about the possibility that there may be scope for more migration from the South to the North. But what about migration from the North to the South? Already, we see non-trivial numbers of elderly people migrating to countries in the South to access cheaper healthcare, or lower costs of living more generally. I wonder whether this trend might have implications for Ralph's results.

Possible further work

There is increasing interest in the implications of demography for macroeconomic policy. As an illustration, last week at the European Central Bank we held a seminar for central banks on the implications of demographic shocks for monetary policy. Another example is the interesting report published last September by the G10.[1] I think we need more and more of this analysis to better integrate demographic factors into our theoretical frameworks. In particular, I would like to see the development of more realistic, integrated economic models – the 'first best' referred to by Ralph. In the meantime, Ralph's paper provides us with a fine starting-point, but much more needs to be done to ensure that this work can best inform policy responses.

1. See G10 (2005), 'Ageing and Pension System Reform: Implications for Financial Markets and Economic Policies', a report prepared at the request of the Deputies of the Group of Ten by an experts group chaired by Ignazio Visco, Central Manager for International Affairs at the Banca d'Italia.

General Discussion

An important theme raised in the discussion was the need to consider the implications of falling fertility and rising longevity separately. One participant questioned whether rising longevity would have any substantial impact on financial markets if retirement ages increase sufficiently to ensure that the proportion of life people spend in the workforce remains constant. While accepting that increased labour force participation could moderate the impacts of demographic change, other participants thought that rising longevity would still affect financial markets even with proportionate increases in retirement ages. In particular, they noted that, even if the proportion of life individuals spend in retirement were to remain stable, individuals would still need to save more to fund extra years in retirement and that this would boost capital-labour ratios. These changes, in turn, would affect asset prices and rates of return. In line with the discussion of the previous session, one participant questioned whether it was feasible to expect that retirement ages will increase in proportion to rising life expectancy, given the historical tendency for the number of years spent in retirement to increase in response to rising incomes. However, another participant argued that further extensions in the share of life spent in retirement would depend on the balance of future gains in income and longevity and the role of public policies. Left to choose retirement ages freely, one participant thought that individuals might choose to extend both their working lives and time spent in retirement.

A related issue that provoked some discussion was the usefulness of concepts such as elderly dependency ratios to project future labour force participation rates. One participant suggested that these concepts exaggerate the impact of population ageing as the labour force participation of the elderly is likely to increase in the future. Ralph Bryant responded that he had run simulations with later retirement ages but that the impact of these changes was small as they do not affect the relative age distributions across countries that drive global capital flows in his model.

A number of participants questioned whether demographic change will produce substantial movements in asset prices. One participant noted that long-term returns to capital in many countries had remained relatively stable over long periods despite substantial changes in demography, technology and economic structure and institutions. Other participants, however, argued that these past experiences may not guide future performance, particularly in light of the unprecedented pace and extent of population ageing likely to occur in many countries. In a similar vein, one participant commented that the demographically-induced international capital flows in Ralph Bryant's paper are small relative to the large current account imbalances currently witnessed in many countries. This suggests that, while global capital flows may help countries to manage the impact of demographic change, they are not a substitute for domestic reforms to pension systems and financial markets.

The ability of simple life-cycle or dynastic models to predict future saving patterns was also discussed at length. One participant noted that life-cycle models generally cannot explain the direction of global capital flows, either in the past or in the present. A number of participants also noted that most empirical work rejects the dynastic model as a reliable explanation for household saving patterns, at least for developed countries. In response to this comment, Henning Bohn noted that his paper had emphasised that the dynastic model is most usefully applied to developing countries and that he still felt it had some value in explaining saving patterns in these countries.

Finally, there was some further debate about the impact of demographic change on capital-labour ratios. One participant argued that population ageing may cause a decrease in capital-labour ratios if governments are forced to increase taxes to pay for old-age pensions and health care, thereby crowding out private saving. Henning Bohn agreed that the introduction of a government into simple overlapping generations models could result in lower capital-labour ratios in response to population ageing. But he argued that it was the reluctance of individuals to save rather than the existence of public pension systems that caused this outcome. Another participant questioned whether the papers should have considered the impact of demographic change on total factor productivity, arguing that individuals tend to become less productive as they age. Related to this, one participant noted that declines in fertility from very high levels in many developing economies permitted parents to provide their offspring with better educations. This in turn helped to offset the impact of lower fertility on the size of the labour force by working to increase the labour force when measured in efficiency units. Ralph Bryant agreed that changes in productivity would have important implications for the results of any model, but suggested that the directions of these movements are too uncertain to make them a worthwhile addition.

Demographic Change, Saving and Asset Prices: Theory and Evidence[1]

Axel Börsch-Supan

Abstract

Population ageing and pension reform will have profound effects on international capital markets. First, population ageing alters the time path of aggregate savings within individual countries. Second, this process may be amplified when a pension reform shifts old-age provision towards more pre-funding. Third, while the patterns of population ageing are similar in most countries, timing and initial conditions differ substantially. Hence, to the extent that capital is internationally mobile, population ageing will induce capital flows between countries. All three effects influence the rate of return to capital and interact with the demand for capital in production as well as the supply of labour.

In order to quantify these theoretical effects, the Mannheim Research Institute for the Economics of Aging (MEA) has developed a computational multi-country overlapping generations (OLG) general equilibrium model. We feed this model with detailed long-term demographic projections for seven world regions and compute the time paths of saving, capital flows and returns to productive capital as demographic change proceeds. Our simulations indicate that capital flows from fast-ageing regions to the rest of the world will initially be substantial but that trends are reversed when households decumulate savings. We also conclude that closed-economy models of pension reform miss quantitatively important effects of international capital mobility.

As an alternative, we also present econometric results from a panel of national time series in which saving rates, rates of return and international capital flows are

1. This paper rests on work done by several researchers at the Mannheim Research Institute (MEA). The overlapping generations model has been developed by Alexander Ludwig. The econometric work was part of Melanie Lührmann's dissertation. The work on asset-price meltdowns has been done by Mathias Sommer. Joachim Winter has helped me a great deal in supervising this work. My primary thanks go to these dedicated MEA researchers.

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related to anticipated demographic change. These estimates support the results from the multi-country OLG model.

1. Introduction

Populations in the G-20 countries are ageing. This demographic change will continue well into the 21st century. While population ageing is common to all G-20 countries, its extent and timing differs substantially between countries. Demographic change will alter the time path of most aggregate macroeconomic variables, including growth, savings and investment. In a world of closed economies, differences in demography will generate differences in growth, saving and investment rates between countries. Differences across countries are likely to be accentuated when some countries implement fundamental pension reforms – that is, shifts towards more pre-funding, induced by the effects of population ageing on public pension budgets – and others do not.

In reality, we do not live in a world of closed economies. To the extent that capital is internationally mobile, population ageing will induce capital flows between countries. These capital flows will modify the effects of population ageing and pension reform in each county *vis-à-vis* a world of closed economies. Global capital flows will affect saving rates, accumulated capital stocks, capital holdings and – significantly for the so-called 'asset-price meltdown' debate – rates of return. It is commonly argued that these international capital flows will help to attenuate cross-country differences. From the perspective of the G-20 countries, they are therefore a welcome mechanism to alleviate the pressures of population ageing.

The core of this paper presents a quantitative analysis of the capital and labour market effects of different ageing processes and pension reforms across countries, with a particular focus on international capital flows. To this end, we present simulation results from a stylised multi-country overlapping generations (OLG) model called MEA-OLGA (see Börsch-Supan, Ludwig and Winter 2002, 2004, forthcoming), which projects macroeconomic aggregates such as international capital flows over a 70-year horizon, using long-term demographic projections for different sets of countries and regions. Although all countries and regions are modelled symmetrically as large open economies, our discussion focuses on continental Europe, for two reasons. First, it is one of the regions most severely affected by ageing and, second, its pension systems are still dominated by relatively generous pay-as-you-go (PAYG)-financed public pensions.

The simulation results are then compared with an econometric analysis (Lührmann 2006) that uses past international capital flows and their dependence on past and expected demographic changes to project future international capital flows.

The analyses in this paper are related to several recent papers that compare implications for capital flows predicted by OLG models with actual current account data (for example, Brooks 2003; Feroli 2003; Henriksen 2002; Domeij and Flodén 2006). In common with our findings, these papers show that calibrated OLG models can explain a good fraction of the low-frequency movements of international capital flows observed in the data. We further show that the existence of PAYG pension systems in different world regions adds an additional, indirect, channel to the interaction between capital flows and demographic change. This channel is of particular importance if countries severely affected by the impact of population ageing, such as the continental European countries, reform their pension systems.

This paper also adds to the discussion about the so-called 'asset-price meltdown' hypothesis. Several articles in the popular press have attributed recent turbulence in stock market prices to population ageing and raised the prospect that an asset-price meltdown might occur when the baby boom generation decumulates its assets. In the academic literature, there is no consensus on the asset-price meltdown hypothesis (see, for example, Poterba 2001; Abel 2001, 2003; Brooks 2002). According to our view, the closed-economy models often used in the academic literature miss the important influence of international capital flows on domestic asset prices. We show that, because of international diversification, the dynamics of capital accumulation and rates of return in open-economy models are different from what would be predicted by closed-economy models. One of the main goals of this paper is to analyse and quantify these mechanisms.

Finally, this paper sheds light on the effects of international diversification on saving behaviour and its interaction with pension reforms. This topic has received increasing attention as the pension reform debate has progressed. For example, Deardorff (1987) contains an early analysis and Reisen (2000) provides a comprehensive overview of these issues. Reisen argues that there are pension-improving benefits of global asset diversification. In a theoretical paper, Pemberton (1999) highlights the importance of international externalities caused by the effects of national pension and savings policies on the world interest rate.

Our results, from simulations as well as econometric estimates, show that capital flows due to population ageing will be substantial. Population ageing results in decreases in saving rates when the baby boomers decumulate their assets. International capital flows follow this trend. The countries and regions most affected by ageing, such as the European Union, will initially export capital, while countries less affected by ageing, like the United States and other OECD regions, will import capital. However, since older households decumulate their assets, capital exports from these fast-ageing countries will eventually decrease; around the year 2020 fast-ageing countries are projected to become net capital importers. Pension reforms encouraging higher degrees of pre-funding are likely to induce more capital exports. They also increase the supply of labour considerably, while the effects on the rate of return to capital are small. While the rate of return is projected to decline in response to population ageing, we cannot find a convincing case to project a devastating 'asset-price meltdown'.

The rest of the paper is structured as follows. Section 2 begins with a short review of the asset-price meltdown debate. Section 3 presents empirical evidence on, and theoretical explanations for, the effects of population ageing on international capital flows. In Section 4, we present a multi-country OLG model that allows us to evaluate these effects quantitatively. Section 5 contains our first set of results: simulations of international capital flows, saving rates and returns to productive assets for several pension policy and capital mobility scenarios. Section 6 presents a sensitivity analysis. Section 7 compares the OLG results with econometric evidence derived from a panel of national time series. Section 8 concludes.

2. The Asset-price Meltdown Debate

The effects of population ageing on the markets for real and housing capital are complex and can only be understood in a general equilibrium context. If elderly people save less than younger people, an ageing society saves less. By itself, this should increase interest rates since the supply of funds gets tight. At the same time, however, the size of younger generations becomes ever smaller, so there is also less demand for new investment. The overall effect is thus uncertain.

Pessimists believe in the so-called 'asset-price meltdown' hypothesis: households' demand for financial assets will plummet between 2030 and 2040, when the baby boomers retire and die. As a consequence asset values will collapse and the return on financial investments will fall sharply.

Optimists stress economic mechanisms which soften or even reverse the negative impacts of ageing on capital markets. One such important counter-mechanism is an ageing society's need for capital as a substitute for increasingly scarce labour. This rising demand for physical capital increases the return to capital at exactly the same time as pessimists fear the prospect of an asset-price meltdown.

A spectacular fall in the price of assets as a result of demographic change was first predicted in 1989 by Mankiw and Weil (1989) in the context of the real estate market in the United States. In theory, returns to real estate should be more affected by demographic change than returns to physical capital because there is much less room for international diversification and because housing cannot substitute for scarce labour. Mankiw and Weil used cross-sectional data on real estate assets from the 1970 US Census to develop an age profile of the demand for property. Their demand forecast is based on the assumption that this age profile remains constant and it is only the size and age structure of the US population that will change. Based on the historical correlation between the growth in demand for housing with the price index for investment in residential buildings, Mankiw and Weil conclude that the demand for residential property must increase by approximately 1.5 per cent per year to keep prices constant. However, the demographically controlled demand variable shows consistently lower growth rates for the period 1990–2010. They conclude that this forecast discrepancy exercises enormous price pressure on the residential property market. The point estimate by Mankiw and Weil implies a 47 per cent price fall within 20 years.

The study sparked a lively debate, which ultimately cast considerable doubt on the forecasts of Mankiw and Weil (1989, 1992). Woodward (1991) grouped together the main points of criticism in the first series of responses refuting the study. In this volume, both Hamilton (1991) and Hendershott (1991) noted that the estimates of Mankiw and Weil imply that, even if demand remains at a constant level, house prices would fall by 8 per cent. This implausible linear time trend has a much greater influence on the forecast than the decline in the annual growth of demand from 1.6 per cent at the start of the 1980s to around 0.6 per cent in 2000. Swan (1995) argues that not only were the effects of a long-term rise in real income completely ignored but the supply side of the residential property market was also not taken into account.

Engelhardt and Poterba (1991) also cast doubt on the findings of Mankiw and Weil. They provide an equivalent analysis for Canada, a country with demographic trends that largely mirror those in the US. The age profile of real estate assets in Canada also broadly corresponds to the equivalent profile in the US. In spite of this, Engelhardt and Poterba cannot find any similar influence of demography on house prices in Canada along the lines identified by Mankiw and Weil for the US.

More recent research highlights the importance of income and cohort effects. Mankiw and Weil's use of cross-sectional data to analyse the demand for residential property over the life-cycle ignores the effects of income and age cohort groups, which have proved to be very important in quantitative terms. In cross-sectional data (that is, data from many people observed at a single point in time), it is not possible to determine whether the elderly save more than the young, for example, because they are old (the age effect) or because they were born a long time ago at a time when, for instance, thrift was considered to be particularly virtuous (the cohort effect).

If one applies this approach to demand for residential property, it is impossible to tell whether an old person uses a small amount of living space because they do not need a large apartment when they are old or whether they do not have a large apartment in old age because when they purchased their apartment they did not have enough real income to afford a large apartment. In their analysis, Mankiw and Weil present the cross-sectional profile of real estate assets in 1980 by way of comparison. However, the assets values of census data in 1980 were, on average, more than 50 per cent above the 1970 sample group for each age group. When it comes to using demand profiles for fairly long-term forecasts, a difference of this order of magnitude shows the quantitative significance of income-related effects and other cohort effects more generally. The increase in the value of asset profiles for all age groups between 1970 and 1980 illustrates the extent to which the demand for real estate could also change in the future.

Studies from the US that adopt a more careful approach than Mankiw and Weil verify that, for just these reasons, the estimates of age-specific demand for residential accommodation are distorted and a possible 'asset-price meltdown' effect is greatly exaggerated – for example, see Venti and Wise (1990), McFadden (1994) and Skinner (1996). Börsch-Supan, Ludwig and Sommer (2003) apply a similar approach for Germany and obtain similar results, although Germany ages faster than the US.

The ultimate judge, of course, is time. Hence it is worth noting that the forecast 'asset-price meltdown', which should have occurred between 1990 and 2010 in the US, has simply not occurred (as of September 2006), neither during the boom in equity markets (which is easy to explain), nor since the bubble burst (which is a more significant refutation of Mankiw and Weil's claim).

Turning to productive capital, the most familiar study based on empirical data of saving behaviour over the life-cycle is the analysis by Poterba (2001). He derives a demand variable from the shift in the age structure of the population, which is produced from an estimated life-cycle savings profile. In contrast to Mankiw and Weil, Poterba estimates the demand from the various age classes in a model which permits explicit cohort effects. The estimated asset profile in old age is largely flat – a result that had already been documented by other authors. Poterba also incorporates a series of other demographic variables that can explain the accumulation of savings in a society. Using a long time series he finds hardly any indication that demography influences returns to equity and only minimal indications of such influences on the market for interest-bearing securities. The only variable for which Poterba found demography had historical influences was the price-earnings ratio of equities, and even here the relationships are not stable. Poterba concludes that a demographically induced fall in asset prices, as predicted by Mankiw and Weil for the real estate market, is extremely unlikely.

Abel (2001) is critical of Poterba's analysis. He sets up a theoretical model in which households are interested in the well-being of their heirs and thus possess a bequest motive. He shows that it is entirely possible for an asset-price meltdown to be consistent with a flat asset profile in old age. Although the older generation's demand for capital is not falling, a demographically induced fall in prices could occur through lower saving by the younger generation. However, there is no evidence that inheritances will fall with the number of children. Abel's theoretical countermechanism to Poterba's analysis thus seems to be of little empirical relevance.

3. Population Ageing and International Capital Flows

Throughout the world, demographic processes are determined by a demographic transition characterised by falling mortality rates followed by a decline in birth rates, resulting in population ageing and a fall in the population growth rate (in some countries, even turning it negative). While demographic change is occurring in almost all countries, its extent and timing differ substantially. Europe and some Asian countries have almost passed the closing stages of the demographic transition process while Latin America and Africa are only at the beginning stages (Bloom and Williamson 1998; UN Population Division 2001).

From a macroeconomic perspective, population ageing will change the balance between capital and labour, particularly in industrialised countries. Labour supply will become relatively scarce whereas capital will become relatively abundant. This will drive up wages relative to the rate of return to capital, reducing households' incentives to save (if the interest elasticity of saving is positive). In addition, a decreasing labour supply reduces the demand for investment goods since less capital is needed to achieve any given capital-labour ratio.

From a microeconomic point of view, the life-cycle theory of consumption and savings (Modigliani and Brumberg 1954; Ando and Modigliani 1963) predicts that saving rates will decline as individuals enter old age. The aggregation of individual, cohort-specific life-cycle savings profiles therefore leads to a decrease of national saving rates in an ageing economy. In a general equilibrium model of forward-looking individuals, it is not only the current demographic structure that alters the time path of aggregate savings, but also future demographic developments. In a closed economy, a decline in national saving leads to a decline in investment by definition. In an open economy, the link between these two aggregates is broken to the extent that capital is internationally mobile.

Empirical evidence lends support to these theoretical mechanisms, as discussed in the paper by Poterba (2001). Following earlier work by Higgins (1998) and others, Lührmann (2006) investigates whether demography influenced international capital flows in the past, using a broad panel of 141 countries over the period 1960–1997. She confirms that cross-country capital flows are indeed influenced by current demographic variables. Moreover, she shows that future changes in population age structures are important determinants of current saving and investment decisions, suggesting that households respond to changes in demography in a forward-looking manner.

The extent to which population ageing induces international capital flows depends crucially on the degree of capital mobility. There has been no shortage of empirical research on this issue since the famous puzzle of Feldstein and Horioka (1980).[2] In their original contribution, Feldstein and Horioka show that national saving and investment rates are highly correlated in virtually all OECD countries. While the correlations have fallen over time, they are still remarkably high in many countries. These findings have been interpreted as an indication that capital is imperfectly mobile. However, there exist several alternative explanations for the observed correlation. For example, high correlations between saving and investment rates are consistent with perfect capital mobility in a growth model with demographic change and technological progress, as pointed out by Obstfeld (1986) (see also Baxter and Crucini 1993; Taylor 1994; Obstfeld and Rogoff 1996, 2001).

Even if capital is fully mobile, this does not necessarily imply that households diversify their portfolios optimally. There is a large empirical literature on 'home bias' in international portfolio choice (for example, French and Poterba 1991). Portes and Rey (2005) suggest that information asymmetries across countries are a major source of home bias and that geographic and informational proximity both affect international capital flows. Applied to pension reform policies, this literature suggests that households might be more willing to invest their retirement savings in 'similar' countries. In the case of European households, this could result in a preference for investing in the EU or OECD countries rather than in developing countries.

The background facts and empirical insights from this section motivate our modelling strategy, which is detailed in the following section, including our calibration choices.

2. See Obstfeld and Rogoff (1996) and Coakley, Kulasi and Smith (1998) for surveys of the literature.

4. A Dynamic, Open-economy Macroeconomic Model

The previous sections have shown that savings, capital returns and international capital flows are the outcome of complex interactions between supply and demand in domestic and international capital markets. These interactions also depend on demographic factors. One actually needs a simulation model in order to understand these equilibrium effects since relative quantities matter even for qualitative results. This section, based on Börsch-Supan *et al* (2002, 2004, forthcoming) determines the general equilibrium by drawing on an OLG model of households. Such OLG models have a long tradition. The theory underpinning these models was developed by Samuelson (1958) and Diamond (1965). This was extended by Auerbach and Kotlikoff (1987) who, for the first time, used an OLG model in a near-reality computer simulation. The MEA-OLGA simulation model, on which the results of this section are based, was the first such model that is not restricted to one country but also covers international trade and capital movements. Details, including a mathematical description, of the latest version of the MEA-OLGA model can be found in Börsch-Supan *et al* (forthcoming). Here we limit ourselves to describing the essential mechanisms and equations for this model. It should be noted that this model takes a long-term perspective and thus abstains from all short-term Keynesian considerations. An important implication of this is that exchange rates have no role to play in our economic model.

4.1 How households behave

The households in the MEA-OLGA model offer a fixed amount of work. They divide their income between consumption and saving but here we only map long-term saving decisions, that is the savings that are required to compensate for the drop in income upon retirement. The accumulation of savings is therefore determined by the life-cycle hypothesis in which a household does not apportion its income into consumption and saving each year but rather over a time scale that depends on the household's discount rate. Consumption in period t, C_t, is smoothed according to this long-term plan so that it greatly depends on consumption in the preceding period, C_{t-1}. Impatient consumers (whose discount rate, ρ, exceeds the market interest rate, r_t) initially consume a large amount. In contrast, patient households (whose discount rate is lower than the market rate) initially save a lot. The development over time of consumption is described by the following simple equation in which the ratio between the discount rate and the market interest rate is weighted by the parameter σ:

$$C_t = C_{t-1} \cdot \left(\frac{1+r_t}{1+\rho} \right)^{1/\sigma}$$

This consumption equation also implicitly describes the saving decision because current income minus current consumption expenditure gives the value of saving. This is added to the stock of current assets (plus interest) to obtain the next period's stock of assets:

$$A_{t+1} = A_t \left(1+r_t\right) + Y_t^n - C_t$$

In many countries, PAYG retirement insurance schemes have a crucial influence on saving decisions because they form a major source of income during retirement. This is supplemented by cashing-in household savings (in the case of Germany, this may include income from 'Riester pensions'). Our model only maps long-term savings in the form of provisions for old age. If the PAYG retirement insurance scheme is so generous that pensions replace 100 per cent of pre-retirement income, no long-term saving occurs in our model. If, at the other extreme, the level of the public pension falls to zero, all income in old age must be provided by private savings, and consumption is correspondingly lower in younger years.

Savings are invested in productive capital. These investments can either occur domestically or abroad. The model assumes that capital moves to where the returns, after accounting for risk and tax, are the highest and that international capital flows will continue until these returns are the same in all countries.

4.2 Production, capital markets and overall economic balance

On the production side, capital and labour are used as substitutes so that wages correspond to marginal labour productivity and capital returns correspond to marginal capital productivity. Production is described by a Cobb-Douglas production function, which converts $L_{t,i}$ and capital $K_{t,i}$ into units of goods and services, measured as gross domestic product (GDP), $Y_{t,i}$. The indices t, i and a stand for year, country and age, respectively.

$$Y_{t,i} = F\left(K_{t,i}, \Theta_{t,i} L_{t,i}\right) = K_{t,i}^{\alpha}\left(\Theta_{t,i}\sum_{a=1}^{65}\varepsilon_a L_{t,a,i}\right)^{1-\alpha}$$

All countries have the same production technology, F, but labour productivity, $\Theta_{t,i}$, varies. Also, the entire workforce $L_{t,i}$ is composed of the various age groups, $L_{t,a,i}$, whose age-specific productivities, ε_a, correspond to the average wage profile.[3]

The different productivity levels, $\Theta_{t,i}$, correspond to the different per capita GDPs. The available quantity of labour supplied by individuals in each age group, $L_{t,a,i}$ is derived from the demographic assumptions.[4]

Wages and interest rates are determined by labour productivity and capital productivity, respectively. In particular, the interest rate is equal to the marginal productivity of the capital deployed minus the rate of depreciation δ:[5]

$$r_{t,i} = f'\left(k_{t,i}\right) - \delta$$

Domestic investment is defined as the net change in the domestic capital stock:

$$I_{t,i} = K_{t+1,i} - \left(1-\delta\right)K_{t,i}$$

3. Rising until the age of 55 and then constant.

4. See Börsch-Supan *et al* (2003) for a description of these.

5. More precisely, it is the marginal productivity of capital deployed per efficiency unit of work, $k_{t,i} = K_{t,i}/\left(\Theta_{t,i}L_{t,i}\right)$. The depreciation rate δ is assumed to be constant and uniform across countries.

Capital $K_{t,i}$, which is used in country i for production, does not have to correspond to the assets that the inhabitants of that country have accumulated and which we have described as $A_{t,i}$. The difference

$$V_{t,i} = A_{t,i} - K_{t,i}$$

represents the net foreign asset position of domestic residents. If a country saves more than it invests, capital flows abroad – for instance, in the form of direct investments – until returns, adjusted for risk and tax, have converged in all countries. A country's current account balance is therefore

$$CA_{t,i} = S_{t,i} - I_{t,i}$$

If one takes all the regions of the world together, both the international capital flows and the net external positions of the various countries must cancel each other out, because the regions of the world form a closed economy. This provides the key condition for the equilibrium of international trade in our model; that is:

$$\sum_{i=1}^{R} V_{t,i} = 0$$

The MEA-OLGA model parameters are calibrated so as to match the overall economic pattern in Germany from 1970 to 1995. The relevant parameters are listed and explained in Börsch-Supan *et al* (forthcoming).

4.3 How international capital movements are modelled

We first applied the MEA-OLGA model to three scenarios for capital mobility: firstly, to Germany as a closed economy; secondly, to Germany as an open economy with perfect capital mobility within the countries of the EU; thirdly, with perfect capital mobility within the countries of the OECD. Although perfect capital mobility within the OECD may not occur, this is probably a reasonable assumption for the EU, because most capital flows occur within the euro area where there is free movement of capital. Focusing on euro-area economies allows us to ignore the impact of exchange rates in the MEA-OLGA model. Even in broader scenarios, this assumption may be reasonable as the model describes very long-term trends in capital movements. Short-term exchange rate movements induce flows of capital which, although considerable, are of short duration and of less interest to us. Long-term exchange rates and capital flows are, however, determined jointly by fundamental variables, such as demography and overall economic development.

4.4 How further capital is accumulated as a result of old-age provision

We mapped the potential scope for the development of pension insurance with two scenarios. The first scenario ('retain PAYG systems') assumes that countries retain PAYG pension systems providing replacement rates of approximately 70 per cent of pre-retirement income (roughly equivalent to the situation in Germany before the ‘Riester reform’. In this scenario, contribution rates increase from 19.5 per cent to 25.7 per cent in the year 2030 to finance ageing-related additional costs. We call the second scenario the ‘freezing model’. This systematic reform model stabilises the contribution rate at 19.5 per cent, so that the PAYG replacement rates fall to just under 51 per cent. At the same time, overall retirement incomes remain constant via a gradual transition to a pension system based on a substantially higher funded component. These are obviously two extreme scenarios. In most countries, political pressures will not permit a situation where contribution rates rise to almost 26 per cent. However, it is also unlikely that contribution rates can be frozen, so the most probable social policy development will be for systems to find a balance between these two extremes.

4.5 Calibration

In order to capture projected international differences in demographic characteristics and the generosity of public pension systems, we distinguish seven world regions in the benchmark scenario: (i) France, (ii) Germany and (iii) Italy as three large European countries severely affected by population ageing, (iv) the remainder of the European Union, (v) North America (the US and Canada), (vi) remaining OECD countries, and (vii) all other countries in the world. While we treat France, Germany and Italy as separate regions in the simulations, we simplify the presentation of most of our simulation results by aggregating them into a combined France-Germany-Italy (FGI) region.

Our demographic model for these regions is calibrated to fit UN Population Division (2001) projections. These projections end in 2050. Between 2050 and 2100, we continue the linear increase in life-expectancy assumed by the UN and impose constant fertility rates at the levels reached in 2050. During the phase-out period of the model beyond 2100, demographic processes adjust so that stable populations are reached by 2200.[6]

PAYG pension systems are calibrated with data on replacement rates taken from Palacios and Pallarès-Miralles (2000) and employees’ social security contributions taken from the OECD (2001). We solve for equilibrium contribution rates using the PAYG budget constraint.

Further parameters of the model describe the households’ preferences, the parameters of the production function and the age-specific productivity profile. For the latter, we use the cohort-corrected non-linear regression estimates by Fitzenberger *et al* (2001). This provides us with a representative age-wage profile that peaks at the age of 55 and then decreases slightly.

With two exceptions, technological and preference parameters are assumed to be constant and equal across all countries. The values of these parameters are

6. Population data for 1950–2050 are given at an annual frequency for five-year age groups. Further input data such as age-specific mortality rates, life expectancy and aggregate migration are only provided at quinquennial frequency. We interpolate between age groups and time intervals and ‘backfit’ our population model to the UN population data for the time period 1950–2050.

standard in the literature and summarised in Table 1. The annual growth rate of labour productivity, g, is set to 1.5 per cent, which is slightly higher than the value of 1.4 per cent suggested by Cutler *et al* (1990) and closer to the long-run projections suggested by the OECD. The capital share parameter, α, is set to an intermediate value of 0.35. The annual depreciation rate of capital, δ, is assumed to be 5 per cent per year.

The adjustment cost parameter, ψ, is set to the value of 1.5 and results in a steady-state value of Tobin's q of 1.0975, which is in the middle of the values used in the literature. As we show in an extensive sensitivity analysis (Börsch-Supan *et al* 2004), adjustment costs allow us to study the time paths of the price of capital, but otherwise do not affect the long-run equilibrium results.

The rate of time preference in all countries, ρ, is set to 0.01, which is close to the estimate of 0.011 in Hurd (1989). With this choice – and given all the other parameter values – our calibrated model produces an average capital-output ratio of about 2.9 for the 'European Union' region over the period 1960–2001. While comparable capital-output ratios for a large cross-section of countries are not available, a value of 2.9 is reasonable for many countries (OECD 2004). The coefficient of relative risk aversion, σ, is set to 2, which is within the standard range of 1 and 4. We follow Altig *et al* (2001) in choosing the value for the intratemporal substitution elasticity $\xi = 1/(1+\gamma) = 0.8$.

Levels of total factor productivity, Θ_i, vary across countries and are calibrated such that the model replicates output data in each country for the period 1960–2001.[7] The relative preferences for consumption and leisure in households' utility functions vary across countries and ages such that the simulation model approximately replicates aggregate labour supply as well as labour supply profiles across ages in each country for the period 1960–2001.

A final remark concerns the initial values of the model for the year 2002 under the different capital mobility scenarios. Conceptually, it is problematic to simulate

Table 1: Calibration of Parameters in the Overlapping Generations Model

α: output share of capital in the CES production function	0.35
g: growth rate of labour productivity	0.015
δ: depreciation rate of capital	0.05
ψ: adjustment cost parameter	1.5
ρ: rate of time preference	0.01
σ: coefficient of relative risk aversion	2
ξ: intratemporal substitution elasticity	0.8
Θ_i: technology level	0.05–0.07
$\bar{\omega}_i$: consumption share parameter	0.535–0.665
$\Delta\omega_i$: increment of consumption share parameter	0.015–0.02

7. Since there is no government consumption in the model, we define output as the difference between actual GDP and government consumption.

a calibrated macroeconomic model under policy scenarios other than the one for which it was calibrated. In our case, the world for which we calibrate the model changes with the number of regions considered in the capital mobility scenarios. On the one hand, it would make sense to adjust the calibration parameters each time we change the number of regions that we consider. On the other hand, this would change households' reactions to changes in policy and it would therefore be more difficult to interpret our results with respect to a reform of public pension systems. Since we are primarily interested in the reaction of households to demographic change and fundamental pension reform, we hold parameter values constant across all capital mobility scenarios. We calibrate the model under the assumption that the 'OECD' capital mobility scenario correctly reflects the 'true' world and therefore that all other capital mobility scenarios are 'counterfactual' worlds. The careful reader will note that this procedure results in differences in the values of the simulated variables in 2002, the base year of our simulations.

5. Simulation Results for Alternative Pension and Capital Mobility Scenarios

In this section we present our main results: how will demographic change affect key macroeconomic variables? Since the speed and extent of demographic change varies across the world, we would observe different rates of return to capital in each region if the regions were closed economies.

In a world of open economies, however, differences in rates of return will induce international capital flows until returns are equal, allowing for tax and risk, in all regions. In order to illustrate the influence of capital mobility across regions, we build four capital mobility scenarios focusing on their impacts on the three largest economies in continental Europe (France, Germany and Italy). The first scenario corresponds to a situation where France, Germany and Italy can invest only in each other. The other three capital mobility scenarios open this closed economy up sequentially: France, Germany and Italy diversify their investments (i) across all countries of the EU, (ii) across all OECD countries, and (iii) across the entire world. The results in Figures 2–5 display lines representing these alternative capital mobility scenarios. The benchmark scenario assumes that capital mobility is restricted to the OECD area.[8]

In addition to these *direct* effects of demographic change, there are *indirect* effects due to the presence of (partially) PAYG-financed social security systems. In order to separate the direct effects of population ageing on capital markets from potential feedback effects due to the existence of pension systems and pension reform, we present our main results under two hypothetical pension policy scenarios (as

8. We choose this scenario as our benchmark for two reasons. First, as noted in Section 2, there is a broad consensus that capital mobility is greater among OECD countries than it is between developed and developing countries. Second, adding the additional countries of the 'rest of the world' region does not substantially affect patterns of aggregate variables because roughly 80 per cent of world GDP is produced in the OECD.

described above): (a) an 'old system scenario' in which FGI maintain their existing current generous public pension systems; and (b) a 'reform scenario' that introduces a transition to a partially funded pension system by freezing contribution rates in these three countries. The other regions' pension systems remain unchanged. By comparing these two extreme scenarios, we can show that a good portion of the capital market effects of population ageing arise even without fundamental pension reform. Accordingly, the figures below have two panels. The top panel corresponds to the 'old system scenario', that is, the direct effects of demographic change and the lower panel shows the differences between these two scenarios, that is, the indirect effects of a fundamental pension reform (which is in turn driven by the pressures of demographic change).

The interplay between these direct and indirect effects of population ageing on macroeconomic variables is complicated because they involve changes in *levels* and *trends*. *Direct level* effects are due to differences in the levels of working-age population ratios across countries. Younger economies, that is, economies with higher working-age population ratios, have higher marginal productivities of capital that will be arbitraged away by international capital flows. *Direct trend* effects are related to the speed of demographic change and affect the dynamics of macroeconomic variables. As working-age population ratios decrease, capital-output ratios increase and both the rates of return and saving rates decline.

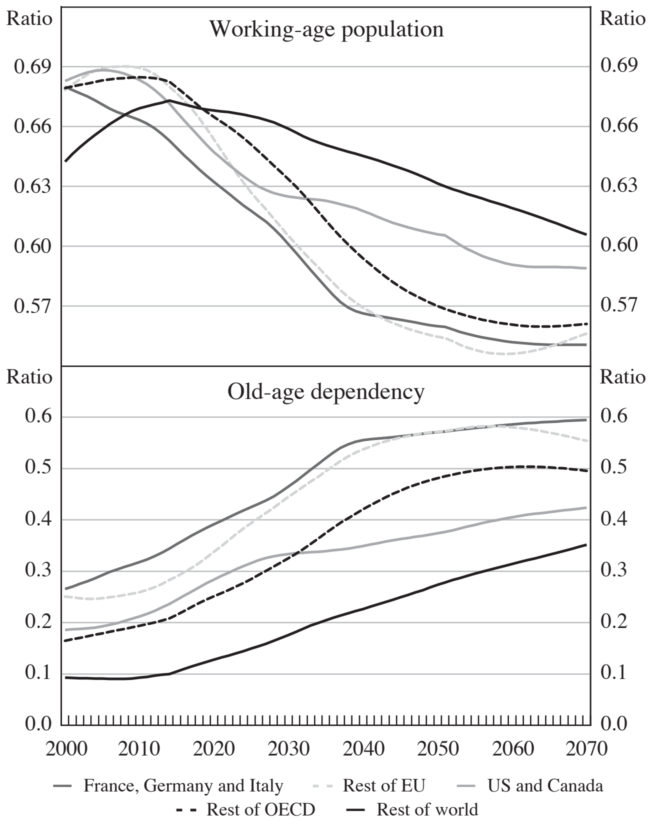
The indirect effects of PAYG-financed pension systems are due to the 'crowding-out' effect that the provision of old-age pensions has on private saving and the corresponding distortionary taxation of labour income. By crowding out private savings, the *indirect level effect* of a PAYG-financed pension system works in the opposite direction to the direct effect of demographic change. That is, relative to a situation without PAYG-financed pension systems, the indirect effect decreases the differences in saving rates and rates of returns between countries. The *indirect trend effect occurs* because, over time, old-age dependency ratio increases force contribution rates to PAYG pension systems to increase (since PAYG replacement rates are taken as given). The *indirect trend effect* is stronger in (older) regions that are currently ageing more rapidly and so are more severely affected by the impact of demographic change.

In order to illustrate the complex interactions between direct and indirect level and trend effects, the presentation of our results proceeds in several steps. Throughout, we focus on the economic consequences of ageing and of fundamental pension reform on the continental European region consisting of France, Germany and Italy. As our point of departure, we analyse the impact of exogenous demographic change on working-age populations and old-age dependency ratios. We then analyse the two ways in which households react to demographic change and fundamental pension reforms by examining how labour supply and saving patterns are affected. We next turn to the firm sector and analyse the evolution of wage rates and the return to capital as well as the price of capital, represented by Tobin's q. Then we focus on the differences between national saving and investment that generate international capital flows and describe how they are affected by demographic change. Our results demonstrate the potential for substantial flows between, and within, the different regions of the world. To highlight this aspect, we present results on saving patterns and international capital flows for France, Germany and Italy. We conclude this section with a brief welfare analysis for households living in Germany.

5.1 Point of departure: demographic change

Figure 1 shows the effects of demographic change on two central demographic measures – the share of persons of working age (15–65 years) out of the total population, and the old-age dependency ratio (the number of persons older than 65 as a share of the working-age population).

Figure 1: Projections of Demographic Change for Five Different World Regions



Note: This figure shows projections of the ratios for working-age population (the number of people aged 15– 65 as a percentage of total population) and old-age dependency (the number of people aged 65+ as a percentage of the working-age population).

Sources: Börsch-Supan *et al* (forthcoming); UN Population Division (2001)

A number of lessons can be drawn from these measures. First, all world regions are affected by demographic change: the proportion of persons of working age will decrease and the old-age dependency ratios will increase. Second, while the shares of persons of working age were similar in 2000 among OECD countries, they are projected to diverge in the decades ahead. The decrease in the share of persons of working age is strongest in the EU, especially among France, Germany and Italy. Third, these three countries are also projected to have the highest old-age dependency ratios. Fourth, there are significant differences in the timing and pattern of demographic change across regions. As we will see, these different patterns have profound implications for the evolution of saving rates, rates of return and international capital flows.

5.2 Labour supply, contribution and replacement rates

These demographic changes have immediate effects on labour supply and the sustainability of pension systems. Labour supply shares in France, Germany and Italy are projected to decrease from 42 per cent currently to below 36 per cent by 2050. The economic dependency ratio, defined as the ratio of pensioners to workers, is projected to increase from roughly 50 per cent in 2002 to about 80 per cent in 2050.[9]

As a consequence of the decrease in labour supply shares and the resulting increase in the economic dependency ratio, contribution rates to PAYG pension systems increase sharply under the 'old system scenario'. These contribution rates are equilibrium contribution rates, meaning that they ensure that the budget of the pension system of each country is balanced at every point in time (implicitly including tax subsidies to the pension system). The time patterns of net replacement and contribution rates for France, Germany and Italy that result from our procedure are summarised in Table 2.

If current generous replacement rates were maintained, our model predicts that the equilibrium contribution rate in Germany would increase from its current level of roughly 27 per cent to 42 per cent by 2050 – an increase of more than 50 per cent. The stylised pension reform freezes contribution rates at the level reached in 2006, roughly at 29 per cent. As a result, average pension levels decrease: the net pension replacement rate is projected to decrease from 70 per cent in 2000 to about 50 per cent by 2050. Hence, for Germany, under this scenario our model predicts a one-third transition towards pre-funding by 2050. Results for the other countries are similar.

Households respond to these decreases in pension benefit levels by saving more and by increasing their supply of labour. The stylised pension reform would lead to substantial increases in aggregate labour supply. Labour supply shares are predicted to increase by more than 2.5 percentage points by 2050. This increase is roughly the same for all capital mobility scenarios. For instance, labour supply shares in

9. The total sum of pensioners ('effective pensioners') as used in this section is defined as the sum of actual pensioners weighted by their age-specific pension entitlements.

Table 2: Predicted Contribution and Replacement Rates of PAYG Pension Systems

	France			Germany			Italy		
	2000	2030	2050	2000	2030	2050	2000	2030	2050
Old system scenario									
Contribution rates	0.275	0.356	0.375	0.268	0.375	0.415	0.325	0.476	0.534
Net replacement rates	0.654	0.654	0.654	0.700	0.700	0.700	0.646	0.646	0.646
Reform scenario									
Contribution rates	0.275	0.295	0.295	0.268	0.294	0.294	0.325	0.340	0.340
Net replacement rates	0.654	0.549	0.513	0.700	0.568	0.504	0.646	0.489	0.415

Note: Figures shown in the table refer to the open economy scenario ‘OECD’.
Source: author’s calculations

the FGI region increase from about 36 per cent in the year 2050 under the ‘old system scenario’ to 38.5 per cent under the ‘reform scenario’. As a consequence, the economic dependency ratio is projected to decrease by almost 6 percentage points. Endogenous labour supply is therefore a helpful mechanism to dampen the effects of population ageing. This effect holds over the entire range of the crucial elasticity parameters in the MEA-OLGA model (Börsch-Supan *et al* 2004).

5.3 Savings and capital stock

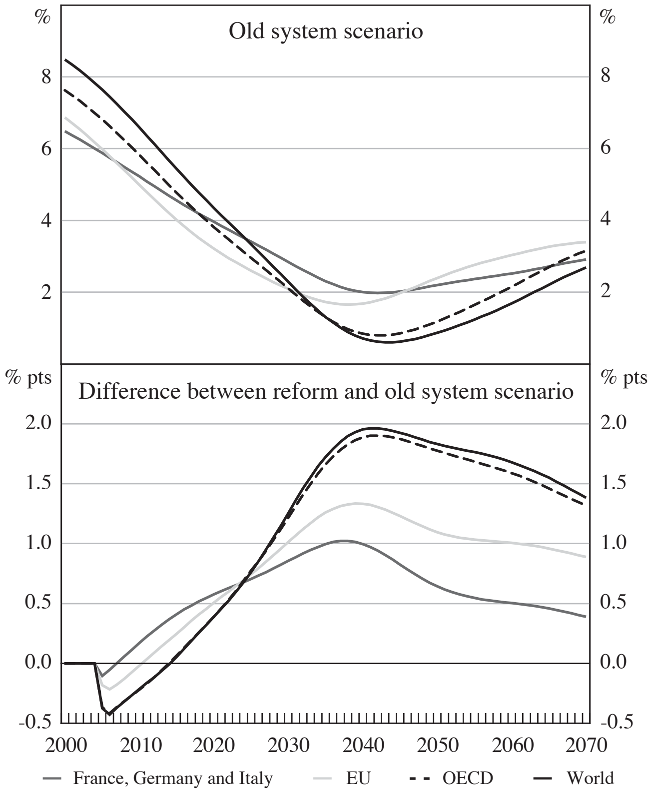
The top panel of Figure 2 shows the aggregate average saving rate of France, Germany and Italy in the four capital mobility scenarios. In the year 2000, saving rates are substantially higher in the open-economy scenarios than in the closed economy scenarios. This reflects the higher rates of return to capital realised in a more rapidly ageing open economy able to export capital to relatively younger economies.

This direct level effect is superseded by the demographic changes that occur during the 2000–2070 prediction window. Saving rates decrease until 2050 across all capital mobility scenarios, since the baby boom generation decumulates assets. Saving rates are projected to rebound after the year 2050. The decrease in the saving rate caused by population ageing – the difference between the value in 2000 and the minimum reached just after 2040 – is roughly 4.5 percentage points if capital mobility is restricted at most to the EU region (the FGI and EU scenarios). If we allow for capital mobility within the OECD or the entire world, this decrease is 6.5 or 8 percentage points, respectively. The larger declines in the open economy scenarios are due to the indirect trend effect described above. The advantages of worldwide capital mobility thus decline and saving rates respond accordingly.

Projected aggregate saving rates under a fundamental pension reform are substantially higher and the effect of a pension reform is stronger in the OECD and World open-economy scenarios (the saving rate is projected to increase by slightly

Figure 2: Aggregate Saving Rates

Households living in France, Germany and Italy



Note: France, Germany and Italy – perfect capital mobility within France, Germany and Italy; EU – perfect capital mobility within the European Union; OECD – perfect capital mobility within the OECD; World – perfect capital mobility across all world regions

Source: Börsch-Supan *et al* (forthcoming)

more than one percentage point in the EU scenario as compared to 2 percentage points in the OECD and World scenarios). An increase in national savings leads to an increase in the capital stock and thereby a decrease in the rate of return to capital, which then discourages further savings. In those scenarios with a larger international capital market, substantially more savings are generated since – as we show below – the rate of return decreases by much less. These projections show that optimal life-cycle behaviour generates additional saving under a fundamental pension reform – in our model, it is not the case that additional retirement saving induced by a pension reform crowds out other saving totally, as has often been claimed.

We also accumulate aggregate savings across regions to obtain the world's asset holdings and capital stocks and the related capital-output ratios (not shown). In the OECD scenario, a consequence of decreasing the supply of labour is that the capital-output ratio increases from its current level of about 3 to about 3.25 by 2040 and then decreases slightly when baby boomers decumulate assets. This decrease is much more pronounced if we restrict the international capital market to the EU area only. Simultaneous fundamental pension reforms in France, Germany and Italy lead to substantial increases in the capital-output ratio if we restrict capital mobility to these countries or the EU area. The increase is much lower if we relax this constraint, suggesting that the additional savings shown in Figure 2 are largely invested abroad.

5.4 The rate of return and the price of capital

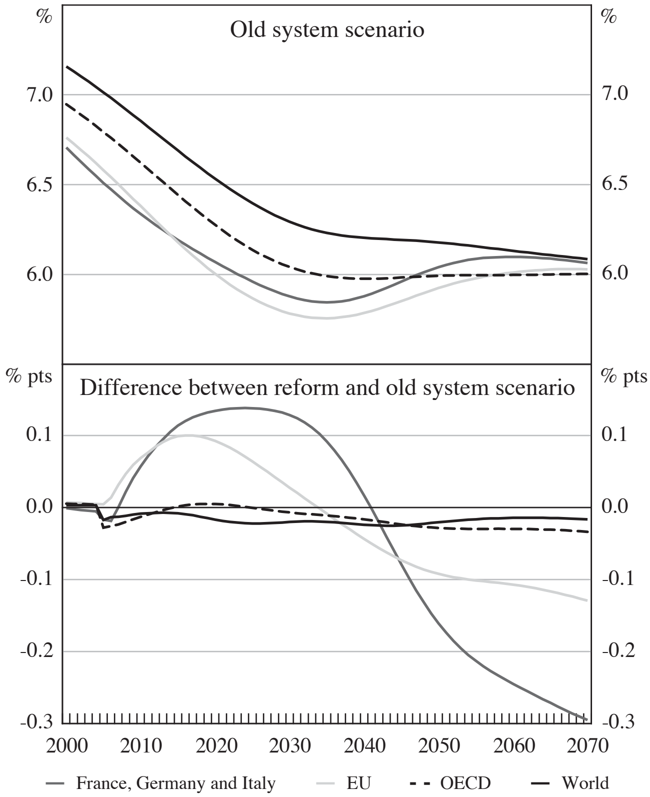
Much of the political and academic debate on the capital market consequences of demographic change and pension reforms has focused on the rate of return to capital, to which we turn next. First, we observe the same level effects as already described in the previous section. It is noteworthy that the demographic effect is larger than a second-level effect. Since the PAYG systems are slimmer in the aggregate rest-of-the-world region than in France, Germany and Italy, the capital stock accumulated for retirement savings is larger, which depresses rates of return.

Second, as a consequence of population ageing and the resulting increase in capital-output ratios, our model predicts that the rate of return to capital will decrease by a bit less than 1 percentage point if capital moves freely within the OECD (see Figure 3). This decrease hardly constitutes an 'asset-price meltdown'. Third, while the rate of return decreases across all capital mobility scenarios, substantial gains would be possible if 'older' countries could 'shift' investments to 'younger' countries since our model predicts that savers in older countries can achieve higher returns if capital is mobile across all world regions. However, as demographic processes are highly correlated across countries (compare Figure 1), allowing for capital mobility across countries more or less only affects the level of the rate of return. Furthermore, diversification advantages decrease over time since indirect trend effects are at work as well.

As the lower panel of Figure 3 suggests, there would be an additional long-run decrease in the rate of return to capital if France, Germany and Italy simultaneously reformed their pension systems in a fundamental way. This decrease would amount to about 0.25 percentage points in 2070 if capital was freely mobile within these countries only. However, due to the response of labour supply to pension reform, this long-run decrease in the rate of return is lower than it would be in a model with exogenous labour supply (Section 6). In contrast to such a model, our model even predicts an increase in the rate of return until about 2030 or 2040 (as a result of the endogenous labour supply reaction). While saving rates immediately start to increase after the reform, labour supply increases as well. The net effect is an initial decrease in the capital-output ratio and an associated increase in the rate of return to capital. Moreover, and in line with earlier results in Börsch-Supan *et al* (2002), the decrease in the rate of return is negligibly small if capital moves freely across OECD countries (or the entire world).

Figure 3: Rate of Return

Aggregate capital stock in France, Germany and Italy

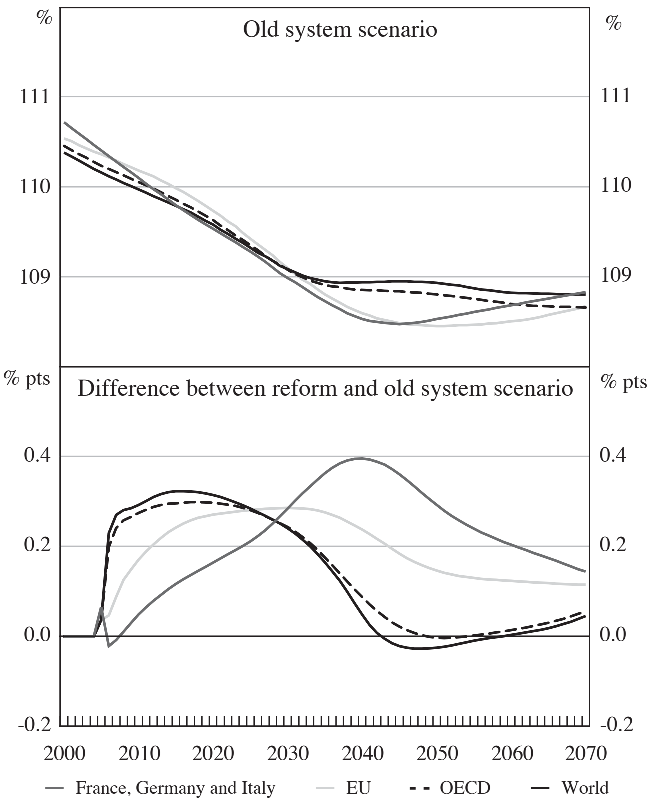


Note: France, Germany and Italy – perfect capital mobility within France, Germany and Italy; EU – perfect capital mobility within the European Union; OECD – perfect capital mobility within the OECD; World – perfect capital mobility across all world regions

Source: Börsch-Supan *et al* (forthcoming)

Tobin's *q*, the price of capital, also decreases as a consequence of population ageing but its level is higher in the demographically younger regions. Results regarding Tobin's *q* for the FGI region are depicted in Figure 4. Notice that the relative decrease of *q*-values is lower under the pure PAYG scenario if capital is mobile across a greater part of the world (top panel). As a consequence of fundamental pension reforms, *q*-values are predicted to increase slightly since the investment to capital ratio increases (lower panel). The long-run effect is stronger if capital mobility is restricted to a smaller region.

Figure 4: Tobin's *q*
France, Germany and Italy



Note: France, Germany and Italy – perfect capital mobility within France, Germany and Italy; EU – perfect capital mobility within the European Union; OECD – perfect capital mobility within the OECD; World – perfect capital mobility across all world regions

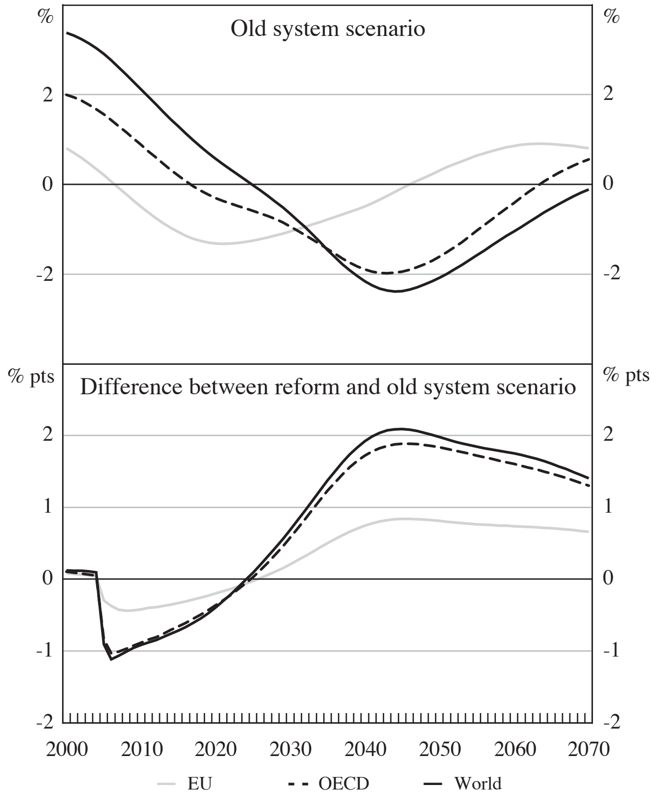
Source: Börsch-Supan *et al* (forthcoming)

5.5 International capital flows

International capital outflows from France, Germany and Italy to other OECD countries roughly follow the pattern of saving rates and decrease steadily until 2050 (see Figure 5). In the OECD and World capital mobility scenarios, they are initially positive at about 2 and 3.2 percentage points of output. Over time, these net capital flows are reversed and the model predicts that France, Germany and Italy will run current account deficits of between 2 and 2.5 percentage points of output by 2050 (top panel).

So far, our analysis has concentrated on France, Germany and Italy in aggregate. However, there are substantial differences across these countries. To highlight this, we next analyse savings patterns and international capital flows within the EU

Figure 5: Current Account to Output Ratios
France, Germany and Italy



Note: EU – perfect capital mobility within the European Union; OECD – perfect capital mobility within the OECD; World – perfect capital mobility across all world regions

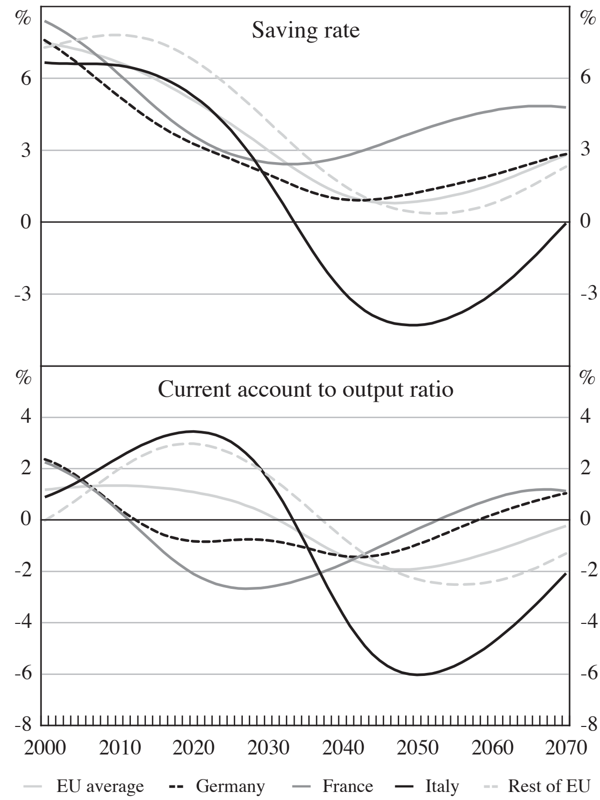
Source: Börsch-Supan *et al* (forthcoming)

region under the assumption that the international capital market is restricted to the OECD area.

Figure 6 (top panel) shows saving rates for France, Germany, Italy, the remaining EU countries and the EU average. The time pattern of German saving rates roughly mirrors the EU average. Germany's saving rate is projected to decrease from current levels of 7 per cent of output to about 2 per cent of output by 2050. For France, the youngest of the three countries, the decline in its saving rate lasts only until 2030 and the overall decrease is smaller than in other EU countries. Italy, faced with the most rapid and extensive population ageing process within Europe, is at the other extreme: Italian households' saving rates are projected to become substantially negative in 2050.

Figure 6: Saving Rates and Capital Flows in the European Union for the OECD Scenario

Old system scenario



Note: EU average – average of all EU countries; rest of EU – all EU countries excluding France, Germany and Italy

Source: Börsch-Supan *et al* (forthcoming)

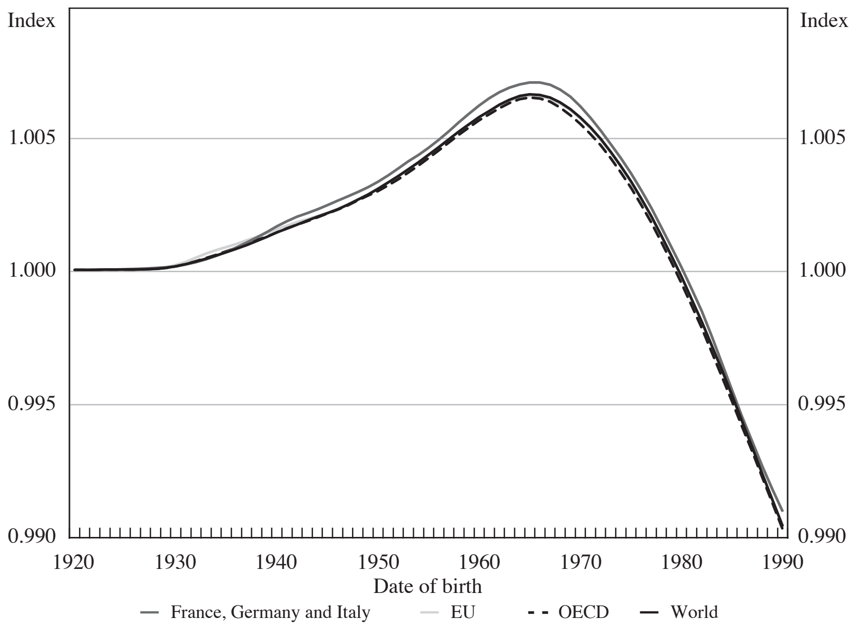
5.6 Welfare analysis

Figure 7 shows the effects of the fundamental pension reform on remaining lifetime utility for different cohorts in Germany. We follow Altig *et al* (2001) and measure the change in remaining lifetime utility as the equivalent variation of income. That is, we construct an index that measures the present value of remaining lifetime resources relative to remaining lifetime resources under the old system that a household would have to receive (pay) under the new system to make it indifferent between the old and the new system. Therefore, an index number greater (smaller) than 1 implies a loss (gain) in remaining lifetime utility.

The results show that remaining lifetime utility of cohorts born between the years 1920 and 1990 decreases as a consequence of the fundamental pension reform. While substantial welfare gains are possible in the long run in all capital mobility

Figure 7: Index of Welfare Differences between the Reform and the Old System Scenarios

Households living in Germany



Note: France, Germany and Italy – perfect capital mobility within France, Germany and Italy; EU – perfect capital mobility within the European Union; OECD – perfect capital mobility within the OECD; World – perfect capital mobility across all world regions

Source: Börsch-Supan *et al* (forthcoming)

scenarios, the figure also illustrates that fewer cohorts experience losses if capital mobility extends to more regions of the world. However, the difference between the alternative capital mobility scenarios is not large.

6. Sensitivity Analysis

One of the weaknesses of computational general equilibrium analysis is the dependence of the results on modelling strategies and parameter values. The usual response is an extensive sensitivity analysis. The existing literature has mostly concentrated on sensitivity analysis of simulation results with regard to values of structural (deep) model parameters, for example, Altig *et al* (2001). Applying this type of conventional sensitivity analysis to this paper shows that the results change very little when we vary the main elasticity parameters within their usual ranges. Our most contentious conclusion – the absence of a serious asset-price meltdown – is robust with respect to the choice of these elasticity parameters.[10]

10. We provide such standard sensitivity analysis in Börsch-Supan *et al* (2004).

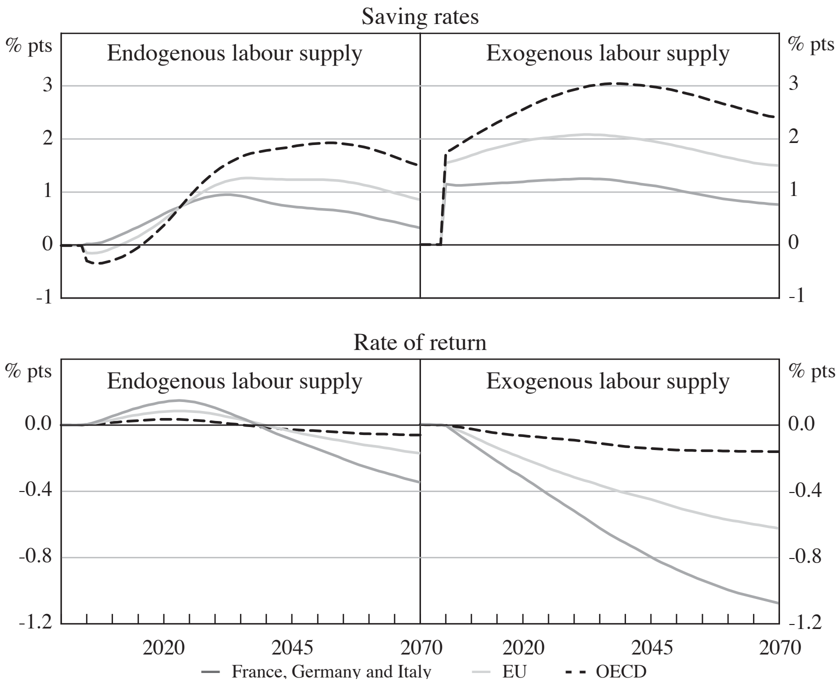
In addition to this conventional sensitivity analysis, we also investigate the robustness of our results with respect to four key dimensions of our model specification. What difference does it make: if labour supply is endogenous or exogenous; if investment incurs adjustment costs; if perfect annuity markets absorb all accidental bequests; or if part of retirement income is provided by a PAYG pension system? We find that the first dimension – whether labour supply is endogenous – matters a lot for assessing the effects of a pension reform, while the other three dimensions – adjustment costs, annuity markets and accidental bequests – matter very little.

In the paper, we therefore only report on the role of endogenous labour supply. For simplicity, we concentrate on a three-region rather than a seven-region model as in the previous section: (i) France, Germany and Italy; (ii) all other EU countries; and (iii) all other OECD countries. We focus on the differential effects between the old system and the reform scenario because this is where the endogeneity of labour supply matters most.

Figure 8 compares the saving rates and rates of return generated by models with endogenous and exogenous labour supply. In the exogenous labour supply

Figure 8: The Influence of Modelling Endogenous Labour Supply

Difference between the reform and the old system scenarios



Notes: This figure shows projections of the differential effects of the fundamental pension reform on saving rates and rates of return for the endogenous and exogenous labour supply models of Section 6. France, Germany and Italy – perfect capital mobility within France, Germany and Italy; EU – perfect capital mobility within the European Union; OECD – perfect mobility within the OECD.

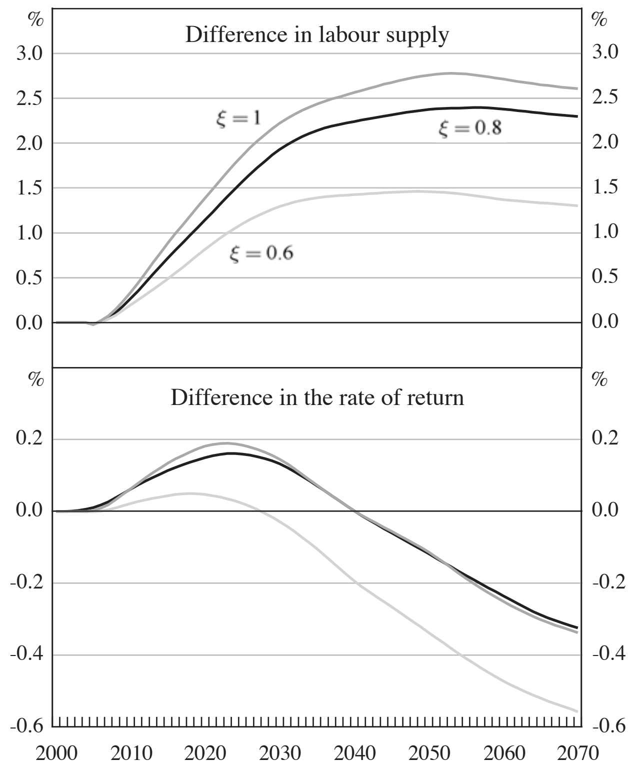
Source: Börsch-Supan *et al* (forthcoming) specification, we hold age-specific labour supply shares constant at levels obtained in the endogenous labour supply scenario in the year 2000. We first show the reaction of saving to the fundamental pension reform. As depicted in Figure 8 (top panel), the increase of the saving rate is much larger if labour supply is exogenous – not surprising perhaps given that with labour supply fixed saving is the only means by which to adjust to the pension reform.

This difference in behaviour directly translates into substantial differences in the time paths of the rate of return to capital, depicted in Figure 8 (lower panel). If labour supply is endogenous, the rate of return initially increases since households increase their labour supply in response to the change in policy. This effect is absent when labour supply is exogenous. Hence, the rate of return to capital immediately decreases. As a result, the overall decrease in the rate of return to capital is much larger.

The size of this endogenous labour supply effect depends on the elasticity of substitution between consumption and leisure, ξ. This is shown in Figure 9, where

Figure 9: Endogenous Labour Supply – The Role of the Intratemporal Substitution Elasticity

Freezing versus pure PAYG



Notes: This figure shows projected differences in labour supply and the rate of return to capital between the freezing and the pure PAYG scenarios under the assumption that capital mobility is restricted to the France, Germany and Italy region. Results are shown for alternative parameterisations of the intratemporal substitution elasticity between consumption and leisure, ξ.

Source: Börsch-Supan *et al* (forthcoming) we vary ξ by $\pm$ 0.2 around its benchmark value of 0.8 and re-calibrate the model such that initial labour supply shares are held constant. We focus on the case where capital mobility is restricted to the FGI region because it exhibits the strongest sensitivity (see Figure 8). In this 'closed economy' case, the increase of labour supply resulting from the fundamental pension reform is only slightly higher if $\xi = 1$ (Cobb-Douglas utility), but quite a lot lower if $\xi = 0.6$. As a result, the decrease in the rate of return to capital is much stronger for $\xi = 0.6$ than for the benchmark calibration of $\xi = 0.8$.

7. Econometric Estimates of Anticipated International Capital Flows

One may distrust a simulation model such as MEA-OLGA that relies entirely on the assumptions of economic theory to predict the future. This section therefore provides econometric estimates based upon past international capital flows and demographic changes. Using these estimates to project future international capital flows requires us to make some heroic assumptions: the demographic changes projected to occur in the 21st century are unprecedented in history, and there is no guarantee that relationships identified on the basis of the relatively subtle demographic changes in the past will remain stable during the huge and incisive changes likely to occur in the future.

Although not directly comparable, this section's econometric estimates support the simulations presented in the preceding sections. These estimates are based on Lührmann (2006). She uses a reduced-form approach to analyse the empirical link between current and future demographic measures and international capital flows. Her estimations are based on time-series and cross-section data for about 120 countries from 1970 to 1997. The demographic data are provided by UN Population Division (2001), while the economic data of the unbalanced panel are taken from the *World Development Indicators* published by the World Bank (2003). Additional data on capital controls are provided by the International Monetary Fund (1999).

The dependent variable is capital outflows, constructed as the net value of gross domestic savings minus domestic investments as a share of GDP.

Explanatory variables are regional fixed effects, present demographic measures, expected demographic changes, financial sector variables and measures of capital mobility. Regional fixed effects relate to the 18 regions identified by the United Nations. Demographic measures are the population shares of 17 age groups (0–4, 5–9, 10–14, …, 75–79, 80+) which are converted into a fourth-order polynomial by the method of Fair and Dominguez (1991). Expected demographic change employs two specifications of the effect of an increased life expectancy on these shares, described in detail by Lührmann (2006). In both specifications, past increases in life expectancies are used to project the age structure in the future. Then, youth and old-age dependency ratios are calculated at several time horizons. One specification uses as a time horizon the expected time of death for each age; a second specification uses a range of time horizons. Capital mobility and financial market influences are described by a set of variables including a dummy variable on capital controls, capital gains taxes, taxes on international trade, the size of the financial market, the ratio of private credits to GDP and the Freedom House (2002) index measuring the extent of law enforcement and property rights. Finally, financial literacy is approximated by the enrolment in secondary education.

Table 3 summarises the regression results obtained by Lührmann (2006). The coefficients of the age-structure polynomial describing current demographic measures are highly significant. If converted into marginal effects, they show that

Table 3: Regression Results

Dependent variable – net capital outflows

	Specification 1	Specification 2	Specification 3
Present demography			
D1	–1.057 (5.73)***	–1.171 (6.51)***	–1.193 (5.87)***
D2	0.312 (7.02)***	0.350 (7.95)***	0.372 (7.35)***
D3	–0.030 (7.32)***	–0.034 (8.26)***	–0.037 (7.89)***
D4	0.001 (7.07)***	0.001 (7.99)***	0.001 (7.95)***
Expected future demography			
OLD		–0.010 (0.52)	
YNG		–0.089 (4.75)***	
OLD10			–0.083 (0.88)
OLD20			0.017 (0.11)
OLD30			0.140 (0.98)
OLD50			–0.079 (1.52)
YNG10			–0.240 (4.34)***
YNG20			0.314 (3.47)***
YNG30			–0.208 (2.04)**
YNG50			–0.089 (1.71)*
Other covariates			
SIZE	–0.023 (2.05)**	–0.0248 (2.27)**	–0.0234 (2.08)**
TAX	0.028 (2.35)**	0.0216 (1.88)*	0.0444 (3.71)***
TRADETAX	–0.126 (8.36)***	–0.1198 (8.06)***	–0.1052 (6.66)***
PRIVATE	–0.034 (4.00)***	–0.0317 (3.80)***	–0.0405 (4.93)***
CONTROL	–0.015 (4.34)***	–0.0162 (4.70)***	–0.0152 (4.36)***
RIGHTS	–0.003 (3.53)***	–0.0025 (3.35)***	–0.0020 (2.55)**
CIVIL	0.002 (1.43)	0.0014 (1.42)	0.0022 (2.15)**
SCHOOL	0.036 (3.21)***	0.0332 (3.01)***	0.0271 (2.38)**
CONSTANT	0.031 (2.35)**	0.0415 (3.37)***	0.0439 (2.91)***
Observations	1 823	1 823	1 802

Notes: Absolute value of z statistics in parentheses. *, ** and *** represent significance at the 10, 5 and 1 per cent levels, respectively. FGLS estimation with country-specific AR(1)-process and heteroskedasticity.

Source: Lührmann (2006)

an increase in the share of the population of people who are in their most productive period of life induces net capital outflows, consistent with the intuition that these people are in their high saving years. In turn, an increase in the population share of retirees produces a net capital inflow, corresponding to the declining savings of older individuals.

Future demographic change enters in specifications 2 and 3. A future decline in the youth dependency ratio implies a large (and statistically significant) increase in net capital outflows. Short-run effects are much larger than longer-run effects (specification 3). Lührmann attributes the insignificant old-age dependency ratios to multicollinearity with the youth dependency ratio.

Most of the financial market and capital mobility variables are significant with the expected signs. The positive effect of schooling on net capital outflows is interesting, however. High human capital levels encourage net capital outflows, probably because they raise productivity, which increases saving rates.

Figure 10 translates these regression coefficients into predicted net capital outflows (measured relative to GDP) for a selected group of countries. Clearly, all ageing countries display a similar pattern: past net capital outflows revert into net capital inflows when population ageing becomes stronger. The effect is most pronounced in Japan. China follows a generation later. Relatively youthful countries, such as India and Indonesia, have the opposite pattern. The magnitudes are large, sometimes exceeding 5 per cent of GDP.

The results in this section do not fit exactly to the specification of the MEA-OLGA model employed earlier. However, the patterns as well as the magnitudes correspond quite closely: capital inflows are associated with faster-ageing countries, outflows with countries that feature a less dramatic demographic change. Typical magnitudes amount to some 3–5 per cent of GDP. The broad correspondence of results obtained from such vastly different methods gives considerable confidence in the results.

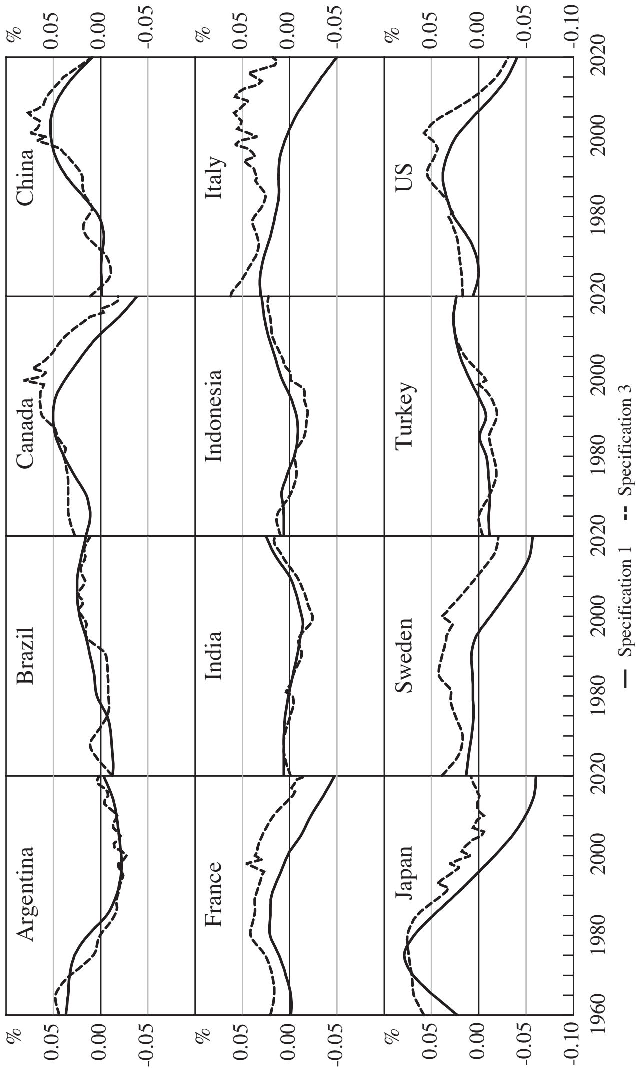
8. Conclusions

Population ageing works through various mechanisms. First, demographic change alters the time path of aggregate savings within each country. Second, this process may be amplified when a pension reform, brought about in response to the demographic change, shifts old-age provision from pure PAYG systems towards systems with at least some pre-funding. Third, while the patterns of population ageing are similar in most countries, timing and initial conditions differ substantially. Hence, to the extent that capital is internationally mobile, population ageing will induce capital flows between countries.

All three effects influence the rate of return to capital and interact with the demand for capital in production and with labour supply. Our simulations predict substantial capital flows due to population ageing. Population ageing results in decreases in the capital-output ratio when baby boomers decumulate their assets. International capital flows follow this trend. The countries and regions most affected by ageing such as

Figure 10: Demographic Effects on Net Capital Outflows

Per cent of GDP



Source: Lührmann (2006)

the European Union will initially export capital, while countries less affected by ageing like the United States and other OECD countries will import capital. This pattern reverses itself by about the year 2020 when baby boomers decumulate assets and the fast-ageing economies therefore become capital-importing regions. Pension reforms with higher degrees of pre-funding are likely to induce more capital exports during the first stage of this process. They also increase labour supply considerably, while the effects on the rate of return to capital are reduced. The results suggest that, while the rate of return to capital declines in response to population ageing, there is no devastating 'asset-price meltdown'.

The timing of this adjustment process is complex and one has to carefully distinguish level effects from changes over time. In the initial year of our projections (2002), saving rates in the FGI region are substantially higher in the open-economy scenarios than under a closed-economy one. This reflects the higher rates of return in economies with a smaller share of older persons. Open economies are able to avoid a large proportion of the demographic effects that depress saving rates and the rate of return to capital.

This level effect is superseded by the demographic changes during the 2002 to 2070 prediction window. Saving rates decrease until 2050 across all capital mobility scenarios since the baby boom generation decumulates assets. But saving rates are projected to rebound after the year 2050. Since PAYG pension systems partially crowd out private savings, declines in saving rates are larger in the older regions (which tend to have more generous PAYG pension systems). As a result, in a closed-economy setting, the decrease in the rate of return would be lower in these regions than in regions with less generous pension systems. The advantages of worldwide capital mobility are therefore not as great for countries with generous PAYG pension systems. We should stress that population projections are reliable one generation ahead, while the projection error increases substantially thereafter. Consequently, results for the post-2030 period should be interpreted with care.

We presented econometric results from a panel of national time series in which saving rates, rates of return and international capital flows are related to anticipated demographic change. These estimates support the results from the multi-country OLG model.

Finally, this paper shows the importance of the interplay between saving and labour supply adjustments in response to population ageing. Saving rates, rates of return and international capital flows react substantially less to demographic change once households absorb some part of the demographic shock by working more.

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Discussion

Avinash D Persaud

Introduction

The most profound ideas tend to be elegant and intuitive and both of the papers presented in this session make some elegant, intuitive and profound points. At the centre of these papers is the connection between external balances, which we know reflect local saving and investment gaps, and demographic changes, which we think drive local saving and investment. It follows that demographic changes should affect current account balances and there is some evidence for this relationship over low frequencies. Obvious enough you may say, but as we will get to in a moment, the predictions and policy implications of this observation are far from the current consensus. Both papers look at a wide range of related issues such as the 'asset-price meltdown' hypothesis, the impact of pension reforms, the role of labour market flexibility and the wider economic impact of China. I will focus on just three topics: global imbalances, asset-price meltdown and labour market flexibility.

One of those surprising, yet obvious things (when you think about it), that I have learned as a practitioner in financial markets is that, most of the time, prices change without any trades. All that market chatter about prices going up because investors are buying is, invariably, what Paul Keating might call drivel. Trades almost only occur when there is a disagreement about the price. My programming is therefore to skip over points of agreement in order to get to the points of difference. So lest my remarks are misunderstood, let me say that I recommend these papers to you all and share most of their conclusions. I have three points of departure. Only one of these is really a disagreement; the other two are important implications of the papers that I believe deserve more development.

Demographics and global imbalances

My first point is this. Both papers suggest that it may be appropriate for countries on the sweet side of the demographic curve, when working-age populations are expanding, to be growing rapidly and yet have more saving than investment opportunities and so also be exporting capital. It may be appropriate for countries on the sour side of this curve, when working populations are declining, to be liquidating savings and assets and importing capital. In other words, relative demographic changes can parsimoniously explain the export of capital from young developing countries that has otherwise confused many and, to some extent, the build-up of large current account imbalances which is currently a cause of concern for many.

This of course is in sharp contrast to the presiding narrative on global imbalances, which is that the current flow of capital is unnatural, needs to be ended and is driven by unfair exchange rate arrangements in developing countries in general and China in particular. But the implication of this demographic analysis is that, were we to remove restrictions on the movements of capital and exchange rates, we would observe similar current account positions to those we observe today. This is so important a conclusion that it is worth repeating. These papers suggest that the focus on exchange rates and competitiveness as a way of dealing with global imbalances is at best irrelevant and potentially harmful. Moreover, in the context of large divergences in the pace of demographic change, what you would expect to see, and what you would want to see, in a well-functioning financial system are ameliorating capital flows that show up as large current account imbalances.

To the extent that today's capital flows can be explained by divergences in demographic changes, we should be less worried about their size and more worried about how efficiently they are being managed. Cause for concern is that today's novice capital exporters have under-developed financial sectors. Surplus savings in developing countries are primarily invested by the public sector via central banks. But these are not the right institutions for investing national savings for the future. Central banks are, rightly, risk-averse liquidity managers. They will concentrate their investments in the most liquid, external asset – US Treasuries. This is far from the efficient frontier from a long-term investment perspective. Indeed, when viewed from all sides, it is a low-return portfolio that is dangerously concentrated.

Attention to the demographic drivers of current account imbalances recasts the problem we are facing from one of managing macro-imbalances to the macro-prudential issue of how efficiently large imbalances are managed. Instead of bullying developing countries off fixed exchange rate mechanisms that may serve them well at certain stages of development, we should be encouraging further liberalisation of trade and capital flows and the associated development of domestic financial sectors. Instead of pressuring surplus developing countries to revalue their nominal exchange rates with uncertain effect, we should take advantage of the opportunity these surpluses offer to encourage them to accept greater trade liberalisation through the Doha round of multilateral trade negotiations. Finally, perhaps prudential investment of national savings and financial sector development can be fast-tracked by outsourcing sovereign asset management to local investment institutions.

Asset-price meltdown

My second point relates to the asset-price meltdown hypothesis. Axel Börsch-Supan describes his disagreement with this hypothesis as his paper's most controversial position. I think he is being more controversial than he realises in other areas. I also think he dismisses the asset-price meltdown hypothesis too readily. This hypothesis suggests that when baby boomers retire, roughly at the same time as each other, and start cashing in their investments in order to spend, there will be a collapse of asset prices. There are two related conditions for this hypothesis to hold: a strong concentration of retirees must exist and they must hold assets that are unattractive to others. Axel argues persuasively that international capital mobility and differing demographics internationally makes these conditions unlikely to hold. If all Italians were to retire at the same time and cash in their Fiat shares, and the share price were to begin falling, this would merely bring out young investors, from China and India say, looking for a bargain.

But suppose that a major part of the pension portfolio of soon-to-be retirees was made up of owner-occupied property, and that they all planned to downsize when they retire. It is not clear that Chinese and Indian investors would want a portfolio of Italian property in an environment where Italians were trying to be net sellers and the Italian population was falling relative to the stock of property. Of course, we have not seen any substantial downsizing as yet. But the essential point is that the asset-price meltdown story is a genuine problem, even in a world of international capital mobility, *if* the value of the assets of the soon-to-be-retired depend on local investment and consumption. Let me put this another way. International capital mobility does not improve the value of an investment in a hairdresser specialising in purple Mohicans in a country that is ageing and balding fast.

International discussions of pension systems are illuminating, but one of their problems is that most of us think our experiences are general. Most German residents, for example, would consider the asset-price meltdown story an odd one because property represents only a modest proportion of individual savings in Germany. But it represents an important and rising proportion of gross savings in many countries including Italy, the United Kingdom, the United States and Australia. Part of the explanation for the low personal saving rates in the US and UK is the widely-held belief that largely owner-occupied property assets can be transformed into high cash flows at retirement. But if property prices can rise as a result of an increase demand for property as a pension asset, making investors feel so wealthy that they decide to save less, why can they not fall when this demand reverses, leaving savers with a lower-than-expected pool of savings.

Often in finance, common buying behaviour, caused by some investment fashion, creates wealth that many hopes and futures are built upon. But this wealth proves to be ephemeral when its owners all try to realise its value at the same time. This type of illusory value and safety in financial markets is an area of my own research. To avoid pension or other assets disappearing down a liquidity black hole, investors should hold assets where there is a strong heterogeneity in the sources of demand as a result of there being investors with different investment horizons, strategies and risk management. International capital mobility can improve that diversity. But it is likely that property is the kind of asset that has too much homogeneity in the sources of demand in a country with a large cohort of soon-to-be-retired.

The interesting implication is that pension funds in countries should be encouraged to hold assets with more internationally heterogeneous demand. Assets where demand is overly dominated by local savings and investment trends include property and, to a lesser extent, domestic government bonds (partly due to regulatory reporting requirements). Yet, in some countries there are proposals to actually encourage property and government bonds being held as pension assets. For whatever reason these assets have increased their share of total pension assets.

Labour supply

For my third point let me say that Axel, Larry and others make the interesting observation that the impact of demographic changes depends in part on the elasticity of labour supply. In Europe that is seen as the substitution between leisure and work. In the United States and other places it would be seen as a question of immigration.

Clearly there are serious political issues at work here and the appetite for immigration in our currently troubled world is weak. The recent treatment of asylum seekers is a sad reflection of current populist concerns. It may be that in this case the European Union provides a model, where international migration is modest, but regional migration in accordance with regional rules is substantial. There are tough restrictions on labour mobility from outside the EU to inside, but substantial mobility within the EU. Perhaps the social problems of increased migration are partly addressed by the lengthy consensual process of joining the EU.

It is said that there are now one million more Poles living in the UK than there were just five years ago. Most people in the UK view this as a positive development. Perhaps the case for EU enlargement should partly be made in terms of how increased regional mobility moderates the demographic challenges facing Europe.

Let us not forget that the enlightened civilisations of our past were partly built on an easy flow between peoples born in different places and that concepts of sovereignty and citizenship are fairly recent, especially in the time frame of demographic change. The so-called demographic time bomb is partly a product of a relatively recent form of autarky.

Will China Eat Our Lunch or Take Us to Dinner? Simulating the Transition Paths of the US, EU, Japan and China

Hans Fehr, Sabine Jokisch and Laurence J Kotlikoff[1]

Abstract

This paper develops a dynamic, life-cycle, general equilibrium model to study the interdependent demographic, fiscal and economic transition paths of China, Japan, the United States and the European Union. Each of these countries/regions is entering a period of rapid and significant population ageing that will require major fiscal adjustments. But the ageing of these societies may be a cloud with a silver lining coming, in this case, in the form of capital deepening that will raise real wages.

In a previous model that excluded China we predicted that tax hikes needed to pay benefits during the developed world's demographic transition would lead to a major capital shortage, reducing real wages per unit of human capital over time by one-fifth. A recalibration of our original model that treats government purchases of capital goods as investment rather than current consumption suggests this concern was overstated. With government investment included, we find much less crowding-out over the course of the century and only a 4 per cent long-run decline in real wages.

Adding China to the model further alters, indeed, dramatically alters, the model's predictions. Even though China is ageing rapidly, its saving behaviour, growth rate and fiscal policies are currently very different from those of developed countries. If successive cohorts of Chinese continue to save like current cohorts, if the Chinese government can restrain growth in expenditures and if Chinese technology and education levels ultimately catch up with those of the West and Japan, the model's long run looks much brighter. China eventually becomes the world's saver and, thereby, the developed world's saviour with respect to its long-run supply of capital and long-run general equilibrium prospects. And, rather than seeing the real wage per unit of human capital fall, the West and Japan see it rise by one-fifth by 2030 and by three-fifths by 2100. These wage increases are over and above those associated with technical progress, which we model as increasing the human capital endowments of successive cohorts.

Even if the Chinese saving behaviour (captured by its time preference rate) gradually approaches that of Americans, developed-world real wages per unit of

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human capital are roughly 17 per cent higher in 2030 and 4 per cent higher at the end of the century. Without China they'd be only 2 per cent higher in 2030 and, as mentioned, 4 per cent lower at century's end.

What's more, the major short-run outflow of the developed world's capital to China predicted by our model does not come at the cost of lower wages in the developed world. The reason is that the knowledge that their future wages will be higher (thanks to China's future capital accumulation) leads our model's workers to cut back on their current labour supply. So the short-run outflow of capital to China is met with a commensurate short-run reduction in developed-world labour supply, leaving the short-run ratio of physical capital to human capital, on which wages positively depend, actually somewhat higher than would otherwise be the case.

Our model does not capture the endogenous determination of skill premiums studied by Heckman, Lochner and Taber (1998). Doing so could well show that trade with China, at least in the short run, explains much of the relative decline in the wages of low-skilled workers in the developed world. Hence, we don't mean to suggest here that all US, EU, and Japanese workers are being helped by trade with China, but rather that trade with China is, on average, raising the wages of developed-world workers and will continue to do so.

The notion that China, India and other developing countries will alleviate the developed world's demographic problems has been stressed by Siegel (2005). Our paper, although it includes only one developing country – China – supports Siegel's optimistic long-term macroeconomic view. On the other hand, our findings about the developed world's fiscal condition are quite troubling. Even under the most favourable macroeconomic scenario, tax rates will rise dramatically over time in the developed world to pay baby boomers their government-promised pension and health benefits. As Argentina has so recently shown, countries can grow quite well for years even with unsustainable fiscal policies. But if they wait too long to address those policies, the financial markets will do it for them, often with quite ruinous consequences.

1. Introduction

This paper develops a dynamic, life-cycle, general equilibrium model to study the interdependent demographic, fiscal, and economic transition paths of China, Japan, the US, and the EU. Each of these countries/regions is entering a period of rapid and significant ageing of the population that will require major fiscal adjustments. Understanding how national ageing and the fiscal reaction to national ageing will affect the macroeconomies of these regions is important. If the macroeconomic response is favourable, governments can do less and take more time to deal with what's coming. If the opposite is true, governments must do more and do it more quickly.

Our past research (Fehr, Jokisch and Kotlikoff 2004a, 2004b, 2005) suggested an unfavourable macroeconomic response to national ageing arising from a growing shortage of physical capital relative to human capital. This long-term capital shortage sufficed to reduce the model's real wage per unit of human capital by 20 per cent over the course of the century. The model's predicted major decline in physical capital per unit of human capital is due to the model's predicted major rise in payroll and income tax rates. These tax hikes, in turn, reflect the need to pay pension and health care benefits to increasingly older populations. As originally stressed by Feldstein (1974), raising taxes on workers to make transfers to the elderly reduces the amount of capital workers individually and collectively can and will accumulate.

But our earlier studies, with their dismal forecasts that the interaction of ageing and huge fiscal commitments to the elderly will undermine the macroeconomies of the developed world, omitted two issues. Both of these issues are taken up here, and both militate against a severe capital shortage.

The first is government investment. In our prior studies we treated all government purchases as current consumption. There is some logic for doing so, since many so-called government investment goods (for example, tanks, office buildings to house bureaucrats, space vehicles) may make little or no contribution to a nation's output and productivity and, indeed, may do the opposite. On the other hand, a major share of government investment, be it in constructing roads, erecting schools or building research labs, does seem to be productive.

Treating what governments call investment as investment in the model doesn't entirely eliminate the predicted long-term capital shortage, but it does significantly mitigate it. Compared with its 2004 value, the model's real wage per unit of human capital in 2100 is reduced by only 4 per cent rather than by 20 per cent.

The second omission is China. As everyone knows, China is already a major producer of world output. Its GDP now equals roughly one-ninth of US output. China is also absorbing Western and Japanese technology at a rapid pace. This acquisition of technology, in combination with improved education, holds the prospect for ongoing real income growth in China. But, given China's exceptionally high saving rate, more income growth in China means more Chinese saving, which can be invested in the developed world as well as in China.

The potential for China and other developing countries to 'bail out' the developed world, at least in terms of its capital needs, has recently been advanced by Jeremy Siegel (2005). But China has a long way to go if it is to play such a role. China's per capita income and wealth levels are currently only a small fraction – probably less than 15 per cent of the developed world's levels. Of course, China has lots of capitas – its population is 2.6 times the combined populations of the US, Japan and the EU. Still, China's current total holdings of wealth appear to be less than one-quarter and could easily be less than one-tenth of total wealth holdings across the four regions.

Moreover, Chinese saving behaviour may change. It's certainly far from what one would expect to see. One would think that having low current income, but the prospect of much higher future income, would lead the Chinese to spend most of what they now produce. But, if official statistics are to be believed, nothing could be further from the truth. According to OECD (2002) data, the Chinese private sector appears to be saving 40 per cent of available private output, defined as net national income minus government purchases of goods and services. This extraordinarily high Chinese private-sector saving rate explains why the Chinese are currently exporting more capital to the rest of the world than they are importing. Based on European Commission (2005) data, the comparable private-sector saving rates in the US, Japan and the EU are only 4 per cent, 11.5 per cent and 11.1 per cent, respectively.

China is also remarkable when it comes to ageing. Like the developed world, China is getting older. But it's projected over the next half century to age much more rapidly than the US, Japan or the EU. This doesn't mean that China will end up older than these regions. It just means it will make the transformation from a relatively young to a very old society much more rapidly than its trading partners in the developed world.

As Table 1 details, only 6.8 per cent of today's Chinese are 65 and older compared with 17.2 per cent in Japan, 16.3 per cent in the EU and 12.3 per cent in the US. In 2050, 23.6 per cent of the Chinese population will be 65 plus. This is larger than the 20.0 per cent elderly share projected for the US, but smaller than the 28.3 and 36.5 per cent shares projected for the EU and Japan, respectively. So the rapidity of China's ageing doesn't reflect where it will end up, but where it is starting.

The fact that China, like Japan and the West, is ageing and faces significant fiscal obligations associated with that process suggests that China's inclusion in our model would make little difference to the model's unpleasant prediction of a looming capital shortage. But because of China's much higher rates of growth and saving and because its population is so large, adding China can, as documented below, transform a capital shortage into a capital glut. Whether or not this occurs depends on how China's fiscal policy and saving behaviour evolve. If, over the course of the next 50 years, China adopts fiscal arrangements and saving propensities that are similar to those of developing nations, China will make only a modest contribution to the world's supply of capital, leaving real wages per unit of human capital at the end of this century only about 4 per cent higher than they are today. If, on the other hand, China limits growth in public expenditures and the Chinese people continue to eschew consumption, China will save enough for its own capital needs as well as those of the developed world, leaving real wages per unit of human capital at the end of this century roughly 60 per cent above the current level.

The usefulness of these findings depends, of course, on the realism of our model. Our life-cycle model's features are extensive. The model includes: age-, region- and year-specific fertility and mortality rates; lifespan uncertainty; age-, region- and year-specific pension, disability, health care and other government transfer policies; region- and year-specific government purchases of goods and services; region-specific levels of debt; high, middle and low earners within each cohort in each region; region-specific personal wage income, capital income, corporate income and payroll taxes; international capital mobility; technological change; quadratic costs of adjusting each region's capital stock; age-specific inheritances; age-specific and unintended bequests; intertemporally separable Constant Elasticity of Substitution (CES) utility functions in consumption and leisure; region-specific Cobb-Douglas production functions; the presence of children's utility in parents' utility functions when the children are young; exogenously specified age-, earnings class-, region- and year-specific immigration; and region- and cohort-specific time preference rates.

Table 1: Comparing Actual and Simulated Population Projections

(continued next page)

Year		2000	2010	2020	2030	2040	2050	2100
Population projection US								
Fertility rate (number of children per female)								
Model		2.11	2.05	2.00	1.95	1.90	1.85	1.77
Official[(a)]		2.11	2.08	2.03	1.95	1.89	1.85	–
Life expectancy at birth (years)								
Model		81.7	82.1	82.5	83.0	83.4	83.8	83.8
Official[(a)]		77.1	78.3	79.1	79.9	81.0	81.6	–
Total population (millions)								
Model		276.2	307.3	340.0	366.4	385.8	400.3	442.0
Official[(a)]		285.0	314.9	344.3	370.4	391.4	408.7	–
Age structure (per cent of total population)								
<15	Model	21.6	20.1	19.7	18.5	18.2	17.8	15.9
	Official[(a)]	21.8	20.5	20.0	19.3	18.5	17.9	–
15–64	Model	66.2	67.2	64.0	61.4	61.7	62.1	60.7
	Official[(a)]	65.9	66.6	64.1	61.5	61.7	62.1	–
65–90	Model	12.2	12.7	16.3	20.1	20.2	20.1	23.3
	Official[(a)]	12.3	12.8	15.9	19.2	19.8	20.0	–
Population projection EU								
Fertility rate (number of children per female)								
Model		1.46	1.53	1.60	1.67	1.74	1.82	1.82
Official[(b)]		1.58	1.61	1.68	1.77	1.84	1.85	–
Life expectancy at birth (years)								
Model		82.2	82.7	83.2	83.6	84.1	84.6	84.6
Official[(b)]		78.6	80.0	81.1	82.0	83.0	83.6	–
Total population (millions)								
Model		376.4	385.8	390.9	391.1	384.1	372.1	340.6
Official[(a)]		377.3	383.2	384.4	382.8	377.8	369.8	–
Age structure (per cent of of total population)								
<15	Model	16.9	15.3	14.5	14.3	14.3	14.8	16.5
	Official[(a)]	16.7	15.3	14.4	14.4	14.7	15.0	–
15–64	Model	66.9	66.9	64.7	60.8	57.7	57.2	59.7
	Official[(a)]	66.9	66.5	64.7	60.8	57.5	56.7	–
65–90	Model	16.2	17.8	20.8	24.9	28.0	28.0	23.9
	Official[(a)]	16.3	18.2	21.0	24.7	27.8	28.3	–

Table 1: Comparing Actual and Simulated Population Projections
(continued)

Year		2000	2010	2020	2030	2040	2050	2100
Population projection Japan								
Fertility rate (number of children per female)								
Model		1.28	1.37	1.47	1.56	1.66	1.75	1.91
Official[(a)]		1.32	1.37	1.49	1.68	1.81	1.85	–
Life expectancy at birth (years)								
Model		83.8	84.6	85.4	86.2	87.0	87.8	87.8
Official[(a)]		81.6	83.5	85.1	86.6	87.7	88.1	–
Total population (millions)								
Model		126.7	128.9	127.1	121.8	114.2	108.8	84.8
Official[(a)]		127.0	128.0	125.6	121.0	115.7	109.7	–
Age structure (per cent of total population)								
<15	Model	14.6	13.4	12.5	11.9	12.5	12.9	16.0
	Official[(a)]	14.6	13.6	12.4	11.8	12.6	13.0	–
15–64	Model	68.2	64.1	59.2	58.1	55.0	52.1	56.3
	Official[(a)]	68.2	64.0	59.5	57.8	53.0	50.4	–
65–90	Model	17.2	22.5	28.2	30.0	32.5	35.0	27.7
	Official[(a)]	17.2	22.4	28.1	30.4	34.4	36.5	–
Population projection China								
Fertility rate (number of children per female)								
Model		1.62	1.67	1.71	1.76	1.80	1.85	2.01
Official[(c)]		1.32	1.37	1.49	1.68	1.81	1.85	–
Life expectancy at birth (years)								
Model		75.8	76.7	77.5	78.4	79.3	80.2	80.2
Official[(c)]		71.5	72.6	73.8	75.3	77.1	78.7	–
Total population (millions)								
Model		1 273.1	1 360.7	1 455.0	1 490.7	1 481.3	1 430.8	1 181.8
Official[(c)]		1 274.0	1 354.5	1 423.9	1 446.5	1 433.4	1 392.3	–
Age structure (per cent of total population)								
<15	Model	24.6	19.5	18.3	16.5	15.6	16.3	18.5
	Official[(c)]	24.8	19.5	18.4	16.9	15.6	15.7	–
15–64	Model	68.6	73.3	70.6	67.8	63.1	61.6	61.7
	Official[(c)]	68.4	72.2	69.7	66.8	62.1	60.7	–
65–90	Model	6.8	7.2	11.1	15.7	21.3	22.0	19.8
	Official[(c)]	6.8	8.3	11.9	16.3	22.3	23.6	–

(a) UN Population Division (2003), medium variant projections
(b) UN Population Division (2003), medium variant projections, Western Europe
(c) UN Population Division (2005), medium variant projections

As with our other three regions, to accommodate Chinese saving behaviour, we've set the Chinese time preference rate to match the current observed saving rate for China. And we've calibrated the multifactor productivity coefficient in the Chinese production function to match the current observed Chinese relative wage. The big questions with respect to China's calibration, however, are not how to treat current saving preferences and technology, but rather how to model future saving preferences and technology.

Consider first the issue of technology. It seems reasonable to believe that the level of Chinese technology will converge to that of the West. The unknown is the rate of convergence. In this study our base case assumes that the Chinese multifactor productivity coefficient rises gradually, reaching the US, Japanese and EU levels by mid century. But we also consider slower and faster rates of technological convergence.

Now consider modelling future Chinese saving behaviour. Here we examine two alternative assumptions. The first is that the Chinese time preference rate remains fixed through time at the very low rate needed to match the current Chinese saving rate. The second is that successive cohorts of Chinese gradually adopt Western saving behaviour such that the Chinese born in 2050 and thereafter have the same time preference rate as Americans in 2004.

2. Our Model and its Predecessors

The development of dynamic life-cycle simulation models was stimulated by Feldstein's (1974) article contending that government pension systems lower national saving. Early dynamic analysis of government pension programs and other policies include Kotlikoff (1979), Summers (1981), Auerbach and Kotlikoff (1983, 1987) and Seidman (1986). More recent papers have considered the importance of land, earnings uncertainty, political economy considerations, liquidity constraints, different options for funding social security and human capital decisions. These studies include Hubbard and Judd (1987), Raffelhüschen (1989, 1993), Imrohoroglu, Imrohoroglu and Joines (1995, 1999), Kotlikoff (1996), Huang, Imrohoroglu and Sargent (1997), Heckman *et al* (1998), Kotlikoff, Smetters and Walliser (1998a, 1998b, 1999, 2002), Cooley and Soares (1999a, 1999b), De Nardi, Imrohoroglu and Sargent (1999), Huggett and Ventura (1999), Bohn (2001), Nishiyama and Smetters (2003), Smetters and Walliser (2004) and Fehr and Habermann (2005).

This model, like our previous ones, builds on Auerbach-Kotlikoff's (1987) overlapping generation (OLG) model. Auerbach and Kotlikoff also simulated demographic transitions, but their model assumed that all agents gave birth at a fixed age, died and bequeathed at a fixed age and received inheritances at a fixed age. Kotlikoff, Smetters and Walliser (2001) advanced the Auerbach-Kotlikoff model by incorporating age-specific fertility and inheritance, lifespan extension, intragenerational earnings heterogeneity, and additional fiscal institutions. Fehr *et al* (2004a, 2004b, 2005) included lifespan uncertainty as well as bequests arising from incomplete annuitisation. They also introduced multiple regions with international capital mobility and immigration.

As in Kotlikoff *et al* (2001), our model features monozygotic reproduction with agents in their child-bearing years giving birth each year to fractions of children. This means of finessing marriage and family formation permits us to incorporate changes through time in age-specific fertility rates and to closely line up our model's age-specific population shares to those forecast for the four regions.

We assume that agents care about their children's utility when they are young and, as a consequence, make consumption expenditures on behalf of their children (pay for their consumption), but only when the children are young. We also assume that agents die with realistic mortality probabilities starting at age 68. Agents fully appreciate the uncertainty of their longevities and maximise, at any point in time, their expected remaining lifetime utilities. The inclusion of lifespan uncertainty permits a realistic modelling of bequests and inheritances.

We generate bequests by assuming that agents fail to annuitise their assets in old age. Hence, when they die, they leave undesired bequests to their children. Since agents die at different ages and have children of different ages, their heirs also inherit at different ages. Agents who were born when their parents were young receive inheritances later in their life than do their younger siblings. Finally, uninsurable lifespan uncertainty leads agents to gradually reduce their consumption in old age.

Our model also includes capital adjustment costs. As is well known, these costs can drive temporary wedges between the marginal products of capital in different regions and lead the market values of capital assets to temporarily differ from their replacement costs. Thus inclusion of adjustment costs in the model generates what amounts to regional stock markets and permits us to explore how population ageing affects world stock prices through time.

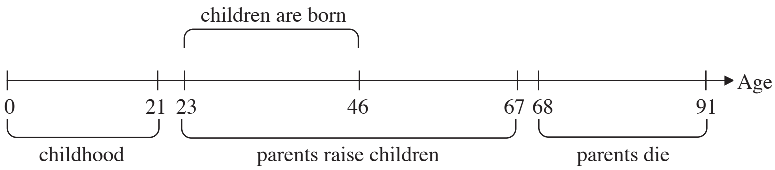
A final, but very important, feature of our framework is its intra-cohort disaggregation. As in Kotlikoff *et al* (2001), we consider three income classes within each generation, each with its own earnings ability. Immigrants are also split into these income classes permitting us to simulate the arrival of immigrants with different stocks of human and physical capital.

The following sub-sections present the general structure of our model. A more detailed description of the three-country model is provided in Fehr *et al* (2003).

2.1 Demographics

Each region is populated by households who live at most to age 90. Consequently, there are 91 generations with surviving members at any point in time. The individual life cycle of a representative agent is described in Figure 1. Between ages 0 and 20 our agents are children who earn no money and are supported by their parents. At age 21 our agents leave their parents and go to work. Between ages 23 and 45 our agents give birth to fractions of children at the beginning of each year, that is, the first (fraction of) children are born when the agents are 23 and the last are born when they are age 45. An agent's first-born children (fractions of children) leave home when the agents are age 43, while the last-born leave when the agents are age 66. Our

Figure 1: The Individual Life-cycle



agents die between ages 68 and 90. The probability of death is 1 at age 91. Children always outlive their parents, meaning that parents always outlive grandparents. To see this, note that if a parent reaches age 90, his or her oldest children will be 67. These are children who were born when the parent was age 23.

In each year, new immigrants in each skill and age group arrive with the same number and age distribution of children and the same level of assets as natives of the identical skill and age. Since the demographic structure has the same general form in all four regions, it suffices to discuss a representative region and omit region indices.

To specify the current and future demographic structure of each region we start with year-2000[2] age-specific population $\left[\bar{N}\left(a,2000\right)\right]$ and age-specific net immigration $\left[\overline{NM}\left(a,2000\right)\right]$ counts.

In constructing existing as well as future age-population counts, we have to link each initial cohort between the ages of 1 and 68 to those of their parents who are still alive. The reason is that children receive bequests from their parents, and the levels and timing of these inheritances depend on the ages of their parents. This link is achieved by applying past fertility rates to each cohort under age 69 in year 2000. If, for example, 15 per cent of the parents of newborns in 1980 were 25 years old, then 15 per cent of the 20-year-olds in year 2000 are assigned to parents aged 45.

In addition, each cohort is split into three income classes k. Specifically, we assume that 35 per cent of each cohort belong to the lowest income class, 10 per cent to the top income class and the remaining 55 per cent to the middle income class. We denote the population vector for year t as $N(a,t,s,k)$ where $a = 1,\ldots,90$, $s = 23,\ldots,45$, $k = 1,2,3$. The term s references the age of the parent at the time of birth of agents aged a in year t.

To determine the evolution of the population in each region over time, we applied region-, age- and year-specific mortality and fertility rates to the cohorts alive in year 2000 as well as to their children as they reach their ages of fertility and mortality. In the baseline path the exogenous current and future mortality and fertility rates follow the medium variant of the United Nations population projection (UN Population Division 2003 for the US, EU and Japan; UN Population Division 2005 for China).

2. Although the economic model starts in the year 2004, we chose the year 2000 as the initial year for the population projections due to data availability.

According to this projection, mortality rates will decline in all four regions over time. Consider the Japanese, whose 2000 life expectancy equalled 81.6 years. According to official projections, Japan's life expectancy in 2050 will reach 88.1 years. The Japanese, who now have a life expectancy 4.5 years higher than Americans and 3.0 years higher than EU citizens, will continue to maintain their longevity lead through time. Indeed, projected 2050 US life expectancy doesn't even exceed current Japanese life expectancy! In China, life expectancy is now a full 10 years lower than life expectancy in Japan. And this 10-year gap is projected to continue for the next half century.

Table 1 shows our agents' life expectancies at birth in the baseline path, which is kept constant after the year 2050. The respective numbers are higher than the actual values, since our model's agents don't die prior to age 68. However, the model's life expectancies conditional on reaching age 60 are close to those reported by the UN Population Division (2005).

Total fertility rates currently equal 2.1, 1.3, 1.6 and 1.5 in the US, Japan, China and the EU, respectively. Nevertheless, the UN expects fertility rates in all four regions to converge to 1.85 children by 2050. This path of fertility rates is also shown in Table 1. In the baseline path, we assume annual net immigration of 1 million per year in the US, 450 000 in the EU and 54 000 in Japan. Net immigration into China is negative; the number of net emigrants is fixed at its current value of 390 000 people per year. Given the population age structure in year 2000 as well as projected future fertility, mortality and net immigration rates, we compute the population vector $N(a,t,s,k)$ for the years t between 2001 and 2050. After the year 2050, fertility rates are endogenously adjusted in order to achieve zero population growth and a stable population age structure. Since net immigration is positive in the US, the EU and Japan, the fertility rates which stabilise the population post-2050 are below 2.0. Equivalently, the fertility rates in China are set above 2.0 after 2050 due to net emigration.

Table 1 also shows projected changes over time in total populations and population age structures. Due to high fertility and net immigration rates, the US population is projected to increase from 276 million in 2000 to 442 million in 2100. In Europe, the population falls over the century from 376 million to 341 million, and in Japan, the population falls from 127 million to 85 million. The Chinese population decreases by even more – from 1.3 billion to 1.2 billion.

As one would expect, the population share of those 65 and older increases in all four regions. There are, however, big differences in the ageing process across the four regions. First, in the US and China the absolute decrease in the shares of the young population through 2050 are almost the same as for the working-age population. In contrast, the EU and Japan experience much larger absolute declines in the share of the population that is of working age. Second, the share of the elderly increases to a much larger extent in Japan and China compared to the US and the EU.

Table 1 indicates that our model's demographic machinery does a remarkably good job of matching official projections for the four regions both with respect to the absolute number and age compositions of their respective populations. We now describe this machinery in more detail.

The total number of children of an agent aged a in income class k in year t is recorded by the following function

$$KID(a,t,k)=\sum_{j=u}^{m}\frac{N(j,t,a-j,k)}{\Sigma_{s=23}^{45}N(a,t,s,k)} \qquad 23\le a\le 65, \quad k=1,2,3 \tag{1}$$

where $u = max(0; a–45)$ and $m = min(20; a–23)$. Recall that agents younger than 23 have no children and those over 65 have only adult children, that is $KID(a,t,k) = 0$ for $0 \le a \le 22$ and $66 \le a \le 90$. Agents between these ages have children. Take, for example, a 30 year-old agent. Such an agent has children who were born in the years (a–j) since she/he was 23. In year t, these children are between age $0 \le j \le 7$. The *KID*-function (1) sums the total number of children of the respective parent-income class generation and divides it by the total number of parents of age a in year t who belong to income class k. This function takes into account that the family's age structure will change over time due to changing fertility. This approach permits the distribution of births by the ages of parents to change over time – an important improvement relative to the birthing process stipulated in Kotlikoff *et al* (2001).

2.2 The household sector

As previously mentioned, we do not distinguish between natives and immigrants once the immigrants have joined the native earnings- and age-specific cohorts. The model's preference structure is represented by a time-separable, nested, CES utility function. Remaining lifetime utility $U(j,t,s,k)$ of a generation of age j at time t whose parents were age s at time of birth and who belong to income class k takes the form

$$U(j,t,s,k)=V(j,t,s,k)+H(j,t,s,k) \tag{2}$$

where $V(j,t,s,k)$ records the agent's utility from her/his own goods and leisure consumption and $H(j,t,s,k)$ denotes the agent's utility from the consumption of her/his children. The two sub-utility functions are defined as follows:

$$V(j,t,s,k)=\frac{1}{1-\frac{1}{\gamma}}\sum_{a=j}^{90}\left(\frac{1}{1+\theta}\right)^{a-j}P(a,i)\left[c(a,i,s,k)^{1-\frac{1}{\rho}}+\alpha\ell(a,i,s,k)^{1-\frac{1}{\rho}}\right]^{\frac{1-\frac{1}{\gamma}}{1-\frac{1}{\rho}}} \tag{3}$$

$$H(j,t,s,k)=\frac{1}{1-\frac{1}{\gamma}}\sum_{a=j}^{90}\left(\frac{1}{1+\theta}\right)^{a-j}P(a,i)KID(a,i,k)c_{\mathrm{K}}(a,i,s,k)^{1-\frac{1}{\gamma}} \tag{4}$$

where $c(a,i,s,k)$ and $\ell(a,i,s,k)$ denote consumption and leisure, respectively, and i is defined as $i = t + a - j$. The children's consumption of income class k parents who are age a in period i and whose parents were age s at the time of their birth is defined as $c_K(a,i,s,k)$. Note that the number of children is independent of the grandparent's age at the time of the birth of the parents.

Since lifespan is uncertain, the utility of consumption in future periods is weighted by the survival probability of reaching age a in year i

$$P(a,i) = \prod_{u=j}^{a} \left[1 - d(u, u - a + i)\right] \tag{5}$$

which is determined by multiplying the conditional survival probabilities from year t (when the agent's age is j) up to year i. Note that $d(j,t)$ is the mortality probability of an agent age j in year t. The parameters θ, ρ, α and γ represent the 'pure' rate of time preference, the intratemporal elasticity of substitution between consumption and leisure at each age a, the leisure preference parameter and the intertemporal elasticity of substitution between consumption and leisure in different years, respectively.

In maximising utility, agents choose their demand for leisure subject to the constraint that leisure in each period not exceed $h(a,i)$, which is the time endowment. The determination of the shadow values of these leisure constraints, when these constraints are binding, is included as part of the maximisation. To ensure that agents retire by a designated maximum retirement age, we set the net wage at that age and thereafter to zero.

Given the asset endowment $a(j,t,s,k)$ of the agent in year t, maximisation of (2) is subject to a lifetime budget constraint defined by the sequence:

$$\begin{aligned} \mathrm{a}(j+1, t+1, s, k) = {} & \left[\mathrm{a}(j,t,s,k) + I(j,t,s,k)\right]\left(1 + r(t)\right) + \\ & w(t) E(a,k)\left[h(a,t) - \ell(a,t,s,k)\right] - \\ & T(j,t,s,k) - c(j,t,s,k) - KID(j,t,k) c_{\mathrm{K}}(j,t,s,k) \end{aligned} \tag{6}$$

where $r(t)$ is the pre-tax return on savings and $I(j,t,s,k)$ denotes the inheritance the agent receives in year t. When the parents die between age 68 and 90, their remaining assets are split between their children. Consequently, inheritances of agents who are age j in year t and whose parents were age s at their birth are defined by:

$$I(j,t,s,k) = \frac{d(j+s)\bar{A}(j+s,t,k)}{\sum_{u=23}^{45} N(j+s-u,t,u,k)} \tag{7}$$

The numerator defines the aggregate assets of income class k parents who die in year t at age $j + s$. The denominator defines these parents' total number of children who are between ages $j+s$–45 and $j+s$–23 in year t. The receipt of inheritances requires us to distinguish members of each cohort according to the ages of their parents at birth. The parents' ages at death determine when the children receive their inheritances. While the oldest children (born when their parents are age 23) receive their inheritances between ages 45 and 67, the youngest children (born when their parents are age 45) receive their inheritances earlier in life, between ages 23 and 45.

As in Altig *et al* (2001) and Kotlikoff *et al* (2001), we assume that technical progress causes the time endowment $h(\cdot)$ of each successive generation to grow at the rate λ, that is

$$h(a,i) = (1+\lambda)h(a,i-1) \tag{8}$$

The proposition here is not that time, *per se*, expands for successive generations, but rather that each successive generation is more effective in using time to either perform work or enjoy leisure. Treating technical change in this manner is essential to ensure that the economy achieves a long-run steady state. The assumption of labour-augmenting technical change would not, for example, be compatible with a long-run steady state given the nature of the model's preferences. And having the economy achieve a long-run steady state provides, in effect, the terminal conditions needed by our algorithm to solve for the model's equilibrium transition path.

Gross labour income of the agent in year t is derived as the product of her/his labour supply and her/his wage rate. The latter is the product of the gross wage rate $w(t)$ in period t and the age- and class-specific earnings ability.

$$\begin{gathered} E(a,k) = \xi(k) e^{4.47+0.033(a-20)-0.00067(a-20)^2} (1+\lambda)^{a-21} \quad \text{with} \\ \xi(1) = 0.2, \xi(2) = 1.0, \xi(3) = 5.0 \end{gathered} \tag{9}$$

The middle-income class profile is taken from Auerbach and Kotlikoff (1987). The shift parameters $\xi(k)$ are then applied to derive income-class-specific profiles. Moreover, since technological change is an important determinant of secular growth over the life-cycle, we multiply the profile of the age-specific longitudinal earnings ability by the term involving λ. Hence, the longitudinal age-wage profile is steeper the greater is the rate of technological change.

The net taxes $T(j,t,s,k)$ of an agent in year t consist of consumption, capital income and progressive wage taxes as well as social security contributions net of pension and disability benefits received. Pension, disability insurance and health care average and marginal payroll tax rates differ across agents, due to our assumed ceiling on payroll tax contributions. Each agent's pension benefits depend on her/his pre-retirement earnings history, while health care and disability transfers are provided on a per capita basis to all eligible age groups.

Given individual consumption, leisure, and asset levels of all agents, we can compute aggregate variables. For example, the aggregate value of assets $\mathcal{A}(t+1)$ at time $t+1$ is computed from

$$A(t+1) = \sum_{k=1}^{3} \sum_{a=21}^{90} \underbrace{\sum_{s=23}^{45} \mathrm{a}(a+1,t+1,s,k) N(a,t,s,k)}_{\bar{A}(a+1,t+1,k)} \tag{10}$$

Since households die at the beginning of each period, we have to aggregate across all agents who lived in the previous period in order to compute $\bar{A}(a+1,t+1,k)$, which we need for the calculation of bequests, see (7). If we aggregate across agents who live in period *t*+1, then we have,

$$\mathcal{A}(t+1)=\sum_{k=1}^{3}\sum_{a=21}^{90}\sum_{s=23}^{45}\mathrm{a}(a,t+1,s,k)N(a,t+1,s,k) \tag{11}$$

which includes the assets of the arriving immigrants of period *t*+1. The difference in the asset aggregates in Equations (10) and (11) arises from the difference in the population counts. Equation (11) uses time *t*+1 counts, which include immigrants who arrive at the beginning of time *t*+1, whereas Equation (10) uses time *t* counts, which include all those who can potentially die and leave bequests at the end of period *t*.

Finally, the aggregate labour supply, measured in efficiency units, of agents in year *t*, *L*(*t*), is computed from the individual labour supplies, that is

$$L(t)=\sum_{k=1}^{3}\sum_{a=21}^{90}\sum_{s=23}^{45}\left[h(a,t)-\ell(a,t,s,k)\right]N(a,t,s,k) \tag{12}$$

2.3 The production sector

The economy is populated by a large number of identical firms, the total number of which is normalised to unity. Aggregate output (net of depreciation) is produced using Cobb-Douglas production technology, that is

$$F\left(K(t),L(t)\right)=\phi K(t)^{\varepsilon}L(t)^{1-\varepsilon} \tag{13}$$

where *K*(*t*) is aggregate capital in period *t*, ε is capital's share in production, and ϕ is a technology parameter. Since we posit convex capital adjustment costs, the firms' marketable output in year *t*, *Y*(*t*), is given by the difference between gross output and adjustment costs, that is

$$Y(t)=F\left(K(t),L(t)\right)-0.5\psi\Delta K(t)^{2}/K(t) \tag{14}$$

where $\Delta K(t)$ measures investment in year *t*. The term ψ is the adjustment cost coefficient. Larger values of ψ imply higher marginal costs of new capital goods for a given rate of investment. The installation technology is linear homogeneous and shows increasing marginal cost of investment (or, symmetrically, disinvestment): faster adjustment requires a greater than proportional rise in adjustment costs.

Corporate taxes, $T^k(t)$, are given by

$$T^{k}(t)=\tau^{k}(t)\left[Y(t)-w(t)L(t)-\in(t)\Delta K(t)\right] \tag{15}$$

where $\tau^k(t)$ and $\in(t)$ define the corporate tax rate and the immediate share of investment expenditures that can be written off, respectively. Adjustment costs are fully deductible from the tax base, while investment expenditures are partly deductible. Hence, arbitrage between new and existing capital implies that the latter has a price per unit of

$$q(t+1)=1-\in(t)\tau^{k}(t)+\left[1-\tau^{k}(t)\right]\psi\Delta K(t)/K(t) \tag{16}$$

Similarly, the arbitrage condition arising from profit maximisation requires identical returns to financial and real investments:

$$r(t)q(t) = \left[1-\tau^k(t)\right]\left\{F_{K(t)} + 0.5\psi\left(\Delta K(t)\right)^2 \Big/ K(t)\right\} + q(t+1) - q(t) \qquad (17)$$

The left side gives the return on a financial investment of amount $q(t)$, while the return on one unit of real capital investment is the net return to capital (which includes the marginal product of capital $F_K(t)$ plus the reduction in marginal adjustment costs) and capital gains.

2.4 The government sector

The consolidated government issues new debt $\Delta B(t)$ and collects corporate taxes and net taxes from households in order to finance general government expenditures $G(t)$ as well as interest payments on its debt:

$$\Delta B(t) + T^k(t) + \sum_{k=1}^{3}\sum_{a=21}^{90}\sum_{s=23}^{45} T(a,t,s,k)\,N(a,t,s,k) = G(t) + r(t)B(t) \qquad (18)$$

With respect to public debt, we assume that the government maintains an exogenously fixed ratio of debt to output. The progressivity of the wage tax system is modeled as in Auerbach and Kotlikoff (1987). Specifically, marginal wage tax rates rise linearly with the tax base.

$PY(t)$ defines the aggregate payroll tax base, which differs from total labour earnings due to the ceiling on taxable wages. This ceiling is fixed at 250, 200, 168 and 300 per cent of average income in the US, the EU, Japan and China, respectively. Aggregate average social security payroll tax rates $\hat{\tau}^p$, $\hat{\tau}^h$ and $\hat{\tau}^d$ are computed each period from the relevant budget constraint for the program and region in question, that is

$$\hat{\tau}^p(t)PY(t) = PB(t),\ \hat{\tau}^h(t)PY(t) = HB(t) \quad \text{and} \quad \hat{\tau}^d(t)PY(t) = DB(t) \qquad (19)$$

where $PB(t)$, $HB(t)$ and $DB(t)$ are total outlays of the pension, health care, and disability systems, respectively. For China we assume that disability insurance is part of the state pension system. Hence, we do not calculate separate disability insurance payroll tax rates for this country.

Due to contribution ceilings, individual pension, disability and health insurance payroll tax rates can differ from the payroll tax rate (applicable on earnings below the ceiling). Above the contribution ceiling, marginal social security contributions are zero and average social security contributions fall with the agent's income. To accommodate this non-convexity of the budget constraint, we assume that the highest earnings class in each region pays pension and (in the EU, Japan and China) health insurance payroll taxes, up to the relevant ceilings, but faces no pension and no health care payroll taxes at the margin. The other earnings classes are assumed to face the full statutory tax rate on all earnings. The disability payroll taxes in the US, the EU and Japan are modelled in an equivalent manner. However, since there is no ceiling on US Medicare taxes, all earnings groups are assumed to face the health insurance payroll tax at the margin.

If a k-income-class agent, whose parents were s years old at her/his birth, retires in year z at the exogenously set retirement age $\bar{a}(z)$, her/his pension benefits $Pen(a,i,s,k)$ in years $i \geq z$ when she/he is age $a \geq \bar{a}(z)$ depend linearly on her/his average earnings, $\bar{W}(z,s,k)$, during his working time:

$$Pen(a,i,s,k) = \omega_0 + \omega_1 \times \bar{W}(z,s,k) \tag{20}$$

The region-specific parameters ω_0, ω_1 in the US, the EU and Japan were chosen in order to approximate replacement rates relative to individual lifetime earnings as reported in Whitehouse (2002). In China, we assumed a pension-replacement rate of 50 per cent of average pre-retirement earnings. There are little reliable data to assess the accuracy of this replacement rate assumption. But the assumption seems reasonable given the Chinese Government's recent decision to recognise the unfunded liabilities of state-owned enterprises.

General government expenditures $G(t)$ consist of government purchases of goods and services, including educational expenditures and health outlays. Over the transition, general government purchases of goods and services are held fixed as a per cent of national income. Age-specific education and disability outlays are held fixed per capita over the transition with an adjustment for technological change. Age-specific health outlays are also held fixed in per capita terms, but are assumed to grow at twice the rate of technological change during the first 25 years of the transition. Afterwards, the age-specific levels of these outlays grow at the same rate as technological change. Note that while the outlays of the health care systems are treated as government expenditures, disability benefits are modelled as direct transfers to the households. The government's budget constraint, Equation (18), is balanced each year by adjusting the intercept in our linear equation determining the average wage tax rate.

2.5 World equilibrium

Up to now we've described the model for the representative economy. The four regions of the model are, however, connected through the world capital market. A condition of this market is that the value of aggregate world assets equals the market value of the worldwide capital stock plus the value of all outstanding government bonds, that is

$$\begin{gathered}\sum_{x \in W} \mathcal{A}(t,x) = \sum_{x \in W} \left[q(t,x) K(t,x) + B(t,x) \right], \\ \text{with} \quad W = \left\{ \text{US, EU, Japan, China} \right\}\end{gathered} \tag{21}$$

2.6 Solving the model

To simulate the model we need, of course, to specify preference, technology and policy parameters. Table 2 reports these values, which, in the case of preference and technology parameters, are mostly taken from Kotlikoff *et al* (2001).

The multifactor technology coefficient in the US Cobb-Douglas function was set to generate a US marginal product of labour of 1.0 in the initial year 2004. For the

Table 2: Parameter Values of the Model

	Symbol	Value			
		US	EU	Japan	China
Utility function					
Time preference rate	θ	0.01	0.00	0.01	–0.13
Intertemporal elasticity of substitution	γ	0.25	0.25	0.25	0.25
Intratemporal elasticity of substitution	ρ	0.4	0.4	0.4	0.4
Leisure preference parameter	α	1.5	1.5	1.5	1.5
Production function					
Technology level	ϕ	1.01	1.01	1.01	0.24
Capital share in production	ε	0.25	0.25	0.25	0.25
Technical progress	λ	0.01	0.01	0.01	0.01
Policy parameters					
Consumption tax rate (%)	τ^c	10.2	23.6	14.7	20.0
Capital tax rate (%)	τ^r	11.0	14.0	8.0	0.0
Corporate tax rate (%)	τ^k	12.0	18.0	16.0	0.0
Expensing fraction (%)	$\in$	0.0	20.0	40.0	0.0
Debt (% of national income)	B/Y	33.3	38.9	41.4	10.0
Age of retirement (years)		63	60	60	60

Source: authors' calculations

EU and Japan we simply adopted this technology level. For China the technology level was set to achieve a 2004 real wage equal to 15 per cent of the US level. During the transition we gradually adjust China's technology level such that it reaches the developed world's level in 2050.

The time preference rates in the four regions were set so that the model's 2004 ratios of private consumption to national income match the region-specific values reported by the European Commission (2005). The US, EU and Japanese time preferences rates are held fixed through time. But in line with our baseline assumption that the Chinese public will eventually adopt American spending habits, we gradually raise the time preference rate of successive Chinese cohorts so that cohorts that reach adulthood (age 21) in 2030 and thereafter have the time-invariant US time preference rate.

The model's government debt levels in the four regions were chosen to accord with real government interest payments reported by the European Commission (2005) for the year 2004. The maximum ages of retirement are taken from Blöndal and Scarpetta (1998) for the US and the EU, from Whitehouse (2002) for Japan and from the OECD (2002) for China. We set the consumption tax rate, personal capital income tax rate, corporate income tax rate and expensing rate for the US, the EU and Japan in line with the structure of indirect and direct tax revenues reported by the European Commission (2005). We use OECD (2002) data to determine China's consumption tax rate, but assume that China has no personal capital income or corporate income taxes. It may well be that such taxes exist in China, but we have no reliable information to understand their magnitudes.

Our wage tax systems are assumed to be progressive, with the parameters of these tax systems in each region set so as to generate what seem to be realistic average and marginal tax rates, which are reported below.

In calibrating health expenditures in our model, we apply the Japanese age-specific government healthcare expenditure profile for Japan as well as China. In the case of the EU, we use the German profile. For the US, the Medicare program applies only to households aged 65 and older. We assume uniform Medicare expenditures by age. We make the same uniform age-distribution assumption with respect to the disability insurance systems in the US, the EU and Japan, which we assume applies only to those older than 20 and younger than 65.

In the case of the US, the EU and Japan, total social insurance outlays for pensions, disability and health, measured as a share of national income, are set to accord with the values of these totals reported by the European Commission (2005). But we determined the composition of these expenditures according to the three types of benefits using data reported in Docteur and Oxley (2003), European Commission (2003) and OECD (2001) and invoking the assumption for the EU and Japan that their ratios of disability expenditures to pension expenditures are the same as prevails in the US. Note that our baseline path assumes a gradual 20 per cent cut in Japanese pension replacement rates through to 2017, which was recently legislated by the Japanese government. For China our division of social insurance outlays is restricted to pensions plus disability payments, on the one hand, and health expenditures, on the other. Calibration here is based on OECD (2002).

We use the German age-specific education profile for all regions in the model and rescale it to get realistic education outlays in the year 2004 in each region (see below). In addition to these parameter values, our model requires an initial distribution of assets by age and income class for each region. These profiles are region-specific.[3]

To run our model as an open world economy, we also need to specify total world assets and how these assets are distributed across regions. The model's level of total world assets was set to generate a capital-output ratio of 3.0 in our model in the absence of China. Our additional assumption that per capita wealth in China equals 10 per cent of per capita wealth in the developed countries sufficed to pin down the capital-output ratio in the four-region model, namely 2.3.

In our simulations with adjustment costs, for the base year, 2004, we also need to specify the shares of wealth in each country owned by citizens of each region. The reason is that the endogenous determination of capital prices in each region will

3. The profile of Japanese average net wealth by age was provided by Charles Horioka, while the European age-specific average net wealth profiles were adjusted from German data provided by Reinhold Schnabel. We calculated a US age-net wealth profile using the 1998 Board of Governors of the Federal Reserve System *Survey of Consumer Finances*. For China, we adopted the Japanese age-net wealth profile.

differentially affect wealth holdings of each region's nationals depending on where they hold their wealth. The data needed to determine the region-specific allocation of each region's wealth holdings are not available. Consequently, we make the following, admittedly crude, assumption. We assume that US, EU, Japanese and Chinese nationals own 70 per cent of the capital installed in their region and that the remaining 30 per cent is owned equally by foreigners from the other three regions. In the case of the US, for example, we assume that the Japanese, EU nationals and Chinese each own 10 per cent of the US capital stock, where these holdings include government claims.

The initial (year 2004) world capital stock, the allocation of this capital stock across regions, the regional ratios of government debt to national income, and the international, intergenerational and intragenerational distributions of assets constitute the initial conditions needed to solve for the perfect foresight general equilibrium transition path of the economy. The algorithm we use to solve the model employs Gauss-Seidel iteration.

Specifically, our algorithm starts with initial guesses for capital stocks and labour supplies in each region for the post-2004 years of the transition. Next we compute from Equation (16) the path of the q's – the region-specific market prices of capital. The path for the world interest rate is derived from the arbitrage condition Equation (17) for the US. Next, region-specific wage rates are computed for each year by setting them equal to their respective marginal products of labour.

The initial region-specific capital values, our working value of q in 2004, and 2004 initial region-specific debt levels suffice to determine total worldwide wealth in 2004 using the world capital market equilibrium condition of Equation (21). These aggregate values are then distributed to the agents of each region based on the initial 2004 region-specific wealth shares and region-specific age-asset profiles.

Given these initial individual asset holdings, our initial guesses of tax rates/tax function parameters and the derived time paths of wage and interest rates, we calculate household consumption, saving and labour-supply decisions. The first-order conditions and lifetime budget constraints determining these decisions are fairly complex and certainly do not have ready closed-form solutions. Part of this complexity arises because of the progressive nature of our assumed wage tax structures, which means that marginal tax rates are themselves endogenous and need to be determined jointly with life-cycle consumption, saving and labour-supply decisions. This is done using Gauss-Seidel iteration. We refer to this as 'inter-loop' convergence. As indicated just below, we also use Gauss-Seidel iteration to determine the time path of the economy's macroeconomic variables. We refer to this iteration on macroeconomic variables as 'outer-loop' convergence.

The next step in our overall solution algorithm uses the annual revenues and social security benefit payments implied by these household decisions to update annual tax rates/tax parameters. We also update the model's region-specific time paths of government debt. These updates are based on Equations (18) and (19).

Aggregating individual labour supplies in each year provides new time paths of aggregate region-specific labour supplies. Determining new time paths of capital stocks in each region is a bit more involved. First, we use year-2004 wealth holdings plus agent-specific saving decisions to determine agent-specific asset holdings in each year during the transition. Second, we aggregate agent-specific assets at each date to determine a time path of aggregate world-wide asset holdings. Third, we use Equation (17) to substitute out for $\Delta K(t)/K$ – the percentage change in capital – in Equation (16). Finally, we equate the interest rates in Japan, the EU and China to that in the US using the modified versions of Equation (17). Given our working values of the q's, this provides us with three equations in a given year to solve for the four region-specific capital stocks. The fourth equation comes from the worldwide capital market condition, which, given our working values of q's and debt, provides another equation in the four unknown region-specific capital stocks.

The new values for the aggregate supplies of capital and labour in each region in each year are then weighted with the initial guesses of these variables to form new guesses of their time paths. The algorithm then iterates until the region-specific time paths of capital stocks and labour supplies converge to a fixed path.

We give our economy 300 years to reach a steady state. In fact, our model reaches a steady state to many decimal places decades prior to year 300. It also converges very tightly around the equilibrium transition path. However, when we include capital adjustment costs, finding the equilibrium transition path is very time-consuming even on today's most powerful desktop personal computers. Doing so requires finding the path with no such costs, which can be done relatively quickly, and then using the region-specific capital and labour supply equilibrium paths from that simulation as the initial guesses for a run with very small adjustment costs. We then use the results of the small adjustment costs simulation as initial guesses for a simulation with somewhat higher adjustment costs and proceed in this manner until we've solved the model with our desired level of adjustment costs. Given the time required for these calculations, we assumed no adjustment costs in all but one simulation presented below. The simulation with adjustment costs is applied to the baseline transition. The results indicate that inclusion of reasonable adjustment costs makes little difference to the results.

3. Initial Equilibrium and the World Economy's Baseline Transition Path

Table 3 reports key macroeconomic variables in 2004 in the four regions. Note that there is a fairly close accordance between actual and computed values of private consumption and government purchases measured as a share of national income. The one exception is EU government purchases. The official data seem too low given the reported ratio of tax revenues to national income. In our calibration, we chose to benchmark government purchases based on the ratio of tax revenues to national income.

Table 3: The Year 2004 of the Baseline Path[(a)]

	Model				Official			
	US	EU	Japan	China	US	EU	Japan	China
National income								
Private consumption	79.7	65.1	70.5	52.4	79.3	67.3	69.3	49.5
Government purchases of goods and services	18.7	31.0	21.9	17.9	17.4	24.3	21.7	17.6
General public expenditures	10.9	19.3	12.3	13.8	–	–	–	–
Aggregate education outlays	5.9	6.0	4.4	2.1	5.9	6.0	4.3	2.1
Aggregate health benefits	1.9	5.7	5.2	2.0	2.5	6.2	6.8	2.0
Current account	2.8	8.3	13.8	–16.1	–6.1	0.5	4.5	1.9
Government indicators								
Social contributions received	8.1	16.4	13.9	7.7	7.9	16.6	13.4	–
Aggregate pension benefits	5.3	9.2	7.6	5.2	5.7	11.6	10.8	3.0
Aggregate health benefits	1.9	5.7	5.2	2.0	2.5	6.2	6.8	2.0
Aggregate disability benefits	0.9	1.5	1.1	0.0	0.9	–	–	–
Pension contribution rate (%)	7.7	14.2	12.1	8.0	10.6	–	17.3	11.0
Health-care contribution rate (%)	2.5	8.8	8.2	3.1	2.9	–	8.5	8.0
Disability-insurance contribution rate (%)	1.4	2.3	1.8	0.0	1.9	–	–	–
Interest payment on public debt (%)	3.3	3.8	4.1	1.0	3.0	3.5	3.7	0.8
Tax revenues (%)	20.3	30.3	21.9	15.8	20.6	31.0	19.1	14.8
Direct taxes	12.2	14.9	11.5	5.3	12.5	15.1	8.9	2.8
Personal income taxes	9.2	10.5	7.5	5.3	9.5	10.7	4.7	0.7
Wage taxes	5.7	5.9	4.9	5.3	–	–	–	–
Capital taxes	3.5	4.6	2.6	0.0	–	–	–	–
Corporate income taxes	3.0	4.4	4.0	0.0	3.0	4.4	4.2	2.1
Indirect taxes	8.1	15.4	10.4	10.5	8.1	15.9	10.2	12.0
Wage tax rates (%)								
Average	7.8	8.0	6.6	7.1	–	–	–	–
Marginal	14.2	13.9	11.9	8.9	–	–	–	–
Capital-output ratio	2.2	2.2	2.3	2.6	–	–	–	–
Capital-labour ratio	3.0	2.9	3.1	0.5	–	–	–	–
Interest rate (%)	9.8	9.8	9.8	9.8	–	–	–	–

(a) As a per cent of national income if not stated differently

Sources: for official data – European Commission (2005) for the US, EU and Japan; OECD (2002) for China

The reported ratios of educational expenditure to national income are very close to actual levels.[4] In the case of pension, health and disability expenditures, we closely match the shares of national income received in the form of social contributions in the US, the EU and Japan as reported by the European Commission (2005). In China, the level of health expenditures measured as a share of national income was set in accord with the World Health Organisation (WHO 2004, p 136). The resulting social security payroll tax rates come close to observed levels. Concerning the overall structure of tax revenues, the assumed tax rates on capital income, corporate income and consumption, as well as the expensing fractions (see Table 2) yield a realistic pattern.[5]

The baseline simulation ignores adjustment costs. Hence, capital prices do not change during the transition. However, due to the differences in the expensing fractions for the corporate tax, capital prices deviate from 1 in the EU and Japan. Thus the capital price is 0.964 in the EU and 0.936 in Japan throughout the transition, while it is 1.000 in the US and China. Finally, the model's year-2004 capital-output ratios seem reasonable not only relative to US Commerce Department figures, but also in terms of the year-2004 marginal product of capital, which equals 9.8 per cent.

Next we turn to the simulation results for the baseline transition. The transition paths for the four regions are reported in the first panels of Appendix Tables A1 to A4 (see Appendix A) for the US, the EU, Japan and China. Note that region-specific indices of national income, the capital stock, the supply of labour and the pre-tax wage rate are all expressed relative to the US values in the year 2004.

Although the four economies are ageing, the baseline path shows a steady increase in the effective labour supply in the US, the EU and Japan. This may seem surprising especially for Japan and the EU where the population and workforce decline over time (see Table 1). The explanation lies in our assumption that each successive cohort has a higher effective time endowment, which admits greater effective labour supply by each successive cohort. Thus, the future decrease in the actual labour force is offset in the EU, Japan and China, and the growth in the actual number of workers in the US is augmented. However, effective labour supply grows at much different rates in the regions. In Japan it increases over the century by 41 per cent. In the EU it more than doubles over the same period. And in the US it increases over the century by a factor of almost four.

The evolution of effective labour supply in China is particularly interesting. During the next two decades the effective labour supply increases, then it declines until mid century when it begins to increase again. This complex pattern reflects major changes in substitution and income effects over the transition, the demographic changes themselves, as well as the ongoing technological change. By the end of the century, China's effective labour supply is larger than it is today, but only by 18 per cent.

4. See OECD (2003a, p 178; 2003b, pp 71, 77).

5. Actual values are calculated from European Commission (2005) and OECD (2003c).

Due to the dramatic ageing of populations, social security tax rates increase through 2050 by 5.5 percentage points in the US, by 12.8 percentage points in the EU, by 13.8 percentage points in Japan and by 7.8 percentage points in China. Over the century the respective increases are 11.4 percentage points in the US and the EU, 10.7 percentage points in Japan and 16.6 percentage points in China. These changes constitute major payroll tax hikes given the base-year values. In the US and China, for example, the model is predicting an increase in payroll tax rates of more than 100 per cent.

Despite the rising payroll tax burden, capital stocks increase dramatically in all regions over the course of the century. The capital stock increases by a factor of 4.7 in the US, 2.5 in the EU, 1.7 in Japan and 9.6 in China. In China this development is due to high investment rates associated with high private saving and the assumed rapid catch-up in the country's level of technology. The other regions also benefit from the economic boom in China. As the development of the current accounts suggests, initially capital mainly flows from the three developed regions to China. However, in subsequent decades the asset holdings in China of the US, the EU and Japan decline and capital starts to flow from China to all three of these regions. After 2050, this is reversed again so that capital flows from the US, the EU and Japan back to China. This reversal is expected; it reflects the repatriation of Chinese foreign capital earnings back to China.

The differences across the four regions in the growth of the effective labour supply and the capital stock and, in the case of China, in the evolution of the multifactor productivity coefficient materially affect overall economic growth. In the US output grows by a factor of 4.1 over the next 100 years. It grows by a factor of 2.2 in the EU, 1.4 in Japan and 8.5 in China. The larger increase in capital compared to the labour supply leads to an increase in the pre-tax wage rate in the developed economies of almost 16 per cent through the middle of the century. In China wages rise by more than 700 per cent thanks, primarily, to the gradual increase in China's technology level. After 2050, however, growth in the labour supply exceeds growth in capital stocks in all regions so that the wage rate starts to decline. At the end of the century real wages per unit of human capital in the developed economies are still above 2004 levels, but only 4 per cent higher.

As one would expect, the worldwide capital deepening in the first half of the century and capital shallowing in the second half has a major impact on the world interest rate. Between 2004 and 2030 the world interest rate declines by 370 basis points – from 9.8 to 6.1 per cent. This is followed by an increase to a 2100 level of 8.7 per cent. Wage tax rates follow a somewhat similar pattern – declining in the first half of the century and rising in the second half.

This interesting pattern in the evolution of factor prices reflects China's ongoing rapid growth and its assumed gradual change in saving behaviour. During the first half of the century, China makes a major contribution to worldwide capital formation. In the second half of the century, more and more of its cohorts have adopted US preferences with respect to spending and the Chinese saving engine starts to sputter and fail.

To understand better the role of China in worldwide capital formation, let's consider what would happen were the developed world forced to evolve without the ability to import capital from China.

4. The World Economy's Baseline Transition Path Excluding China

Table 4 reports baseline transition paths for the developed economies if we calibrate the model as above, but simply exclude China. Doing so has dramatic effects. Capital stocks in all three regions in the initial years of the transition are much higher compared to the four-country case since more capital now remains in the developed world. For example, in 2010 the capital stock index in the US is 1.60 compared with 1.19 in the four-region simulation (see Table 4). In both simulations, the capital stock is measured relative to the US value in 2004 in the four-country simulation.

Interestingly, even though the developed world has more capital to work with initially, real wages are actually lower in 2010 than in the transition with China. The reason is that the labour supply is initially also much higher in the developed world in the no-China simulation. Presumably this reflects the income effect of having lower real wages in the medium term when China is no longer serving as the developed world's saving machine.

With China out of the picture, capital stocks in the developed regions increase much less rapidly over time. This puts a significant damper on output growth. During the first 25 years of the simulation, capital growth is somewhat larger than labour supply growth. Thus wage rates increase by approximately 2 per cent and the world interest rate decreases by about 30 basis points. In the second half of the century, however, all three regions experience a capital shortage due to the high tax burden. As a consequence, wage rates decline. Indeed, the 2100 wage per unit of human capital is 4 per cent below its 2004 level, and the interest rate is 100 basis points above its base-year value. The lower level of real wages in the no-China transition leads to higher average wage and payroll tax rates, both of which limit capital accumulation.

The current accounts show that capital flows primarily to the US during the coming decades due to its younger population and higher population growth rate. After 2050, capital flows to the EU and increasingly to Japan as the Europeans and Japanese repatriate their US-earned income.

As indicated in the introduction, the no-China developed world transition path shows a relatively modest capital shortage compared to our previous findings reported in Fehr *et al* (2004a, 2004b, 2005). The main reason, again, is that we are now calibrating the model to include government investment. In addition, we've switched to using European Commission (2005) data for our measures of social contributions received. This lowers, somewhat, initial payroll tax rates as well as subsequent payroll tax hikes.

Table 4: Simulation Results for the Three-region Simulation

	Year	Index of national income	Index of capital stock	Index of labour supply	Current account/ national income	Index of pre-tax wage	Interest rate	Social security payroll tax rate	Average wage tax
US	2004	1.01	1.37	1.01	–0.057	1.00	0.072	0.114	0.076
	2010	1.16	1.60	1.17	–0.050	1.00	0.072	0.116	0.078
	2020	1.45	2.04	1.43	–0.039	1.01	0.070	0.141	0.080
	2030	1.70	2.45	1.68	–0.041	1.02	0.069	0.183	0.084
	2050	2.30	3.00	2.34	0.008	0.99	0.075	0.193	0.090
	2075	3.07	3.71	3.20	0.010	0.96	0.081	0.214	0.082
	2100	3.97	4.78	4.16	–0.001	0.96	0.082	0.231	0.077
EU	2004	1.45	1.90	1.47	0.014	0.99	0.072	0.250	0.083
	2010	1.57	2.08	1.59	0.014	0.99	0.072	0.259	0.077
	2020	1.75	2.40	1.76	0.023	1.00	0.070	0.296	0.067
	2030	1.83	2.55	1.83	0.025	1.01	0.069	0.365	0.056
	2050	1.99	2.52	2.05	–0.013	0.98	0.075	0.428	0.056
	2075	2.40	2.81	2.53	–0.012	0.95	0.081	0.398	0.082
	2100	3.08	3.59	3.26	0.000	0.95	0.082	0.374	0.093
Japan	2004	0.50	0.68	0.50	0.077	1.01	0.072	0.216	0.061
	2010	0.51	0.71	0.51	0.072	1.01	0.072	0.250	0.049
	2020	0.53	0.75	0.52	0.030	1.02	0.070	0.307	0.034
	2030	0.55	0.79	0.54	0.044	1.02	0.069	0.335	0.026
	2050	0.52	0.70	0.53	0.014	0.99	0.075	0.410	0.010
	2075	0.57	0.71	0.59	–0.004	0.97	0.081	0.375	0.028
	2100	0.70	0.85	0.72	0.008	0.97	0.082	0.339	0.041

5. Adjustment Costs

Table 5 repeats the baseline simulation, but includes capital adjustment costs. A comparison of this table with the first panels in Appendix Tables A1–A4 shows that adjustment costs make very little difference to the four-region dynamic equilibrium. The initial levels and time paths of regional stock prices per unit of physical capital (the ratio of the market value to the replacement cost) are, however, interesting.

In 2004, EU stock prices are 5.1 per cent lower than US stock prices. Japanese stock prices are 12.6 per cent lower, and Chinese stock prices are 16.1 per cent higher. The model predicts increases in stock values in all four regions for the next 10 to 20 years, depending on the region, followed by a long-term decline in stock values. The US stock market value is 1.000 in 2004, hits 1.062 in 2020, and falls to 0.917 in 2100. The EU's 2004 stock market value is 0.949. It is 0.979 in 2020 and then it gradually falls to 0.882 by 2100. Japan's 2004 stock market value is 0.874. In 2020 it is 0.938, but it falls to 0.851 by century's end. And China's stock market value starts at 1.161, reaches 1.196 in 2020 and declines to 0.914 by 2100.

6. Examining China's Saving and Absorption of Technology

This section returns to the four-region model without adjustment costs and examines the importance of our assumptions about the evolution of Chinese saving behaviour and the rate at which China absorbs developed-world technology. Specifically, we first consider keeping the time preference rate of successive Chinese cohorts at the same level that was calibrated for all Chinese cohorts for 2004 in the baseline transition. Next we assume the technology coefficient in the Chinese Cobb-Douglas production function rises only to 50 per cent of the US level (rather than 100 per cent) by 2050 and remains at that value thereafter.

6.1 Constant time preference rate in China

The second simulation reported in Appendix Tables A1–A4 permanently maintains the Chinese time preference rate at its year-2004 level. Doing so has dramatic consequences. In particular, the 2100 world stock of capital is 5.9 times higher than in the base case! China not only becomes the world's saver, it also becomes the world's investor, sending huge flows of capital to the developed world over the course of the century. By 2100, the capital stocks in the US, the EU and Japan are 5.6, 5.6 and 5.8 times their initial values, respectively.

This huge impetus to capital formation has a major impact on economic growth in all four regions, leaving world output roughly 50 per cent higher in 2100 than it would otherwise have been. This is true notwithstanding a basically unchanged supply of labour in the four regions. The rough constancy of the labour supply reflects competing income and substitution effects arising from the level of the real wage per unit of human capital being roughly 55 per cent higher in the long run

Table 5: Simulation Results for the Base Case with Adjustment Costs

	Year	Index of national income	Index of capital stock	Index of labour supply	Current account/ national income	Index of pre-tax wage	Capital price	Interest rate	Social security payroll tax rate	Average wage tax
US	2004	1.02	1.00	1.02	–0.015	1.00	1.000	0.098	0.114	0.083
	2010	1.16	1.22	1.13	–0.072	1.02	1.038	0.088	0.116	0.075
	2020	1.46	1.87	1.38	–0.145	1.08	1.062	0.068	0.136	0.073
	2030	1.86	2.74	1.65	–0.114	1.14	1.017	0.054	0.166	0.081
	2050	2.61	3.72	2.32	0.040	1.13	0.907	0.066	0.173	0.094
	2075	3.26	3.88	3.07	0.039	1.07	0.902	0.084	0.208	0.077
	2100	4.09	4.53	3.95	0.017	1.04	0.917	0.087	0.230	0.064
EU	2004	1.48	1.38	1.53	0.034	0.98	0.949	0.098	0.244	0.104
	2010	1.61	1.64	1.61	0.005	1.01	0.970	0.088	0.253	0.084
	2020	1.85	2.28	1.74	–0.042	1.08	0.979	0.068	0.258	0.069
	2030	2.05	3.00	1.82	–0.036	1.14	0.933	0.054	0.326	0.069
	2050	2.30	3.33	2.02	0.033	1.14	0.843	0.066	0.378	0.072
	2075	2.55	3.01	2.41	0.027	1.06	0.858	0.084	0.382	0.062
	2100	3.15	3.39	3.07	0.023	1.03	0.882	0.087	0.370	0.062
Japan	2004	0.47	0.50	0.46	0.100	1.02	0.874	0.098	0.229	0.049
	2010	0.49	0.55	0.47	0.046	1.05	0.909	0.088	0.261	0.030
	2020	0.53	0.72	0.49	–0.069	1.11	0.938	0.068	0.303	0.021
	2030	0.60	0.91	0.52	–0.057	1.16	0.901	0.054	0.308	0.032
	2050	0.61	0.95	0.52	0.045	1.17	0.804	0.066	0.356	0.035
	2075	0.61	0.78	0.56	0.036	1.09	0.818	0.084	0.352	0.031
	2100	0.71	0.82	0.68	0.026	1.05	0.851	0.087	0.329	0.030
China	2004	1.24	1.52	8.57	–0.066	0.15	1.161	0.098	0.110	0.052
	2010	2.04	2.32	9.45	0.025	0.23	1.235	0.088	0.085	0.074
	2020	3.78	4.81	9.95	0.086	0.39	1.196	0.068	0.088	0.068
	2030	5.42	8.25	9.05	0.059	0.61	1.080	0.054	0.117	0.045
	2050	8.36	12.84	8.06	–0.025	1.04	0.937	0.066	0.187	0.004
	2075	9.66	13.32	8.69	–0.023	1.12	0.885	0.084	0.264	0.018
	2100	11.37	14.48	10.51	–0.014	1.09	0.914	0.087	0.277	0.036

(year 2100). The long-run capital glut also leads to a major decline in the world real interest rates – from 9.8 per cent in 2004 to 2.3 per cent in 2100.

The long-run increase in real wages has a major effect on long-run payroll tax rates, although it does little to payroll tax rates over the next three decades. Year-2100 payroll tax rates are now 16.4 per cent instead of 23.0 per cent in the US, 26.1 per cent instead of 36.7 per cent in the EU, 22.7 per cent instead of 32.8 per cent in Japan and 26.0 per cent instead of 27.7 per cent in China. Higher output growth immediately translates into increased government expenditures. This explains the higher wage tax rates in the medium and long run.

6.2 Slower technology growth in China

Our next simulation, reported in the third panels of Appendix Tables A1–A4, assumes that the multifactor technology coefficient in the Chinese production function rises to only 50 by 2050, rather than 100 per cent of the US level and remains fixed at half the US level thereafter. As a comparison with the base case shows, slower Chinese technological growth means much lower capital demand, output and real wage levels in China. Indeed, in 2100 the Chinese capital stock and output levels are just over half of their baseline values. And the Chinese real wage is only 39 per cent of what it would otherwise have been.

In contrast to what happens to China's capital stock, China's labour supply is significantly higher along the entire transition path. This reflects the income effects (relative to the base case) experienced by the Chinese who receive lower real wages as well as smaller inheritances. These income effects matter to the labour supply from the get go. Indeed, the immediate increase in labour supply explains why Chinese output and capital stock levels are initially higher than they are in the base case.

The rise in China's labour supply doesn't suffice to offset the lower path of wages with respect to determining the Chinese payroll tax base. Consequently, social security payroll tax rates are markedly higher during this transition.

The most interesting thing about this simulation of slower Chinese technological progress is what happens to the economies of the developed world. The answer, surprisingly, is very little. Although China saves much less than in the base case, it also demands significantly less capital. Consequently, the US, the EU and Japan end up with essentially the same capital stocks, wage rates and tax rates over time that they enjoy in the base case.

The welfare effects of this simulation are given in Table 6. The numbers show the change in welfare measured as an equivalent variation and expressed as a percentage of remaining lifetime resources for cohorts born between 1920 and 2030. As expected from the macroeconomic development, middle-aged and future cohorts in China experience large welfare losses due to reduced wages and increased payroll tax rates during their lifetimes. The welfare changes for developed-world cohorts are, in contrast, quite small.

Table 6: Welfare Effects of Lower Technology Growth in China

Birth year	US income class			EU income class		
	1	2	3	1	2	3
1920	–0.73	–0.49	–0.10	–0.68	–0.48	–0.15
1930	–1.58	–1.18	–0.38	–1.25	–1.08	–0.63
1940	–2.34	–1.88	–0.72	–2.01	–1.74	–1.02
1950	–1.53	–1.43	–1.02	–1.98	–1.76	–1.15
1960	–0.10	–0.66	–0.98	–0.21	–0.79	–1.10
1970	1.61	0.54	–0.50	0.97	0.06	–0.86
1980	2.35	1.32	0.10	1.12	0.33	–0.65
1990	2.16	1.35	0.33	1.38	0.80	–0.22
2000	1.38	0.90	0.28	0.71	0.39	–0.20
2010	0.57	0.38	0.14	–0.03	–0.09	–0.20
2020	0.05	0.07	0.07	–0.46	–0.35	–0.14
2030	–0.40	–0.21	0.00	–0.74	–0.52	–0.09
	Japan income class			**China income class**		
	1	2	3	1	2	3
1920	–0.70	–0.40	–0.11	1.06	2.24	2.06
1930	–1.57	–1.16	–0.55	0.22	1.33	1.31
1940	–2.40	–1.94	–1.12	–1.06	0.10	0.40
1950	–2.25	–1.98	–1.35	–10.08	–8.07	–4.25
1960	–0.26	–0.85	–1.11	–21.70	–17.12	–7.99
1970	1.22	0.24	–0.75	–28.60	–22.17	–9.05
1980	1.55	0.68	–0.39	–33.45	–24.66	–7.85
1990	2.10	1.35	0.17	–40.40	–30.67	–12.50
2000	1.46	0.99	0.18	–45.17	–35.54	–18.92
2010	0.66	0.48	0.10	–48.43	–38.65	–22.54
2020	0.12	0.14	0.08	–51.18	–41.00	–24.34
2030	–0.33	–0.16	0.09	–53.03	–42.83	–25.89

7. Population Scenarios

In this section we analyse three different population scenarios. The first scenario keeps fertility rates fixed at their initial levels. The second scenario considers increases in life expectancy relative to the base case. The third scenario doubles rates of immigration in all four regions.[6]

7.1 Fixed fertility rates in all regions

The fourth panels in Appendix Tables A1–A4 show the impact of keeping the initial fertility rate of 2.11 births per woman in the US, 1.46 births in the EU, 1.28 births in Japan and 1.62 births in China fixed through to 2050.[7]

The higher short-term US fertility rate increases that country's total population as well as its effective labour supply. The latter variable is first affected in 2026 when the first cohort generated by the higher birth rate enters the labour force. The effective labour supply and national income in 2100 are raised by 17 per cent relative to the baseline simulation. Due to the younger population age-structure and the increased labour supply, social security contribution rates in the US decrease. In 2100 the social security payroll tax is 20.9 per cent, compared to 23 per cent in the base case. However, the average wage tax rate rises. Compared with the baseline results, the average wage tax rate is 1.1 percentage points higher in 2100. This reflects the need to finance additional government expenditures associated with the population increase. The capital stock keeps pretty close track with the higher time path of labour supply. In 2100 the capital stock is 16 per cent higher relative to the base case.

In the case of the EU, Japan and China, holding fertility rates fixed at their 2004 values for the next 45 years leads to smaller workforces and populations. In the EU, the labour supply and national income in 2100 are 23 per cent below their baseline values. These are big differences. In China, effective labour supply and national income in 2100 are both 17 per cent lower. And in Japan, the maintenance of current fertility patterns through 2050 reduces effective labour supply at the end of the century by 33 per cent and national income by 32 per cent. Indeed, the absolute size of the Japanese economy, as measured by national income, is smaller in 2100 than in 2004 notwithstanding almost 100 years of technological progress!

Lower fertility rates raise dependency ratios in the three developed regions. This necessitates larger increases in social security tax rates. On the other hand, average wage tax rates are slightly reduced during the transition, since government expenditures on education decrease with the reduction in the number of young people and general government expenditures decrease with the reduction in population growth. The higher payroll taxes in China, Japan and the EU lead households to

6. A more extensive analysis of how different population policies affect the future fiscal and economic development in the developed world is presented in Fehr *et al* (2004a, 2004b).

7. After 2050, fertility rates gradually adjust again in order to achieve a zero long-run population growth rate.

save less and export more capital to the US. Thus, capital stocks in the three regions decline during the second half of the century. Finally, since capital-labour ratios are little affected in the four regions, wage rates and the world interest rate remain almost the same as in the baseline path.

7.2 Higher life expectancies in all regions

Now we consider a simultaneous rise in longevity in all regions. To be precise, we gradually raise life expectancy in each region through 2050 by approximately 3 years, that is life expectancy in 2050 is 86.8 years in the US, 87.6 years in the EU, 91 years in Japan, and 83.3 years in China. These values for the developed regions find support in the projections of Tuljapurkar, Li and Boe (2000). Simulation results for this scenario are reported in the fifth panels of Appendix Tables A1–A4.

Greater longevity leads to more saving for retirement as well as more labour supply to help generate this saving. Consequently, the labour supply and the capital stock increase in all four regions compared to the base case. The broadening of the tax base implies a slight decline in wage tax rates in the medium and long run. However, at the same time, higher life expectancy leads to a rise in dependency ratios. Hence, the year-2100 social security contribution rates are increased relative to the base case by 2.4 percentage points in the US, 2.3 percentage points in the EU, 2.2 percentage points in Japan, and 4.1 percentage points in China. Since the increase in capital exceeds the increase in labour, wage rates rise slightly during the transition. Consequently, the values of the world interest rate are lower than in the baseline path.

7.3 Doubling of immigration in all regions

The sixth panels in Appendix Tables A1–A4 show the impact of doubling immigration immediately and permanently in all four regions. This means, for example, that in 2004, 2 million immigrants enter the US, 900 000 enter the EU, 108 000 enter Japan and 780 000 exit China.

As is clear from the figures for the effective labour supply, doubling immigration makes a material difference to the long-run supply of labour in all four regions. Take the developed regions. Relative to the baseline simulation, this policy raises the effective labour supply in 2100 by 31 per cent in the US, 21 per cent in the EU, and 10 per cent in Japan. The remarkable thing is how long it takes for immigration to alter effective labour supplies. In the US, for example, the effective supply of labour is only 11 per cent larger in 2030 despite a doubling of immigration starting in 2004. The comparable figures for the EU and Japan are 6 per cent and 2 per cent.

Given that the developed world's severe fiscal problems associated with ageing will begin to appear well before 2030, it would seem that even a doubling of immigration is 'too little too late'. This, indeed, is what the other figures in the second panel of results show. Relative to the baseline simulation, doubling immigration makes little difference to any of the three countries in terms of their macroeconomic variables.

Take the US. With a doubling of immigration, the payroll tax rate is 15.3 per cent in 2030 – not much lower than the 16.4 per cent rate without the extra immigrants. In 2100 the payroll tax rate is 22.4 per cent, compared with 23.0 per cent under the baseline immigration policy. Factor prices are also essentially unchanged by a doubling of immigration. In 2030, the pre-tax wage is 1.17 in both simulations. And in 2100, the pre-tax wage is 1.05 compared to 1.04 in the base case. The explanation here is that, while the long-run US labour supply rises by 31 per cent, the long-run capital stock rises by 33 per cent, leaving the long-run capital-labour ratio essentially unchanged.

If the long-run real wage in the US stays fixed, but labour supply rises by 31 per cent, why doesn't the payroll tax rate and, for that matter, the average wage tax rate fall by 31 per cent in light of the 31 per cent larger long-run supply of effective labour? The answer is that the model provides new immigrants with public goods and social insurance benefits on the same basis as existing natives. And doubling the number of immigrants on an across-the-board basis ends up costing the US government almost as much in additional expenditures as the US government earns in additional revenues. As Appendix Tables A2 and A3 indicate, the same can be said of the EU and Japan.

Of course, the opposite happens in China. Higher emigration reduces China's long-run labour supply by 5 per cent and long-run capital stock by 3 per cent. More emigrants mean a reduction in the taxable wage base and thus an increase in payroll tax rates. However, as the results indicate, the changes in payroll tax rates are quite small.

Table 7 reports the welfare effects of doubling immigration. Almost all cohorts in the developed regions experience welfare gains, albeit mostly very small ones. For initially younger and future generations these gains stem from the reduction in payroll taxes. The gains are smaller for members of the high-income class because the ceiling on key payroll taxes limits the benefits they can experience from cuts in these taxes. Welfare gains are generally higher in the US and the EU. This is particularly true of younger and future cohorts. Indeed, for the low-income cohort born in 2030, the welfare gain is 2.07 per cent in the EU and 1.35 per cent in the US, but only 1.03 per cent in Japan. Unlike the gains of initial older generations, these gains are substantial. They appear to reflect the reduction in excess burden arising from even the modest reductions in marginal tax rates arising from the immigration reform.

Initially middle-aged people in China experience small welfare gains which are mainly due to small reductions in the average wage tax. In contrast, younger and future cohorts experience welfare losses. Of course, the reason is the higher payroll tax rates throughout the transition. As one would expect from the macroeconomic outcomes, welfare effects in China are much smaller than in the developed regions.

Table 7: Welfare Effects of Doubling Immigration in All Regions

Birth year	US income class 1	US income class 2	US income class 3	EU income class 1	EU income class 2	EU income class 3
1920	0.00	0.00	0.00	0.00	0.00	0.00
1930	0.03	0.02	0.01	0.02	0.02	0.02
1940	0.06	0.05	0.03	0.06	0.05	0.04
1950	0.13	0.09	0.04	0.10	0.08	0.05
1960	0.07	0.06	0.04	0.04	0.06	0.05
1970	–0.03	0.01	0.01	0.02	0.06	0.05
1980	0.69	0.50	0.23	0.21	0.19	0.07
1990	0.64	0.47	0.19	0.41	0.34	0.02
2000	0.89	0.67	0.30	0.79	0.65	0.03
2010	1.04	0.78	0.37	1.28	1.05	0.10
2020	1.12	0.83	0.39	1.70	1.40	0.20
2030	1.35	0.98	0.44	2.07	1.68	0.30

Birth year	Japan income class 1	Japan income class 2	Japan income class 3	China income class 1	China income class 2	China income class 3
1920	0.01	0.00	0.00	0.00	0.00	0.00
1930	0.04	0.03	0.02	0.02	0.02	0.02
1940	0.08	0.07	0.05	0.08	0.08	0.06
1950	0.11	0.10	0.07	0.21	0.18	0.11
1960	0.05	0.07	0.06	0.22	0.18	0.11
1970	0.00	0.04	0.05	0.11	0.12	0.09
1980	0.03	0.06	0.05	–0.05	0.04	0.06
1990	0.05	0.07	0.01	–0.20	–0.06	0.05
2000	0.18	0.17	–0.01	–0.29	–0.14	0.03
2010	0.39	0.32	0.00	–0.25	–0.12	0.04
2020	0.68	0.53	0.04	–0.18	–0.09	0.01
2030	1.03	0.79	0.10	–0.21	–0.14	–0.03

8. Social Security Policies

This section considers different social insurance policy scenarios. The first is a larger increase in health expenditures than that assumed in the base case. The second and third scenarios analyse the consequences of different financing methods for the social security systems. The fourth scenario considers cuts in state pension systems. The final scenario is a privatisation of public pension systems.

8.1 Increased health expenditures

In this simulation, health expenditures increase by 3 per cent during the first 25 years of the transition instead of the 2 per cent rate assumed in the base case. The simulation results are shown in the seventh panels of Appendix Tables A1–A4.

Higher health expenditures increase social security contributions. The additional increases in payroll taxes depend on the relative sizes of overall health expenditures and populations in each region. Thus in 2030, payroll tax rates are above their baseline values by 1.3 percentage points in the US, 3.2 percentage points in the EU, and 3.5 percentage points in Japan and China. In the year 2100 the difference is 1.8 percentage points in the US, 3.2 percentage points in the EU, 3.7 percentage points in Japan, and 0.8 percentage points in China.

The higher payroll tax burden leads to lower net wages. Consequently, medium-term and long-run capital stocks are below their respective baseline values. Lower capital formation is partly offset by higher capital inflows into the three developed regions from China during the first decades of the century. This explains the slightly increased output growth during this period. In the long run, output in the US and China is lower compared to the base case and higher in the EU and Japan. This is due to the adjustment in the effective labour supply in order to offset the income losses. Higher output growth during the first decades and lower wages in the second half of the century lead to an additional increase in wage tax rates.

The welfare effects of this simulation as reported in Table 8 confirm our macroeconomic findings. Apart from small welfare gains for initially older generations in the EU and Japan, all cohorts already alive in the initial year and all future cohorts experience welfare losses from increased health expenditures. The explanation is the higher payroll and wage tax rates. Since the additional tax burden increases with time, welfare losses rise with the birth year of the observed generations. Note also the differences in welfare losses between the four regions. Generations in the EU and Japan are hurt much more than in the US and China. This indicates the bigger size of health expenditures in the former two regions and thus the larger required increase in tax rates.

Table 8: Welfare Effects of a Rise in Health Expenditures by 3 Per Cent in All Regions

Birth year	US income class 1	US income class 2	US income class 3	EU income class 1	EU income class 2	EU income class 3
1920	0.00	0.01	0.00	0.07	0.08	–0.01
1930	–0.03	–0.01	–0.01	0.05	0.07	–0.02
1940	–0.05	–0.03	–0.02	0.03	0.04	–0.03
1950	–0.06	–0.04	–0.02	–0.06	–0.03	–0.04
1960	–0.08	–0.06	–0.03	–0.29	–0.19	–0.08
1970	–0.18	–0.13	–0.06	–0.69	–0.50	–0.14
1980	–0.35	–0.25	–0.13	–1.17	–0.88	–0.23
1990	–0.67	–0.49	–0.26	–2.17	–1.73	–0.45
2000	–1.08	–0.79	–0.44	–3.29	–2.68	–0.71
2010	–1.35	–0.98	–0.54	–4.05	–3.36	–0.91
2020	–1.50	–1.08	–0.58	–4.54	–3.81	–1.04
2030	–1.68	–1.22	–0.64	–4.91	–4.15	–1.15

Birth year	Japan income class 1	Japan income class 2	Japan income class 3	China income class 1	China income class 2	China income class 3
1920	0.07	0.04	–0.02	–0.02	–0.01	–0.01
1930	0.04	0.02	–0.03	–0.04	–0.03	–0.03
1940	0.02	0.00	–0.05	–0.08	–0.07	–0.06
1950	–0.07	–0.05	–0.05	–0.17	–0.14	–0.08
1960	–0.33	–0.22	–0.08	–0.19	–0.15	–0.05
1970	–0.77	–0.55	–0.13	–0.26	–0.19	–0.04
1980	–1.26	–0.92	–0.19	–0.42	–0.25	–0.02
1990	–2.32	–1.79	–0.35	–0.78	–0.48	–0.07
2000	–3.49	–2.72	–0.56	–1.29	–0.88	–0.29
2010	–4.20	–3.29	–0.71	–1.72	–1.22	–0.53
2020	–4.77	–3.79	–0.83	–1.90	–1.34	–0.58
2030	–5.23	–4.20	–0.93	–2.02	–1.42	–0.61

8.2 Financing social security benefits at the margin with general tax revenues

Next we consider a scenario where payroll tax rates are fixed at their year-2004 values throughout the transition. The budgets of the social security systems are then financed by general tax revenues. The results are reported in the eighth panels of Appendix Tables A1–A4.

Balancing the future budgets of the social security systems by general tax revenues increases the wage tax rate in all four regions. In year 2100, the average wage tax rate is now 17.8 per cent in the US instead of 6.8 per cent in the base case. In the EU it is 17.8 per cent instead of 7.4 per cent, in Japan 12.0 per cent instead of 2.7 per cent, and in China 17.6 per cent instead of 1.9 per cent. Note that the wage tax rates do not increase as much as the payroll tax rates would otherwise have risen because there is no ceiling on wages subject to taxation. This differentially reduces the welfare of high-earning agents. It also reduces their ability to save and their desire to work. Thus capital stocks, labour supply and national income are lower than in the base case. The paths of current accounts, wage rates and interest rates are, however, little changed.

Table 9 records the welfare effects of this policy. Agents in the low- and middle-income classes experience welfare gains since they now face a lower tax burden. Note also the differences in welfare effects between the developed regions, which stem from the different extents of population ageing in the three regions. At first glance it might be surprising that initially middle-aged and younger cohorts in the low- and middle-income classes in China experience small welfare losses while those in the high-income class enjoy welfare gains. The reason is that payroll taxes in China decline in the baseline transition during the first few decades. Keeping payroll tax rates fixed at the year-2004 level translates into lower average net wages during these decades than would otherwise be the case. This, of course, hurts people in the low- and middle-income classes, while those in the high-income class end up better off. High-income workers are less affected by the maintenance of existing payroll tax rates due to the payroll tax ceiling gain.

8.3 Financing social security benefits with government debt

This scenario examines the consequences of financing social security benefits through to 2029 with government debt. To be precise, we keep payroll tax rates in each region fixed at their year-2004 values through to 2029. We also fix the intercept and the progressive terms of our wage tax rate formula at their 2004 values. The governments' general budgets and the budgets of the social security systems are then balanced with government debt. Starting in year 2030, payroll tax rates and the intercept of the payroll tax rate formula endogenously adjust to balance social security systems and government general budgets, respectively. In the year 2030 and thereafter we keep government debt fixed as a share of national income. The ninth panels in Appendix Tables A1–A4 report results.

Table 9: Welfare Effects of Financing Benefits by General Tax Revenues in All Regions

Birth year	US income class			EU income class		
	1	2	3	1	2	3
1920	–0.02	–0.01	0.00	–0.05	–0.03	–0.04
1930	–0.02	–0.01	0.00	–0.05	–0.04	–0.05
1940	–0.04	–0.02	–0.01	–0.06	–0.05	–0.04
1950	–0.02	–0.02	–0.01	–0.02	–0.02	–0.02
1960	0.00	–0.01	–0.01	0.09	0.04	–0.03
1970	0.05	0.02	–0.02	0.22	0.14	–0.10
1980	0.12	0.07	–0.08	0.39	0.27	–0.20
1990	0.20	0.13	–0.16	0.73	0.56	–0.62
2000	0.28	0.19	–0.25	1.13	0.89	–1.09
2010	0.33	0.23	–0.28	1.48	1.21	–1.53
2020	0.34	0.25	–0.35	1.65	1.38	–1.87
2030	0.35	0.26	–0.49	1.65	1.40	–2.06
	Japan income class			**China income class**		
	1	2	3	1	2	3
1920	–0.08	–0.04	–0.23	0.00	0.02	–0.08
1930	–0.08	–0.04	–0.19	0.00	0.01	–0.08
1940	–0.10	–0.06	–0.26	–0.02	–0.01	–0.10
1950	0.05	0.02	–0.14	–0.19	–0.15	0.02
1960	0.37	0.23	–0.12	–0.34	–0.27	0.11
1970	0.62	0.43	–0.34	–0.30	–0.24	0.10
1980	0.80	0.58	–0.50	–0.20	–0.18	0.04
1990	1.19	0.91	–0.94	–0.02	–0.07	–0.03
2000	1.47	1.11	–1.17	0.21	0.11	–0.13
2010	1.75	1.34	–1.43	0.35	0.23	–0.19
2020	2.05	1.62	–1.82	0.38	0.26	–0.30
2030	2.18	1.75	–2.09	0.44	0.30	–0.46

From 2004 to 2100, in the US debt increases from 33.3 to 73.8 per cent of national income, in the EU from 38.9 to 134.6 per cent, and in Japan from 41.4 to 249.5 per cent. In China, payroll tax and wage tax rates decline (with some minor exceptions) in each year during the first few decades of the baseline transition. Consequently, holding these tax rates fixed through 2030 in China means running a budget surplus. Indeed, in 2100 government debt in China is negative 38.8 per cent of national income, rather than positive 10 per cent – its baseline year-2100 value.

Higher debt ultimately implies higher average tax rates in order to finance higher interest payments. In 2100, average wage tax rates are 11.9 per cent in the US, 22.5 per cent in the EU, and 33.1 per cent in Japan. The corresponding 2100 baseline average wage tax rates are 6.8 per cent in the US, 7.4 per cent in the EU and 2.7 per cent in Japan.

These are, obviously, huge increases. Of course, one would expect capital formation, labour supply and output growth to be greatly reduced by this policy. But this doesn't happen because China's budget surplus provides an additional pool of savings for foreign investment.

Next, consider the welfare effects of this policy, shown in Table 10. Initial middle-aged and younger generations in the US, the EU and Japan gain from this policy reform. This reflects, of course, the fact that they enjoy constant rather than rising tax rates through 2030. The gains are largest in Japan since in the baseline path its taxpayers experience the largest increase in social security contributions. Future cohorts in the developed regions experience remarkably large welfare losses. These stem from the large increase in wage taxes to finance the higher government debt. Take, as an example, members of the 2030 Japanese birth cohort. Low-income members of this cohort experience a 20.25 per cent welfare loss. This demonstrates the dramatic increase in excess burdens due to the adjustment in the wage taxes. The opposite is observed in China. Here middle-aged people lose from the reform since they now face higher payroll tax burdens. Future cohorts, however, experience welfare gains from the lower and even negative wage taxes.

8.4 Cutting pension-benefit replacement rates

As mentioned, our baseline path includes the legislated cut in the pension replacement rates in Japan of 20 per cent that is being phased in between now and 2017. We now assume the same cut occurs in all other regions over the same period. The simulation results are reported in the tenth panels of Appendix Tables A1–A4. In 2100, social security contribution rates are reduced by 3.6 percentage points in the US, by 4.7 percentage points in the EU and by 4.6 percentage points in China compared to the respective baseline values. As one would expect, this policy increases capital formation in the three regions. Thus the long-run capital stock is increased by 11.6 per cent in the US, by 10.3 per cent in the EU and by 11.2 per cent in China relative to the base case. At the same time, the labour supply is slightly reduced and output growth increases. The higher capital-labour ratios lead to higher wages and lower interest rates during the transition. Due to higher wage income, the average wage tax rates in the three regions are lower than in the baseline path.

Table 10: Welfare Effects of Financing Benefits by Debt

Birth year	US income class			EU income class		
	1	2	3	1	2	3
1920	0.01	–0.02	0.00	–0.09	–0.12	0.02
1930	0.09	0.05	0.02	–0.04	–0.07	0.06
1940	0.18	0.13	0.06	0.06	0.02	0.11
1950	0.26	0.19	0.11	0.35	0.23	0.15
1960	0.43	0.31	0.17	0.83	0.60	0.27
1970	0.53	0.44	0.27	1.53	1.18	0.42
1980	0.23	0.28	0.24	0.90	0.87	0.34
1990	–0.07	0.10	0.18	0.06	0.32	0.07
2000	–1.00	–0.58	–0.14	–2.45	–1.69	–0.69
2010	–3.03	–2.16	–1.06	–7.01	–5.74	–2.21
2020	–3.55	–2.52	–1.22	–8.56	–7.11	–2.85
2030	–4.08	–2.89	–1.36	–10.72	–9.06	–3.77
	Japan income class			**China income class**		
	1	2	3	1	2	3
1920	–0.28	–0.18	0.08	0.07	0.06	0.03
1930	–0.19	–0.19	0.10	0.13	0.12	0.08
1940	–0.10	–0.02	0.19	0.29	0.28	0.20
1950	0.62	0.42	0.26	0.56	0.48	0.29
1960	2.27	1.53	0.44	0.46	0.39	0.24
1970	3.50	2.59	0.62	0.21	0.24	0.20
1980	1.75	1.62	0.39	0.23	0.32	0.20
1990	–0.62	0.00	–0.39	–0.02	0.17	0.22
2000	–6.90	–5.10	–2.30	–0.53	–0.22	0.09
2010	–15.80	–12.97	–5.31	–1.00	–0.60	–0.18
2020	–17.05	–14.03	–5.95	–0.93	–0.49	–0.05
2030	–20.25	–16.94	–7.42	–0.75	–0.30	0.16

The pension reform in the US, the EU and China also affects the Japanese economy in the future. Larger capital stocks in the US, the EU and China lead to larger capital imports by Japan. Consequently, Japan's capital stock and national income are also higher compared to the base case. The increase in wages during the transition lowers payroll tax rates slightly since the labour supply remains unaffected. However, the average wage tax rate increases due to the higher growth in general government expenditures arising from higher output growth.

As the welfare effects in Table 11 indicate, initially middle-aged people lose from this policy reform in all four regions. In the US, the EU and China this reflects the cut in pension replacement rates. People now receive lower benefits than under the baseline scenario. In Japan the losses stem from the increases in the average wage tax rate. Initial older cohorts in the four regions are almost unaffected. Initial young and future cohorts, however, gain in all four regions. The reason is mainly the reduction in payroll and wage tax rates in the US, the EU and China and the increased wages that outweigh the benefit losses. In Japan, the welfare gains of the low- and middle-income classes also stem from the reduction in payroll taxes and the higher wages. The highest income classes are adversely affected by the increase in the wage tax rate.

8.5 Privatising pensions

Our final scenario is complete pension privatisation, which we model as the elimination of any new public pension benefit accrual coupled with the establishment of individual accounts. The reform entails paying off all accrued benefits to those retired in 2004 and to those working in 2004 when they reach retirement. To approximate this pay-off of accrued benefits we pay initial retirees their full benefits over time and pay post-2004 retirees benefits in retirement whose values are linearly phased out over a 45-year period starting in 2004. Thus, the members of the cohort retiring in 2005 receive in public pension benefits 44/45ths of what they would otherwise have received. The members of the cohort retiring in 2006 receive 43/45ths of what they would have received, and so on.

We finance the move to individual accounts via consumption taxation. Specifically, we completely eliminate those payroll taxes used to finance state pensions and impose a new consumption tax in each region to pay, over time, all accrued benefits. By 2078 all accrued pension benefits have been paid off, so the new consumption tax rates from that point on are zero.

The key feature of the reform is not 'privatisation' *per se*, but rather the intergenerational redistribution associated with moving to private accounts. The redistribution comprises three elements. First, the shift from payroll to consumption taxation reduces the tax burden on current and future workers and shifts it onto current retirees. Second, paying current workers (those working in 2004) when they reach retirement only their accrued state pension benefits rather than their projected benefits represents a cut in transfer payments that hurts those workers but benefits future workers who would otherwise have had to help pay for those benefits. Third, factor price changes arising from this policy help later generations at the cost of

Table 11: Welfare Effects of a Cut in Replacement Rates in All Regions

Birth year	US income class			EU income class		
	1	2	3	1	2	3
1920	0.21	0.12	0.00	0.34	0.23	–0.04
1930	0.10	0.03	–0.03	0.28	0.17	–0.10
1940	–0.02	–0.08	–0.09	0.13	0.03	–0.17
1950	–2.84	–1.59	–0.48	–3.04	–1.75	–0.48
1960	–1.80	–1.11	–0.46	–2.98	–1.84	–0.57
1970	–0.49	–0.34	–0.25	–1.11	–0.70	–0.35
1980	0.67	0.46	0.08	0.41	0.35	–0.10
1990	1.64	1.15	0.38	2.29	1.83	0.36
2000	2.84	1.76	0.64	4.21	3.33	0.78
2010	3.04	2.13	0.79	5.76	4.57	1.11
2020	3.51	2.42	0.86	6.87	5.48	1.34
2030	4.02	2.77	0.94	7.58	6.07	1.48
	Japan income class			**China income class**		
	1	2	3	1	2	3
1920	–0.10	–0.03	0.00	0.04	0.18	0.25
1930	–0.20	–0.12	–0.05	–0.05	0.08	0.16
1940	–0.36	–0.26	–0.15	–0.27	–0.13	0.00
1950	–0.45	–0.36	–0.23	–3.71	–3.14	–1.79
1960	–0.23	–0.27	–0.25	–3.18	–2.55	–1.32
1970	0.06	–0.11	–0.25	–1.71	–1.39	–0.73
1980	0.23	0.01	–0.23	–0.74	–0.74	–0.43
1990	0.60	0.28	–0.13	0.50	0.07	–0.29
2000	0.83	0.41	–0.12	2.03	1.23	0.19
2010	0.98	0.50	–0.15	3.33	2.22	0.83
2020	1.16	0.62	–0.20	3.84	2.53	0.93
2030	1.31	0.71	–0.31	4.36	2.86	1.00

hurting earlier ones. Specifically, later generations benefit from higher real wages, while earlier generations lose from receiving lower returns on their assets.

There is no need to formally model the private accounts in which agents would be forced to save as part of this privatisation reform. The reason is that our agents face no liquidity constraints. Hence, they are free to borrow against their private account balances if they wish to consume more than their disposable income net of contributions to these accounts. Consequently, forcing our agents to save has no impact on their behaviour.[8]

In the US, the additional consumption tax rate needed to pay off accrued pension benefits is initially 6.8 per cent and gradually declines thereafter. The US payroll tax rate declines immediately by 7.8 percentage points. Over the transition, the payroll tax rate rises by 2.7 percentage points since expenses for health care and disability insurance grow.

In the EU, the added consumption tax rate has an initial value of 15.0 per cent and then declines. Because of this reform, the payroll tax is reduced by 14.6 percentage points in 2004 and rises to a maximum of 13.9 per cent in 2075. In Japan, the consumption tax rate is initially 11.1 per cent. It then rises to a maximum of 12.7 per cent in 2016 before declining. The payroll tax is 12.1 percentage points lower in 2004. And the maximum value reached is 15.7 per cent in 2050. Finally, the initial rate of the new consumption tax in China is 10.5 per cent. The payroll tax rate is initially reduced by 8 percentage points and rises to its maximum value of 5.5 per cent in 2075.

Of course, since part of the tax burden is shifted from payroll taxes towards consumption taxes, the burden on younger households falls and that on the elderly rises. The intergenerational redistribution associated with the consumption tax depresses aggregate consumption, which permits an increase in national saving and capital formation. The long-run consequences of this reform are dramatic in all three regions. Relative to the baseline simulations, the year 2100 capital stock increases by 87.6 per cent in the US, by 81.1 per cent in the EU, by 90.4 per cent in Japan, and by 83.2 per cent in China.

The higher capital stocks increase gross wages, which rise by by approximately 18 per cent in all four regions by 2100. The combination of higher gross wages and reduced payroll and wage taxes boosts net wages, which almost double in the four regions. The reductions in labour supply in the four regions, reported in Appendix Tables A1–A4, are a direct consequence of the positive income effects experienced by younger generations. Finally, capital accumulation leads to lower year-2100 interest rates.

8. Including liquidity constraints would require solving our agents' utility maximisation problems using dynamic programming. Doing so would be much more time-consuming. It would also introduce a degree of approximation error into the solution that we avoid with our current formulation in which we find the solutions to the first-order conditions and budget constraints of our agents to a very high degree of precision using Gauss-Seidel iteration.

Of course, the advantageous macroeconomic effects of privatisation come at a cost, which is shown in Table 12. The reform entails a major redistribution from older generations in all four economies towards younger and future generations. The intergenerational and intragenerational redistribution is less severe in the US compared to the EU, Japan and China, whose initial consumption tax rates are much higher.

The elderly are hurt because they are now forced to pay for their pension benefits via the consumption tax. Younger and future generations benefit enormously from the policy since they face much lower payroll tax burdens during their working years and experience much higher wages. Consider middle-income agents in the US. The oldest such agents included in Table 12 – those born in 1920 – experience a 2.9 per cent reduction in welfare. In contrast, the youngest such agents included in the table – those born in 2030 – enjoy a 12.2 per cent rise in welfare. For the

Table 12: Welfare Effects of Privatising Pensions in All Regions

Birth year	US income class			EU income class		
	1	2	3	1	2	3
1920	–4.72	–2.88	–1.01	–8.92	–6.14	–3.39
1930	–5.14	–3.19	–1.08	–9.06	–6.39	–3.73
1940	–5.73	–3.82	–1.48	–9.42	–6.67	–3.73
1950	–6.31	–4.17	–2.11	–9.06	–6.22	–3.12
1960	–4.50	–3.17	–2.09	–5.82	–4.05	–3.05
1970	–1.69	–1.19	–1.57	–2.40	–1.29	–2.60
1980	1.22	1.18	–0.34	0.97	1.51	–1.59
1990	3.67	2.99	0.73	5.19	5.36	0.22
2000	7.10	5.28	1.80	11.93	10.22	1.77
2010	10.84	7.60	2.72	19.36	15.48	3.31
2020	14.59	9.89	3.48	26.30	20.25	4.62
2030	18.27	12.21	4.22	30.92	23.49	5.50
	Japan income class			**China income class**		
	1	2	3	1	2	3
1920	–8.12	–5.31	–2.32	–7.11	–6.34	–4.36
1930	–8.84	–5.78	–2.42	–6.73	–6.01	–4.12
1940	–9.49	–6.60	–3.25	–7.14	–6.43	–4.48
1950	–6.01	–4.37	–2.81	–9.38	–8.07	–5.68
1960	–1.94	–1.62	–2.45	–8.63	–7.02	–4.49
1970	0.35	0.55	–2.10	–7.01	–5.71	–3.47
1980	2.20	2.31	–1.29	–5.52	–4.69	–2.50
1990	4.56	4.62	–0.15	–2.17	–2.54	–2.37
2000	8.29	7.09	0.61	5.13	2.71	–0.51
2010	12.78	9.99	1.35	12.82	8.31	2.74
2020	17.83	13.38	2.12	17.11	10.89	3.81
2030	21.54	15.90	2.64	21.21	13.34	4.65

other regions, corresponding welfare losses and gains experienced by the 1920 and 2030 middle classes are 6.1 per cent and 23.5 per cent in the EU, 5.3 per cent and 15.9 per cent in Japan, and 6.3 per cent and 13.3 per cent in China.

Another key feature of Table 12 is that, among those who are initially elderly, the poor experience larger welfare losses than the middle-class or the rich. The explanation for this differential welfare loss is that both the poor and rich elderly are constrained with respect to their consumption of leisure because they are both fully retired. However, the rich elderly are consuming a lot more than the poor. Hence, while both the rich and the poor experience roughly the same percentage reduction in consumption from the imposition of the consumption tax, the impact on their utilities are not the same because: (a) their initial consumption-leisure ratios differ; and (b) utility is not separable with respect to the two arguments.

9. Conclusion

The developed world and China all face enormous demographic changes which will greatly challenge their already overly stressed fiscal institutions. Fortunately, our dynamic life-cycle model suggests there may be a macroeconomic silver lining to this very grey demographic cloud. The silver lining is China, whose continued rapid acquisition of technology and human capital and extraordinarily high rate of saving can dramatically raise the world's supply of capital. Assuming the developed world's capital market remains open, China will gradually become the developed world's major source of capital.

Indeed, assuming China attains the developed world's living standard by the middle of this century and also maintains its very high propensity to save, it will raise real wages in the developed world by 40 per cent. This is over and above real wage increases arising from technological change. Even were China to gradually adopt Western spending habits, real wages at mid century will still be 16 per cent higher than is currently the case. This again is above and beyond what technological change can be expected to deliver.

Moreover, China's contribution to the developed world's own development is positive in both the short run and the long run. Even though capital initially moves from the developed world to China, there are no major short-run reductions in developed-world real wages. The reason is that the prospect of higher future real wages leads developed-world workers to supply less current labour. This keeps initial developed-world capital-labour ratios and the real wages on which they depend from falling.

Absent China, our model suggests a very gradual decline in the developed world's capital intensivity, with real wages per unit of human capital 4 per cent lower at the end of the century than they are today. This is much less ominous news than we delivered in previous studies that omitted China. The reason is that we now incorporate government investment, which implies more developed-world saving.

In addition to examining China's role in world economic development and incorporating government investment, this study has entertained a variety of demographic and fiscal scenarios. Our demographic scenarios, which we apply to all four regions simultaneously, are: (a) maintaining fertility rates at their current, generally very low, levels for much longer than governments now project; (b) increasing longevity at faster than projected rates; and (c) immediately and permanently doubling rates of immigration.

Each of these demographic changes has very little impact on the overall macroeconomic situation, but each makes a non-trivial difference to where payroll tax rates end up. For example, Japan's payroll tax rate ends up 25 per cent higher at the end of the century if its fertility rate fails to rise to the now-projected 2050 level; the EU's payroll tax rate ends 5 percentage points higher in 2030 if EU life expectancy rises by three years more by 2050 than now expected; and the US payroll tax rate is reduced by 1 per cent in 2050 if it doubles its rate of immigration.

Our five policy simulations: raised the rate of growth of health expenditures over the next quarter-century; switched, at the margin, to income-tax finance of government pension benefits; financed future increases in aggregate pension benefits via increases in public debt rather than payroll taxes; reduced generosity of welfare benefits to retirees; and privatised state pension systems by paying off accrued pension benefits with a consumption tax. Each of these policies has important macroeconomic impacts. But the one with the biggest impact is the privatisation of state pensions, which more than doubles long-run ratios of physical capital per unit of human capital and raises long-run real wages by roughly a quarter. The policy delivers major benefits to future generations, both because of the higher wages they earn and the dramatically lower payroll tax rates that they face.

To conclude, there is no reason to believe that China is currently eating our lunch or will do so in the near future. On the contrary, there is good reason to believe that China is in the process of taking us to dinner by slowly but surely becoming the world's biggest saver and the developed world's major supplier of capital.

Appendix A

Table A1: Simulation Results for the US

(continued next page)

	Year	Index of national income	Index of capital stock	Index of labour supply	Current account/ national income	Index of pre-tax wage	Interest rate	Social security payroll tax rate	Average wage tax
Baseline	2004	1.00	1.00	1.00	0.028	1.00	0.098	0.116	0.078
	2010	1.13	1.19	1.12	–0.039	1.02	0.093	0.119	0.070
	2020	1.47	1.92	1.35	–0.144	1.09	0.075	0.138	0.069
	2030	1.89	3.04	1.62	–0.168	1.17	0.061	0.164	0.078
	2050	2.63	4.11	2.28	0.054	1.16	0.063	0.171	0.093
	2075	3.29	4.05	3.08	0.037	1.07	0.080	0.207	0.080
	2100	4.11	4.67	3.96	0.017	1.04	0.087	0.230	0.068
Constant time preference in China	2004	1.00	1.00	1.00	0.024	1.00	0.098	0.116	0.078
	2010	1.13	1.20	1.11	–0.053	1.02	0.093	0.119	0.070
	2020	1.46	1.99	1.33	–0.210	1.11	0.072	0.138	0.069
	2030	1.90	3.50	1.57	–0.323	1.22	0.054	0.163	0.078
	2050	3.02	8.39	2.17	–0.253	1.40	0.036	0.151	0.087
	2075	4.62	18.45	2.95	–0.171	1.58	0.025	0.153	0.081
	2100	6.09	26.09	3.78	–0.084	1.62	0.023	0.164	0.078
Lower technology growth in China	2004	0.98	0.98	0.99	–0.063	1.00	0.099	0.117	0.074
	2010	1.17	1.35	1.11	–0.115	1.05	0.085	0.114	0.073
	2020	1.55	2.28	1.37	–0.158	1.14	0.067	0.130	0.077
	2030	1.95	3.41	1.63	–0.142	1.20	0.056	0.160	0.085
	2050	2.67	4.29	2.29	0.059	1.17	0.061	0.171	0.096
	2075	3.24	3.86	3.07	0.044	1.06	0.083	0.211	0.082
	2100	4.06	4.50	3.94	0.016	1.03	0.089	0.233	0.069
Constant fertility in all regions	2004	1.00	1.00	1.00	0.028	1.00	0.098	0.116	0.078
	2010	1.13	1.19	1.12	–0.039	1.02	0.093	0.119	0.070
	2020	1.47	1.92	1.35	–0.147	1.09	0.075	0.138	0.070
	2030	1.89	3.06	1.62	–0.180	1.17	0.061	0.164	0.080
	2050	2.73	4.34	2.35	0.033	1.16	0.062	0.166	0.098
	2075	3.69	4.67	3.43	0.024	1.08	0.078	0.188	0.093
	2100	4.81	5.42	4.64	0.033	1.04	0.087	0.209	0.079

Table A1: Simulation Results for the US

(continued next page)

	Year	Index of national income	Index of capital stock	Index of labour supply	Current account/ national income	Index of pre-tax wage	Interest rate	Social security payroll tax rate	Average wage tax
Higher life expectancy in all regions	2004	1.00	1.00	1.00	0.024	1.00	0.098	0.116	0.077
	2010	1.14	1.22	1.12	–0.046	1.02	0.092	0.119	0.070
	2020	1.49	2.02	1.36	–0.152	1.10	0.073	0.138	0.069
	2030	1.93	3.29	1.63	–0.182	1.19	0.058	0.168	0.077
	2050	2.75	4.72	2.31	0.043	1.19	0.057	0.184	0.090
	2075	3.42	4.46	3.14	0.052	1.09	0.075	0.228	0.079
	2100	4.23	4.92	4.05	0.020	1.05	0.085	0.254	0.065
Doubling immigration in all regions	2004	1.01	1.00	1.00	0.026	1.00	0.098	0.116	0.076
	2010	1.17	1.22	1.14	–0.044	1.02	0.093	0.117	0.069
	2020	1.57	2.04	1.45	–0.148	1.09	0.076	0.131	0.069
	2030	2.10	3.34	1.80	–0.170	1.17	0.062	0.153	0.079
	2050	3.13	4.84	2.71	0.048	1.16	0.064	0.160	0.091
	2075	4.17	5.14	3.90	0.035	1.07	0.080	0.198	0.078
	2100	5.41	6.22	5.18	0.021	1.05	0.085	0.224	0.063
Health expenditures rise by 3 per cent in all regions	2004	1.00	1.00	1.00	0.028	1.00	0.098	0.116	0.078
	2010	1.14	1.20	1.12	–0.039	1.02	0.093	0.120	0.070
	2020	1.47	1.93	1.35	–0.140	1.09	0.075	0.143	0.069
	2030	1.89	3.05	1.62	–0.166	1.17	0.061	0.177	0.079
	2050	2.63	4.06	2.29	0.054	1.15	0.064	0.184	0.094
	2075	3.28	3.96	3.09	0.037	1.06	0.081	0.224	0.082
	2100	4.10	4.55	3.97	0.017	1.03	0.089	0.248	0.070
Financing benefits by general tax revenues	2004	1.00	1.00	1.00	0.028	1.00	0.098	0.116	0.078
	2010	1.13	1.20	1.12	–0.039	1.02	0.093	0.116	0.073
	2020	1.47	1.92	1.35	–0.144	1.09	0.075	0.116	0.090
	2030	1.88	3.05	1.61	–0.172	1.17	0.061	0.116	0.125
	2050	2.63	4.13	2.28	0.054	1.16	0.063	0.116	0.146
	2075	3.27	4.04	3.07	0.037	1.07	0.080	0.116	0.169
	2100	4.07	4.59	3.93	0.018	1.04	0.087	0.116	0.178

Table A1: Simulation Results for the US
(continued)

	Year	Index of national income	Index of capital stock	Index of labour supply	Current account/ national income	Index of pre-tax wage	Interest rate	Social security payroll tax rate	Average wage tax
Financing benefits by debt	2004	1.00	1.00	1.00	0.031	1.00	0.098	0.116	0.078
	2010	1.13	1.18	1.11	–0.039	1.01	0.094	0.116	0.070
	2020	1.47	1.88	1.35	–0.146	1.09	0.077	0.116	0.069
	2030	1.86	2.99	1.60	–0.164	1.17	0.061	0.166	0.098
	2050	2.61	3.91	2.29	0.044	1.14	0.066	0.173	0.116
	2075	3.24	3.74	3.10	0.035	1.05	0.085	0.210	0.123
	2100	4.03	4.21	3.99	0.016	1.01	0.094	0.234	0.119
Cut in replacement rates in all regions	2004	1.00	1.00	1.01	0.029	1.00	0.098	0.116	0.078
	2010	1.14	1.21	1.12	–0.039	1.02	0.092	0.177	0.069
	2020	1.48	1.99	1.35	–0.143	1.10	0.073	0.126	0.068
	2030	1.91	3.19	1.62	–0.169	1.18	0.059	0.144	0.076
	2050	2.66	4.39	2.26	0.054	1.18	0.060	0.148	0.088
	2075	3.35	4.46	3.06	0.034	1.10	0.074	0.176	0.076
	2100	4.21	5.21	3.94	0.016	1.07	0.079	0.194	0.065
Privatising pensions	2004	1.01	1.00	1.02	0.021	0.99	0.100	0.038	0.077
	2010	1.17	1.29	1.13	–0.047	1.03	0.089	0.039	0.068
	2020	1.54	2.26	1.36	–0.144	1.13	0.067	0.044	0.065
	2030	1.99	3.77	1.62	–0.171	1.24	0.052	0.054	0.071
	2050	2.81	5.79	2.22	0.050	1.27	0.048	0.052	0.076
	2075	3.68	7.01	2.99	0.018	1.24	0.052	0.060	0.062
	2100	4.71	8.76	3.85	0.010	1.23	0.053	0.065	0.054

Table A2: Simulation Results for the EU

(continued next page)

	Year	Index of national income	Index of capital stock	Index of labour supply	Current account/ national income	Index of pre-tax wage	Interest rate	Social security payroll tax rate	Average wage tax
Baseline	2004	1.42	1.38	1.45	0.083	0.99	0.098	0.253	0.080
	2010	1.53	1.57	1.53	0.032	1.01	0.093	0.265	0.060
	2020	1.79	2.27	1.67	–0.052	1.08	0.075	0.286	0.051
	2030	2.03	3.17	1.76	–0.083	1.16	0.061	0.327	0.058
	2050	2.28	3.44	2.00	0.031	1.14	0.063	0.381	0.071
	2075	2.57	3.06	2.44	0.014	1.06	0.080	0.380	0.079
	2100	3.19	3.50	3.11	0.020	1.03	0.087	0.367	0.074
Constant time preference in China	2004	1.42	1.38	1.45	0.081	0.99	0.098	0.253	0.080
	2010	1.53	1.58	1.53	0.025	1.01	0.093	0.265	0.060
	2020	1.81	2.38	1.66	–0.094	1.09	0.072	0.286	0.053
	2030	2.09	3.71	1.74	–0.194	1.21	0.054	0.321	0.066
	2050	2.69	7.21	1.95	–0.215	1.39	0.036	0.329	0.101
	2075	3.67	14.11	2.36	–0.157	1.56	0.025	0.273	0.123
	2100	4.76	19.68	2.99	–0.076	1.60	0.023	0.261	0.120
Lower technology growth in China	2004	1.41	1.36	1.44	0.005	0.99	0.099	0.255	0.078
	2010	1.58	1.78	1.53	–0.035	1.04	0.085	0.255	0.071
	2020	1.89	2.71	1.69	–0.069	1.12	0.067	0.272	0.072
	2030	2.11	3.57	1.79	–0.057	1.19	0.056	0.317	0.075
	2050	2.31	3.60	2.01	0.037	1.16	0.061	0.377	0.081
	2075	2.54	2.93	2.44	0.022	1.05	0.083	0.385	0.082
	2100	3.15	3.38	3.10	0.020	1.02	0.089	0.369	0.074
Constant fertility in all regions	2004	1.42	1.38	1.44	0.082	0.99	0.098	0.253	0.080
	2010	1.53	1.56	1.53	0.030	1.01	0.093	0.265	0.060
	2020	1.78	2.25	1.66	–0.054	1.08	0.075	0.287	0.050
	2030	2.01	3.14	1.74	–0.083	1.16	0.061	0.329	0.055
	2050	2.17	3.34	1.90	0.034	1.15	0.062	0.394	0.062
	2075	2.19	2.67	2.06	0.017	1.07	0.078	0.424	0.060
	2100	2.45	2.67	2.39	0.005	1.03	0.087	0.412	0.065

Table A2: Simulation Results for the EU

(continued next page)

	Year	Index of national income	Index of capital stock	Index of labour supply	Current account/ national income	Index of pre-tax wage	Interest rate	Social security payroll tax rate	Average wage tax
Higher life expectancy in all regions	2004	1.43	1.38	1.45	0.081	0.99	0.098	0.253	0.080
	2010	1.55	1.60	1.54	0.029	1.01	0.092	0.264	0.061
	2020	1.83	2.40	1.69	–0.056	1.09	0.073	0.286	0.053
	2030	2.09	3.44	1.78	–0.090	1.18	0.058	0.330	0.059
	2050	2.39	3.98	2.04	0.022	1.18	0.057	0.397	0.069
	2075	2.68	3.39	2.50	0.026	1.08	0.075	0.402	0.079
	2100	3.29	3.70	3.18	0.023	1.04	0.085	0.390	0.072
Doubling immigration in all regions	2004	1.43	1.38	1.45	0.082	0.99	0.098	0.253	0.080
	2010	1.55	1.58	1.55	0.030	1.00	0.093	0.263	0.060
	2020	1.85	2.32	1.72	–0.052	1.08	0.076	0.281	0.052
	2030	2.14	3.30	1.86	–0.084	1.15	0.062	0.317	0.060
	2050	2.53	3.79	2.22	0.032	1.14	0.064	0.360	0.075
	2075	3.02	3.61	2.86	0.016	1.06	0.080	0.364	0.079
	2100	3.89	4.33	3.77	0.023	1.03	0.085	0.356	0.069
Health expenditures rise by 3 per cent in all regions	2004	1.43	1.38	1.45	0.084	0.99	0.098	0.253	0.080
	2010	1.54	1.58	1.54	0.033	1.01	0.093	0.270	0.061
	2020	1.80	2.29	1.68	–0.050	1.08	0.075	0.303	0.053
	2030	2.04	3.18	1.77	–0.086	1.16	0.061	0.359	0.061
	2050	2.30	3.43	2.02	0.026	1.14	0.064	0.413	0.078
	2075	2.59	3.03	2.48	0.011	1.05	0.081	0.412	0.090
	2100	3.22	3.46	3.17	0.017	1.02	0.089	0.399	0.087
Financing benefits by general tax revenues	2004	1.42	1.38	1.45	0.084	0.99	0.098	0.253	0.080
	2010	1.53	1.57	1.53	0.032	1.01	0.093	0.253	0.071
	2020	1.79	2.27	1.67	–0.051	1.08	0.075	0.253	0.081
	2030	2.02	3.17	1.75	–0.085	1.16	0.061	0.253	0.124
	2050	2.26	3.44	1.98	0.028	1.15	0.063	0.253	0.184
	2075	2.56	3.06	2.43	0.013	1.06	0.080	0.253	0.195
	2100	3.17	3.46	3.10	0.021	1.03	0.087	0.253	0.178

Table A2: Simulation Results for the EU
(continued)

	Year	Index of national income	Index of capital stock	Index of labour supply	Current account/ national income	Index of pre-tax wage	Interest rate	Social security payroll tax rate	Average wage tax
Financing benefits by debt	2004	1.42	1.38	1.44	0.080	0.99	0.098	0.253	0.080
	2010	1.52	1.55	1.53	0.026	1.00	0.094	0.253	0.060
	2020	1.79	2.23	1.68	–0.063	1.07	0.077	0.253	0.051
	2030	1.96	3.04	1.70	–0.112	1.16	0.061	0.340	0.112
	2050	2.26	3.28	2.01	0.006	1.13	0.066	0.383	0.135
	2075	2.58	2.89	2.50	–0.012	1.04	0.085	0.378	0.196
	2100	3.27	3.31	3.28	–0.009	1.00	0.094	0.359	0.225
Cut in replacement rates in all regions	2004	1.43	1.39	1.46	0.085	0.99	0.098	0.251	0.080
	2010	1.55	1.60	1.54	0.036	1.01	0.092	0.260	0.060
	2020	1.82	2.36	1.68	–0.044	1.09	0.073	0.267	0.050
	2030	2.06	3.32	1.76	–0.074	1.17	0.059	0.293	0.055
	2050	2.29	3.66	1.98	0.040	1.17	0.060	0.332	0.061
	2075	2.59	3.33	2.39	0.017	1.09	0.074	0.333	0.062
	2100	3.22	3.86	3.05	0.022	1.06	0.079	0.320	0.057
Privatising pensions	2004	1.46	1.40	1.49	0.097	0.98	0.100	0.107	0.085
	2010	1.60	1.71	1.57	0.055	1.02	0.089	0.111	0.063
	2020	1.90	2.69	1.70	–0.015	1.12	0.067	0.116	0.049
	2030	2.15	3.95	1.77	–0.044	1.22	0.052	0.127	0.048
	2050	2.41	4.81	1.93	0.070	1.26	0.048	0.137	0.035
	2075	2.78	5.12	2.28	0.020	1.22	0.052	0.139	0.022
	2100	3.52	6.34	2.92	0.024	1.21	0.053	0.135	0.021

Table A3: Simulation Results for Japan

(continued next page)

	Year	Index of national income	Index of capital stock	Index of labour supply	Current account/ national income	Index of pre-tax wage	Interest rate	Social security payroll tax rate	Average wage tax
Baseline	2004	0.49	0.50	0.49	0.138	1.01	0.098	0.221	0.066
	2010	0.50	0.53	0.49	0.082	1.02	0.093	0.257	0.043
	2020	0.54	0.72	0.49	–0.050	1.10	0.075	0.299	0.027
	2030	0.60	1.00	0.52	–0.070	1.18	0.061	0.301	0.031
	2050	0.60	0.95	0.52	0.060	1.17	0.063	0.359	0.022
	2075	0.61	0.77	0.57	0.027	1.08	0.080	0.354	0.026
	2100	0.71	0.83	0.69	0.028	1.05	0.087	0.328	0.027
Constant time preference in China	2004	0.49	0.50	0.49	0.139	1.01	0.098	0.220	0.066
	2010	0.50	0.54	0.49	0.081	1.03	0.093	0.256	0.043
	2020	0.55	0.76	0.49	–0.085	1.11	0.072	0.295	0.028
	2030	0.63	1.17	0.51	–0.172	1.23	0.054	0.291	0.039
	2050	0.72	2.03	0.51	–0.180	1.41	0.036	0.304	0.051
	2075	0.89	3.62	0.56	–0.127	1.59	0.025	0.256	0.067
	2100	1.10	4.82	0.68	–0.050	1.63	0.023	0.227	0.065
Lower technology growth in China	2004	0.48	0.49	0.48	0.057	1.00	0.099	0.224	0.067
	2010	0.51	0.61	0.49	0.016	1.06	0.085	0.248	0.050
	2020	0.57	0.86	0.50	–0.066	1.14	0.067	0.283	0.040
	2030	0.63	1.12	0.52	–0.040	1.21	0.056	0.290	0.041
	2050	0.61	1.00	0.52	0.065	1.18	0.061	0.354	0.028
	2075	0.60	0.73	0.57	0.034	1.07	0.083	0.360	0.026
	2100	0.71	0.80	0.68	0.028	1.04	0.089	0.332	0.025
Constant fertility in all regions	2004	0.49	0.50	0.49	0.138	1.01	0.098	0.222	0.066
	2010	0.49	0.53	0.49	0.081	1.02	0.093	0.257	0.043
	2020	0.54	0.71	0.49	–0.053	1.10	0.075	0.300	0.026
	2030	0.60	0.99	0.51	–0.068	1.18	0.061	0.302	0.027
	2050	0.56	0.91	0.48	0.069	1.17	0.062	0.378	0.009
	2075	0.48	0.62	0.44	0.021	1.09	0.078	0.425	–0.004
	2100	0.48	0.55	0.46	–0.010	1.05	0.087	0.400	0.007

Table A3: Simulation Results for Japan

(continued next page)

	Year	Index of national income	Index of capital stock	Index of labour supply	Current account/ national income	Index of pre-tax wage	Interest rate	Social security payroll tax rate	Average wage tax
Higher life expectancy in all regions	2004	0.49	0.50	0.49	0.142	1.00	0.098	0.220	0.067
	2010	0.50	0.55	0.49	0.087	1.03	0.092	0.255	0.044
	2020	0.55	0.76	0.50	–0.047	1.11	0.073	0.298	0.027
	2030	0.62	1.08	0.52	–0.072	1.20	0.058	0.305	0.030
	2050	0.63	1.10	0.53	0.059	1.20	0.057	0.367	0.019
	2075	0.63	0.85	0.58	0.036	1.10	0.075	0.382	0.021
	2100	0.73	0.87	0.70	0.033	1.06	0.085	0.350	0.021
Doubling immigration in all regions	2004	0.49	0.50	0.49	0.138	1.01	0.098	0.221	0.066
	2010	0.50	0.54	0.49	0.083	1.02	0.093	0.256	0.043
	2020	0.54	0.72	0.50	–0.048	1.10	0.076	0.296	0.027
	2030	0.62	1.00	0.53	–0.068	1.17	0.062	0.297	0.031
	2050	0.63	0.99	0.54	0.058	1.16	0.064	0.349	0.024
	2075	0.66	0.83	0.62	0.028	1.08	0.080	0.343	0.027
	2100	0.79	0.94	0.76	0.030	1.05	0.085	0.320	0.026
Health expenditures rise by 3 per cent in all regions	2004	0.49	0.50	0.49	0.139	1.01	0.098	0.221	0.066
	2010	0.50	0.54	0.49	0.085	1.02	0.093	0.261	0.044
	2020	0.54	0.73	0.50	–0.049	1.10	0.075	0.316	0.028
	2030	0.61	1.00	0.52	–0.075	1.18	0.061	0.336	0.032
	2050	0.60	0.95	0.52	0.055	1.16	0.064	0.399	0.027
	2075	0.62	0.76	0.58	0.023	1.07	0.081	0.394	0.034
	2100	0.72	0.82	0.70	0.027	1.04	0.089	0.365	0.036
Financing benefits by general tax revenues	2004	0.49	0.50	0.49	0.142	1.01	0.098	0.221	0.065
	2010	0.49	0.53	0.49	0.086	1.02	0.093	0.221	0.072
	2020	0.54	0.72	0.49	–0.052	1.10	0.075	0.221	0.091
	2030	0.60	1.00	0.51	–0.074	1.18	0.061	0.221	0.098
	2050	0.60	0.96	0.51	0.060	1.17	0.063	0.221	0.140
	2075	0.61	0.77	0.57	0.025	1.08	0.080	0.221	0.142
	2100	0.71	0.82	0.68	0.030	1.05	0.087	0.221	0.120

Table A3: Simulation Results for Japan

(continued)

	Year	Index of national income	Index of capital stock	Index of labour supply	Current account/ national income	Index of pre-tax wage	Interest rate	Social security payroll tax rate	Average wage tax
Financing benefits by debt	2004	0.48	0.50	0.48	0.125	1.01	0.098	0.221	0.065
	2010	0.49	0.53	0.48	0.061	1.02	0.094	0.221	0.043
	2020	0.54	0.71	0.50	–0.076	1.09	0.077	0.221	0.027
	2030	0.55	0.91	0.47	–0.161	1.18	0.061	0.328	0.170
	2050	0.61	0.94	0.53	0.004	1.15	0.066	0.354	0.158
	2075	0.64	0.76	0.61	–0.028	1.05	0.085	0.339	0.265
	2100	0.78	0.84	0.77	–0.030	1.02	0.094	0.302	0.331
Cut in replacement rates in all regions	2004	0.49	0.50	0.49	0.131	1.00	0.098	0.222	0.066
	2010	0.50	0.54	0.49	0.072	1.03	0.092	0.256	0.044
	2020	0.54	0.75	0.49	–0.063	1.11	0.073	0.295	0.029
	2030	0.61	1.05	0.52	–0.080	1.19	0.059	0.296	0.034
	2050	0.61	1.03	0.52	0.057	1.19	0.060	0.352	0.026
	2075	0.63	0.86	0.57	0.018	1.11	0.074	0.345	0.033
	2100	0.75	0.94	0.70	0.021	1.08	0.079	0.315	0.038
Privatising pensions	2004	0.49	0.50	0.49	0.134	1.00	0.100	0.100	0.071
	2010	0.51	0.58	0.49	0.081	1.04	0.089	0.110	0.047
	2020	0.57	0.85	0.50	–0.042	1.14	0.067	0.129	0.032
	2030	0.64	1.24	0.52	–0.064	1.24	0.052	0.138	0.033
	2050	0.65	1.36	0.51	0.068	1.28	0.048	0.157	0.014
	2075	0.69	1.33	0.55	0.005	1.25	0.052	0.155	0.016
	2100	0.83	1.58	0.68	0.008	1.24	0.053	0.143	0.024

Table A4: Simulation Results for China
(continued next page)

	Year	Index of national income	Index of capital stock	Index of labour supply	Current account/ national income	Index of pre-tax wage	Interest rate	Social security payroll tax rate	Average wage tax
Baseline	2004	1.33	1.52	8.90	–0.161	0.15	0.098	0.111	0.071
	2010	2.29	2.76	9.78	–0.020	0.24	0.093	0.082	0.088
	2020	4.23	6.31	10.13	0.078	0.42	0.075	0.085	0.076
	2030	5.82	10.71	8.99	0.091	0.65	0.061	0.115	0.043
	2050	8.52	15.15	7.87	–0.029	1.09	0.063	0.189	–0.015
	2075	9.57	13.44	8.62	–0.018	1.12	0.080	0.269	–0.002
	2100	11.31	14.65	10.47	–0.014	1.09	0.087	0.277	0.019
Constant time preference in China	2004	1.33	1.52	8.95	–0.155	0.15	0.098	0.111	0.073
	2010	2.33	2.82	9.92	–0.007	0.24	0.093	0.082	0.092
	2020	4.56	7.06	10.77	0.115	0.43	0.072	0.080	0.094
	2030	7.01	14.62	10.38	0.161	0.68	0.054	0.099	0.086
	2050	12.12	38.24	9.27	0.121	1.32	0.036	0.149	0.063
	2075	14.80	67.12	9.05	0.100	1.65	0.025	0.224	0.013
	2100	17.66	86.13	10.54	0.053	1.69	0.023	0.260	–0.010
Lower technology growth in China	2004	1.39	1.58	9.36	0.020	0.15	0.099	0.110	0.097
	2010	1.90	2.52	10.30	0.095	0.19	0.085	0.096	0.089
	2020	2.80	4.71	11.00	0.147	0.26	0.067	0.122	0.058
	2030	3.40	6.77	10.31	0.124	0.33	0.056	0.151	0.012
	2050	4.48	8.21	9.99	–0.063	0.45	0.061	0.224	–0.054
	2075	5.02	6.83	11.54	–0.043	0.44	0.083	0.282	–0.016
	2100	6.00	7.57	14.11	–0.025	0.43	0.089	0.283	0.016
Constant fertility in all regions	2004	1.33	1.52	8.91	–0.160	0.15	0.098	0.111	0.071
	2010	2.29	2.76	9.78	–0.018	0.24	0.093	0.082	0.088
	2020	4.23	6.29	10.12	0.081	0.42	0.075	0.085	0.076
	2030	5.80	10.68	8.96	0.095	0.65	0.061	0.115	0.043
	2050	8.27	14.95	7.60	–0.025	1.09	0.062	0.193	–0.018
	2075	8.57	12.35	7.66	–0.016	1.13	0.078	0.293	–0.012
	2100	9.35	12.03	8.68	0.018	1.08	0.087	0.305	0.012

Table A4: Simulation Results for China

(continued next page)

	Year	Index of national income	Index of capital stock	Index of labour supply	Current account/ national income	Index of pre-tax wage	Interest rate	Social security payroll tax rate	Average wage tax
Higher life expectancy in all regions	2004	1.33	1.52	8.96	–0.157	0.15	0.098	0.111	0.073
	2010	2.32	2.82	9.85	–0.015	0.24	0.092	0.083	0.090
	2020	4.33	6.67	10.24	0.082	0.43	0.073	0.086	0.079
	2030	6.01	11.65	9.13	0.097	0.66	0.058	0.117	0.047
	2050	8.94	17.48	8.01	–0.023	1.12	0.057	0.202	–0.015
	2075	10.00	14.88	8.84	–0.027	1.14	0.075	0.303	–0.013
	2100	11.65	15.44	10.71	–0.016	1.10	0.085	0.318	0.017
Doubling immigration in all regions	2004	1.33	1.52	8.90	–0.159	0.15	0.098	0.111	0.071
	2010	2.28	2.74	9.75	–0.016	0.24	0.093	0.083	0.089
	2020	4.20	6.21	10.07	0.085	0.42	0.076	0.085	0.076
	2030	5.73	10.43	8.89	0.101	0.65	0.062	0.117	0.042
	2050	8.27	14.61	7.67	–0.032	1.09	0.064	0.192	–0.017
	2075	9.16	12.91	8.26	–0.023	1.12	0.080	0.273	–0.003
	2100	10.79	14.19	9.95	–0.021	1.09	0.085	0.278	0.021
Health expenditures rise by 3 per cent in all regions	2004	1.33	1.51	8.91	–0.163	0.15	0.098	0.111	0.071
	2010	2.29	2.77	9.78	–0.022	0.24	0.093	0.084	0.089
	2020	4.25	6.35	10.15	0.076	0.42	0.075	0.090	0.077
	2030	5.94	10.73	9.02	0.092	0.65	0.061	0.150	0.045
	2050	8.53	15.00	7.92	–0.028	1.08	0.064	0.238	–0.012
	2075	9.57	13.17	8.68	–0.017	1.11	0.081	0.303	0.001
	2100	11.30	14.30	10.54	–0.013	1.08	0.089	0.285	0.022
Financing benefits by general tax revenues	2004	1.32	1.52	8.90	–0.164	0.15	0.098	0.111	0.071
	2010	2.29	2.76	9.79	–0.021	0.24	0.093	0.111	0.063
	2020	4.25	6.34	10.16	0.078	0.42	0.075	0.111	0.053
	2030	5.84	10.78	9.00	0.093	0.65	0.061	0.111	0.047
	2050	8.47	15.15	7.81	–0.029	1.09	0.063	0.111	0.060
	2075	9.43	13.27	8.49	–0.018	1.12	0.080	0.111	0.149
	2100	11.16	14.33	10.36	–0.014	1.08	0.087	0.111	0.176

Table A4: Simulation Results for China
(continued)

	Year	Index of national income	Index of capital stock	Index of labour supply	Current account/ national income	Index of pre-tax wage	Interest rate	Social security payroll tax rate	Average wage tax
Financing benefits by debt	2004	1.33	1.52	8.91	–0.154	0.15	0.098	0.111	0.071
	2010	2.28	2.73	9.77	–0.012	0.23	0.094	0.083	0.088
	2020	4.21	6.16	10.12	0.087	0.42	0.077	0.085	0.075
	2030	5.81	10.62	8.99	0.106	0.65	0.061	0.115	0.043
	2050	8.40	14.37	7.87	–0.016	1.07	0.066	0.191	–0.018
	2075	9.27	12.21	8.54	–0.007	1.09	0.085	0.274	–0.010
	2100	10.79	12.87	10.27	–0.001	1.06	0.094	0.283	0.007
Cut in replacement rates in all regions	2004	1.33	1.51	8.94	–0.162	0.15	0.098	0.111	0.072
	2010	2.31	2.80	9.82	–0.020	0.24	0.092	0.081	0.089
	2020	4.29	6.55	10.17	0.076	0.42	0.073	0.077	0.077
	2030	5.91	11.25	9.02	0.088	0.66	0.059	0.101	0.044
	2050	8.62	16.20	7.82	–0.031	1.11	0.060	0.162	–0.014
	2075	9.76	14.82	8.57	–0.017	1.15	0.074	0.225	–0.002
	2100	11.54	16.29	10.38	–0.013	1.12	0.079	0.231	0.017
Privatising pensions	2004	1.33	1.50	9.01	–0.171	0.15	0.100	0.031	0.077
	2010	2.36	2.98	9.91	–0.031	0.24	0.089	0.028	0.094
	2020	4.49	7.51	10.33	0.061	0.44	0.067	0.030	0.083
	2030	6.28	13.55	9.19	0.076	0.69	0.052	0.039	0.052
	2050	9.18	21.55	7.74	–0.038	1.19	0.048	0.052	–0.007
	2075	10.69	23.20	8.33	–0.012	1.29	0.052	0.055	–0.002
	2100	12.66	26.84	9.95	–0.011	1.28	0.053	0.053	0.010

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Discussion

Wen Jiandong

I would like to start by congratulating Larry Kotlikoff for his excellent paper, which provides us with an insight into the impacts of demographic change on global macroeconomic variables. The paper focuses on Japan, the United States and the European Union as examples of developed countries/regions and China as an example of a developing country. Its main conclusion, with which I agree, is that China, by acting initially as a capital absorber and then later as a supplier of savings, can play an important role in moderating the impacts of demographic change and enhancing the welfare of both developing and developed economies.

Using an extension of the overlapping generations model (Samuelson 1958; Diamond 1965) with consumers whose saving patterns conform to the life-cycle hypothesis (Ando and Modigliani 1957), the paper reinforces the importance of cross-country interdependence. Cross-border movements of goods and finance can act as a buffer, cushioning the impacts of ageing by providing economies with greater investment opportunities and sources of funds, across space and time. However, achieving these gains will require greater co-ordination of macroeconomic policies and the abandonment of protectionism. Barriers to trade and foreign direct investment do harm to present as well as future generations. I also feel that another solution to the challenges brought about by population ageing may be freer movement of people, as proposed by Mode IV of the World Trade Organisation's General Agreement on Trade in Services.

If we accept the argument of this paper (and others presented at this workshop), global imbalances, which are a controversial issue right now, are to some extent the natural result of demographic change. It is important to note that China, despite its high saving rate, currently runs a trade deficit with 'younger' economies, like those of the Association of Southeast Asian Nations. In turn, China runs a trade surplus with the EU and the US and exports its savings to these economies. This pattern is not unique to China. As Ito and Krueger (1999) show, Japan's foreign exchange reserves are highly correlated with demographic variables and there is also high correlation between current account outcomes and age-dependency rates.

As China plays such a significant role in Larry's paper, it will be useful to briefly consider a few background statistics. China is a large, open economy, whose total trade flows (exports plus imports) are currently equivalent to about 64 per cent of its GDP. Although still young by developed country standards, China's population is ageing rapidly. Despite rapid economic growth, which has averaged 9.5 per cent annually over the past five years, China remains relatively poor, with GDP per capita of just US$1 735 per year. Investment, which accounts for around 43 per cent of China's GDP, has been a key driver of growth in recent years. But China's saving rate is even higher at close to 50 per cent of GDP. As a result, China is a substantial capital exporter and ran a capital and financial account deficit of US$63 billion, equivalent to 2.8 per cent of GDP, in 2005.

Will the saving behaviour of Chinese households remain stable? In my view, answering this question requires an understanding of the rationale behind China's current high saving rate. Aside from cultural factors, there are two important factors that may encourage the saving rate to remain high. First, Chinese households face many uncertainties in the future, including concerns related to protectionism, the liberalisation of factor and product markets, and the perceived inadequacy of the social security system. Second, capital markets are still underdeveloped, requiring a high self-financing rate.

However, since the 1990s, the Chinese government has begun to establish a social security system. Although the pension scheme is currently underfunded, the government is attempting to remedy this, including by injecting part of the revenue from the privatisation of state-owned enterprises into the social security system and setting up individual accounts. Also, major reforms have been implemented to improve stock market regulations, and the markets for property mortgages and credit cards are developing rapidly. Therefore, it seems reasonable to assume that China's saving rate will gradually converge to that of developed countries.

I have a few additional suggestions for improvements that could be made to the paper. First, the assumption that total factor productivity in China will catch up with the US by 2050 (or even reach 50 per cent of the US level, as in Larry's alternative scenario) is too ambitious. It seems to me that it will become more and more difficult for China to close the gap in the later stages of its development process, particularly as its production becomes more technology-intensive (of course, China's need to import this technology represents another channel through which its development will enhance the welfare of the developed world). Second, the paper might have benefited from a greater focus on what demographic change means for foreign exchange markets. Exchange rate movements will have a great impact on rates of return to cross-border investments. From my perspective, China's current account surplus is partly a reflection of its relatively young population and should not be taken as an indication that its exchange rate is presently undervalued. Third, it may be misleading to assume that the same income distribution pattern exists in China as in the other countries examined in this paper. In China, the highest earners are in the white-collar group that only emerged in the past two decades. Fourth, Larry may be interested to note that, although it does not tax capital gains, China has taxes on interest and dividend payments (of 20 per cent) and corporate taxes (with an effective tax rate of about 25 per cent) instead of the zero rates he assumes in his paper.

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General Discussion

The question of whether life-cycle models can predict the size and direction of future capital flows was widely debated. One participant noted that such models consistently fail to explain the observed pattern of historical and present current account balances and questioned why their projections should be more accurate in the future. Other participants argued that medium- and long-run changes in aggregate saving rates are difficult to reconcile with the predictions of simple life-cycle models and suggested that movements in saving rates implied by life-cycle behaviour might be overwhelmed by other factors. In particular, the life-cycle hypothesis suggests that saving rates should have risen in many OECD countries over the past couple of decades, and yet household saving rates have in fact fallen over this period. Although most participants agreed that modelling exercises could play a useful role in helping policy-makers to understand the consequences of demographic change, there was general consensus on the need to develop a better understanding of the motives for private saving. In response to these comments, Larry Kotlikoff agreed that the direction and size of global capital flows over recent years are difficult to explain. But he argued that perceived failures of the life-cycle hypothesis often reflect the inability to develop measures of saving that are consistent with theory and noted that his own research has shown that, when appropriately measured, personal saving behaviour is consistent with the life-cycle hypothesis.

There was considerable discussion about the assumptions regarding the future development of the Chinese economy in Larry Kotlikoff's paper. One participant questioned whether one should expect Chinese private saving rates to remain high in the future, noting that present saving trends may simply reflect a shift in the desired stock of physical capital relative to labour. It was also noted that the paper's findings are particularly sensitive to assumptions about future trends in total factor productivity, about which there is little certainty. One participant observed that the magnitude of the projected capital flows, relative to output, in Larry Kotlikoff's paper far exceeded current levels. Given the current concern over potential 'global current account imbalances', other participants wondered whether such large capital flows would be feasible in the future.

There was also some discussion of the effect of pay-as-you-go (PAYG) pension systems on private saving behaviour. One participant questioned how Axel Börsch-Supan and Larry Kotlikoff could reconcile their papers'conclusions that the scaling-back of public PAYG pension systems would lead to an increase in private saving rates with the observation that countries which still rely heavily on PAYG systems, particularly in continental Europe, often have higher private saving rates than countries such as the United Kingdom or Australia, where pre-funded individual retirement saving plans are far more prevalent. A number of answers to this paradox were proposed. One participant suggested that high private saving rates in continental Europe reflect the concern that governments have, and may continue to, renege on their pension obligations. Another questioned whether low observed private saving rates might indicate that individuals are myopic and asked whether the authors could incorporate this into their models. In response to these comments, Axel Börsch-Supan argued that the deregulation of financial markets and relatively high rates of home ownership in many Anglo-Saxon countries explain their relatively low private saving rates. He suggested that, once these factors are taken into account, researchers will find a positive relationship between private pension provision and private saving rates.

Demographic Change and Asset Prices

Robin Brooks[1]

Abstract

Will the ageing of the baby boomers lead to a financial market meltdown? Will population ageing raise the equity premium, as ageing households become less willing to bear risk? This paper investigates these questions, using a new dataset that covers stock and bond prices, as well as age distributions, for a large cross-section of developed countries from the early 1900s. It uses an econometric specification that links real stock and bond prices, real returns and the equity premium to the relative importance of all age groups in the age distribution. It finds little evidence to suggest that asset prices will suffer abrupt declines when the baby boomers retire. In fact, in countries where stock market participation is greatest, including Australia, Canada, New Zealand, the United Kingdom and the United States, evidence suggests that real financial asset prices may continue to rise as populations age, consistent with survey evidence that households continue to accumulate financial wealth well into old age and do little to run down their savings in retirement.

1. Introduction

When it comes to predicting the effects of population ageing on financial markets, there are two camps: those who believe in the doomsday scenario – the market meltdown – and those who do not. The meltdown scenario holds that retiring baby boomers will be selling their assets to a smaller generation of young investors. This will drive asset prices down, leaving many baby boomers with a smaller nest-egg than anticipated. The opposing view maintains that forward-looking financial markets are pricing assets to reflect the highly predictable ageing of the baby boomer generation. As a result, there cannot be a market meltdown when the baby boomers retire, because it has already been priced in.

The ageing of the baby boomers and speculation over the possible effects on financial markets has raised the profile of this issue, both in the financial press and in academic circles.[2] Indeed, a recent convert to the asset-price meltdown camp, Wharton Business School Professor Jeremy Siegel, has done much to enliven the debate, by claiming that baby boomers across the industrialised world may see

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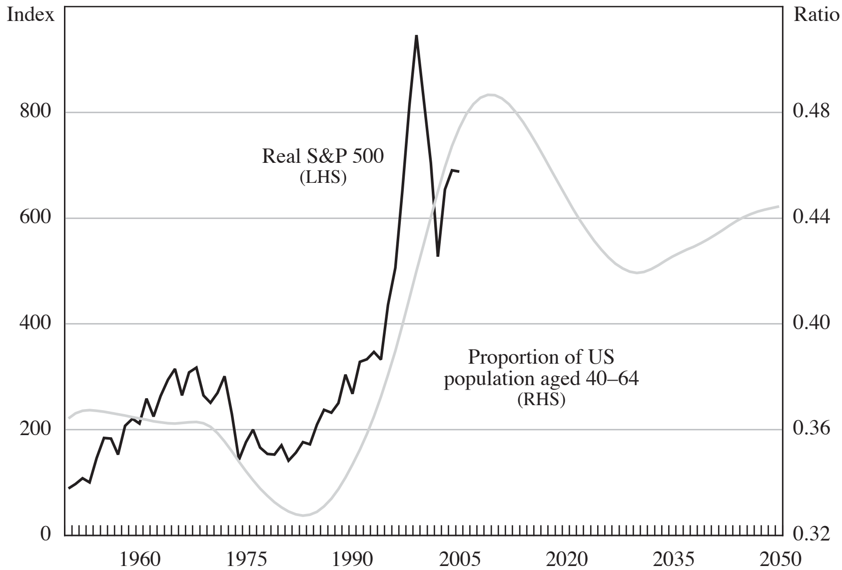
2. Recent articles on this subject have appeared in the *Wall Street Journal* (May 5, 2005), *The Economist* (May 19, 2006), *Business Week* (June 5, 2006), *Fortune* (June 26, 2006) and *The Associated Press* (July 5, 2006).

the value of their accumulated assets – stocks, bonds and homes – plunge by up to 50 per cent over their remaining life span, as they try to unload their assets on a smaller generation of buyers. In a forthcoming book, *The Global Solution*, Siegel warns that the only way to forestall this meltdown is to allow retiring baby boomers to sell their assets to Chinese and Indian investors, whose soaring economies will make them net buyers in coming decades.

But will the asset-price meltdown happen? A casual case for the meltdown scenario can easily be made. Figure 1 shows a real US stock price index (S&P 500) and the ratio of the US population aged 40–64 relative to the rest of the population (those aged 0–39 and 65+) from 1950 to 2050, using population projections from the United Nations. This demonstrates that the decline in real stock prices during the 1970s and early 1980s coincided with a fall in the relative importance of those aged 40–64, as large ranks of baby boomers (defined as the 78.2 million people in the US born between 1946–1964) entered the population and pulled down this population ratio. Proponents of the meltdown scenario argue that the fall in the proportion of the population aged 40–64 caused a decline in the demand for stocks, as the parents of the baby boomer generation shifted their focus to buying houses and raising their children, which in turn depressed real stock prices. As the baby boomer generation aged and moved into its prime saving years, typically defined as between ages 40–64, the demand for stocks rose, pushing up real stock prices. Proponents of the asset-price meltdown scenario thus see the stock market rally of the late 1990s as resulting from the ageing of the baby boomer generation.

As compelling as Figure 1 may be, there are several problems with interpreting it as a predictor of a future asset-price meltdown. First, since its peak in 2000, the stock market has fallen 30 per cent in real terms and much of the run-up in the late 1990s is now seen – with the benefit of hindsight – as a stock market bubble, fueled by unrealistic expectations about the effects of information technology on profits. Of course, the stock market has not reversed all gains since the late 1990s, leaving open the possibility that demographics is a factor behind some of the sustained increase since then. Second, Figure 1 paints a deceptive picture, because it omits other factors that may have driven both demographics and the stock market. A prime candidate is a long-run cycle in economic activity, driven for example by global events such as World War II. The war may have caused US fertility rates to fall and also depressed real stock prices, due in part to the greater uncertainty at the time. The end of World War II saw a dramatic recovery in economic activity around the world, causing the stock market to soar, while better economic prospects led to a rebound in fertility rates. Economic prospects suffered again in the 1970s and 1980s, as a series of oil shocks pushed up inflation, forced policy-makers to slow economic growth, and sent stock markets plunging in real terms. At around this time, fertility rates fell dramatically around the world, driven by increased labour force participation rates among women and the introduction of 'the pill'. In other words, the empirical association between the two series in Figure 1 may not reflect a causal relationship, but simply an omitted factor. Third, the effective number of observations in Figure 1 is too small to draw a decisive conclusion on the link between demographics and financial markets. While such a link may well exist, it

Figure 1: Meltdown Scenario



Note: Population projections interpolated between 5-yearly observations

Sources: Global Financial Data, Inc.; UN Population Division (2005)

is impossible to identify on the basis of 'one' baby boom. Given these concerns, it may not be so surprising that the academic literature has failed to identify a strong link between demographics and financial markets, suggesting that Figure 1 needs to be interpreted with caution.

Against this background, this paper revisits the debate over whether there is a link between demographics and financial markets. It makes two important advances over the existing literature. First, it constructs a new dataset for developed economies that contains a long time series on stock and bond prices, as well as age distributions. The long time-series dimension of the data (most of the data start between 1900 and 1925) increases the number of effective observations, and helps to clarify the impacts of demographic changes, which typically occur only at low frequencies. Second, it employs a new empirical specification which links real asset prices, real returns and the equity premium to the entire age distribution, effectively deriving the sensitivity of financial markets with respect to all age groups. Compared to the existing literature, which predominantly uses ratios such as the relative importance of those aged 40–64, this approach has the advantage of avoiding an *ad hoc* partition of the age distribution into those more likely to save and those less likely to save.

This paper does not find a strong historical link between demographics and financial markets. While the existing literature has found that the relative importance of middle-aged cohorts tends to be associated with high real stock and bond prices, this paper shows that this association does not hold for countries with strong equity market participation among households, such as Australia, Canada, New Zealand, the UK and the US. In these countries, higher real financial asset prices tend to be associated with an increase in the proportion of the population in the old tail of the age distribution. This is consistent with survey evidence from the US that shows that households run up financial wealth well into old age and then do little to run it down in retirement. Taken at face value, this suggests that real financial asset prices in the US will actually rise as the population continues to age, though a number of considerations – including the changing nature of markets over time and general equilibrium effects – caution against drawing this conclusion. Nonetheless, this finding underscores that historical evidence provides little support for the hypothesis that financial market prices will fall abruptly when the baby boomers retire.

The remainder of this paper is structured as follows. Section 2 reviews the existing theoretical literature on the link between demographics and financial markets. Section 3 reviews existing empirical work. Section 4 describes the data used in this paper, while Section 5 describes the estimation approach. Section 6 discusses the results. Section 7 concludes.

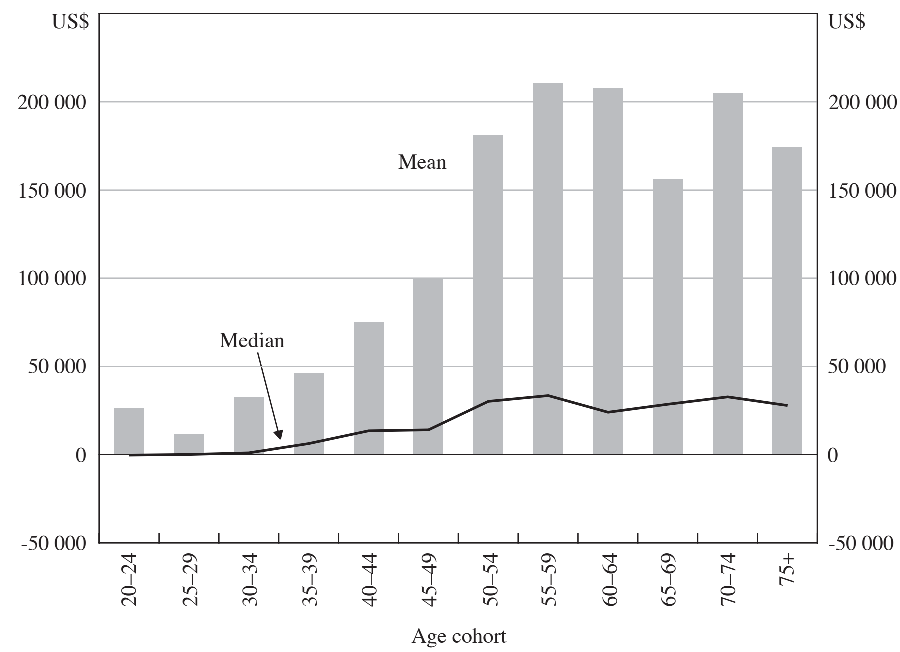
2. Existing Theoretical Work on Demographics and Financial Markets

A number of papers have calibrated numerical intertemporal general equilibrium models to simulate the effects of demographic dynamics on asset prices and returns. Yoo (1994a) uses an overlapping generations (OLG) model in which agents live for 55 periods and work for 45. For a simulated baby boom that is calibrated to match the experience of the US over the last four decades, Yoo finds that the return to capital may fall by up to 40 basis points when the boomers shift into retirement, consistent with the claim that baby boomers may face lower financial market returns over their lifetime. Brooks (2002) also uses an OLG model to simulate the effects of demographic dynamics on stock and bond returns. Agents in Brooks' model live for four periods: childhood, young working age, old working age and retirement. In childhood, agents are not independent decision-makers and depend on their parents for consumption. In the two middle periods, agents supply labour inelastically and save for retirement, investing in either risky capital or safe bonds. In retirement, they run down their savings, there being no bequests. Brooks simulates a baby boom and bust that is calibrated to match the US experience and finds that demographic dynamics have a small effect on the return to capital, but a larger effect on the risk-free rate, as ageing boomers crowd into safe bonds as they approach retirement, in order to reduce consumption risk. This pushes down the risk-free rate relative to the return to capital, though the overall effect – in the order of 50 basis points – is still modest in size. Abel (2001, 2003) derives analytical results based on an OLG model. He shows that a stylised baby boom, in which the birth rate first rises and then falls, reduces the rate of return relative to what it would be in the absence of population changes. He concludes that baby boomers face less attractive capital market opportunities than smaller cohorts around them, a conclusion that is also derived analytically by Bohn (2001). Geanakoplos, Magill and Quinzii (2004) use an OLG model that is closely calibrated to match the US, including realistic age-income patterns. Their findings suggest that demographic shocks like those experienced in the post-WW II US could generate substantial swings in asset values, but that actual peak-to-trough movements in the stock market are two to three times greater than the demographic analysis can explain.

These papers are subject to several important caveats. First, they all assume that the life-cycle hypothesis of Modigliani and Brumberg (1954) holds, whereby agents smooth consumption over their life spans. This implies a profile of wealth that rises until retirement and subsequently falls, as agents run down their assets to fund consumption. However, household survey data from the US suggest that actual savings behaviour does not conform well to this pattern. In particular, there is little evidence that households dissave dramatically in retirement. As Figure 2 shows, net financial wealth according to the 2001 *Survey of Consumer Finances* peaks between the ages of 55–59, but declines very little thereafter. This lack of evidence to support the life-cycle hypothesis could reflect a number of factors. Precautionary saving may rise as households age, as the need to self-insure against medical emergencies rises. It is also possible that the cross-sectional nature of the *Survey of Consumer Finances* gives a distorted picture, as it lumps together households of different ages. For example, it is possible that people born during the Great Depression are more risk averse than young people of today. In a simple cross-section, this could give the distorted picture that wealth rises with age, when in fact this finding merely reflects different risk preferences. However, attempts to

Figure 2: US Net Financial Asset Holdings

2001 prices



Source: Board of Governors of the Federal Reserve System, *Survey of Consumer Finances* control for such cohort effects, by Poterba (2001) and others, yield little change in estimated age-wealth profiles, suggesting that such effects are small.

Second, existing efforts to model the impact of demographics on financial markets typically assume a representative agent within each cohort, when in fact holdings of financial assets are skewed towards the very rich. Figure 2 provides an indication of this. It shows that median net financial wealth is substantially lower across all age groups than mean net financial wealth. Indeed, with median net financial wealth so low in the US, Figure 2 suggests that a substantial number of households do not have significant holdings of financial assets at all. With the exception of Storesletten, Telmer and Yaron (2004), the high degree of heterogeneity across households within age groups has largely been ignored.

Third, the existing literature tends to work within the confines of closed-economy models, which preclude agents from diversifying away demographic risk by investing in countries with different demographic profiles. Attanasio and Violante (2000), Börsch-Supan, Ludwig and Winter (2005), Brooks (2003) and others have used OLG models to simulate the effects of differential demographic trends around the world on saving-investment balances. Though these papers suggest that international capital flows will tend to attenuate any adverse effects of population ageing on financial markets, they fail to match the historical pattern of capital flows (the global imbalances conundrum), raising the question as to the relevance of such approaches.

In summary, the existing theoretical literature suggests that the baby boomers will earn returns on their retirement savings that will be below the historical norm, but that any adverse effects will be small and may be swamped by other sources of volatility. In particular, important shortcomings of these models suggest that any simulated effects should be treated as upper bounds, given that they are generated in models that assume dissaving in retirement, a representative investor in each age group, and a closed economy.

3. Existing Empirical Work on Demographics and Financial Markets

Several papers have studied the empirical link between demographic change and asset prices. Yoo (1994b) regresses real returns on stocks, bonds and Treasury bills in the US on various measures of the age distribution that aim to proxy for demand for financial assets (similar to that used in Figure 1). For Treasury bills he finds a significant relationship, whereby a higher fraction of the population in their prime saving years is associated with a lower real return, while large standard errors make it hard to draw any firm inferences about the link between demographics and stock and bond returns. Bergantino (1998) uses cross-sectional data from the *Survey of Consumer Finances* to estimate age-specific demands for corporate stock and owner-occupied real estate, and combines these estimates with data on the changing age composition of the population to create measures of aggregate demand for both equities and housing. He finds a positive association between his measure of asset demand and the level of stock prices and concludes that demographic changes can explain a substantial share of the post-war fluctuations in equity prices. Brooks (1998) exploits cross-country variation by relating the level of real equity prices to the relative importance of the population aged 40–64. For 11 of the 14 countries in his sample, there is a positive relationship between this demographic variable and the real stock price. Poterba (2001) builds on these studies and re-examines the relationship between several measures of demographic structure and real returns on Treasury bills, government bonds and equities. As in Yoo (1994b), there is weak evidence linking the population age structure to real returns on Treasury bills, but little other evidence. Poterba notes, however, that there is some evidence of a link between price-dividend ratios and demographic variables, suggesting that perhaps the volatility of returns data tends to obscure a possible link to a low frequency source of variation such as demographics. Davis and Li (2003) focus on a smaller sample of seven countries with substantial equity markets. They find a statistically significant effect of the share of the population aged of 40–64 on the level of real stock and bond prices. Their finding is robust to the inclusion of variables that control for non-demographic factors that may affect asset prices, such as the rate of economic growth and inflation. Geanakoplos *et al* (2004) present empirical evidence consistent with their own simulation analysis (described earlier). Their results suggest that the real level of share prices, measured by the S&P 500 index, is related to the ratio of middle-aged to young individuals in the population. This 'MY ratio' is defined as the number of 40–49 year olds divided by the number of 20–29-year olds. The results suggest a statistically significant link between the MY ratio and real stock returns, with a change like that projected for the 2000–2050 period resulting in roughly a 60 basis point decline in annual real returns. They also study France, Germany, Japan and the UK, and find mixed results. For France and Japan there appears to be a link between the MY ratio and the real price of corporate equities, but the relationship does not emerge in the other economies.

The empirical literature thus finds some evidence of a link between demographics and financial markets, though the estimated effects are small, consistent with the theoretical literature. A particular curse that bedevils the empirical literature is that the effective number of observations is small. As Poterba (2004a, p 13) puts it: 'Since there is only one Baby Boom in the United States, it may be misleading to suggest that there are many years of data on demographics and asset market returns. It may be more accurate to view the existing data as the result of one realization of time-varying birth rates'. This paper attempts to address this problem by extending data back to the early 1900s, while much of the existing literature has focused on the post-war period.

4. Data Description

This paper constructs a new dataset that contains a long time-series on stock and bond prices, as well as age distributions, across advanced countries. The long time-series dimension of the data (most of the data start between 1900 and 1925) aims to increase the effective number of observations in light of the slow-moving nature of demographic change.

Table 1 summarises the composition of the data across countries and over time. For each country there is a stock price index, a total return index for the stock market (which differs from the stock price index because it assumes that dividends are reinvested), a total return bond index, a total return Treasury bill index, a consumer price index and age distribution data, which describe the number of people in 5-year age groups (0–4, 5–9, ..., 75+). All data are available at an annual frequency. Data for the US are available from 1900 onwards, while the majority of countries join the sample between 1910 and 1925. In the case of Germany and Italy, the lack of demographic data for the pre-war period means that data are only available from 1950.

Table 2 summarises projected ageing trends in the sample countries, showing the old-age dependency ratio, which is calculated as the number of people aged 65 and older relative to the number of people aged between 20–64. As is well known, population ageing is projected to be most severe in Japan, where the old-age dependency ratio is forecast to rise by 50 percentage points to 78 per cent by 2050. Population ageing is also projected to be severe in Italy, where the orders of magnitude are similar. In contrast, population ageing in the US is projected to be relatively benign, with the old-age dependency ratio forecast to rise from 21 per cent in 2000 to 37 per cent by 2050. Ageing trends are similarly restrained in the UK, although its population is already older than the US population.

Although the data have a significant cross-country dimension, there are important caveats. First, especially with respect to the demographic data, it is important to recognise that fertility and longevity trends in advanced countries have to a large extent

Table 1: Data Composition

	Start date	End date
Australia	1921	2005
Belgium	1920	2005
Canada	1921	2005
Denmark	1915	2005
Finland	1922	2005
France	1921	2005
Germany	1950	2005
Italy	1950	2005
Japan	1920	2005
Netherlands	1901	2005
NZ	1926	2005
Norway	1918	2005
Sweden	1921	2005
Switzerland	1921	2005
UK	1911	2005
US	1900	2005

Notes: Financial data are from <www.globalfinancialdata.com>. Population data are from the statistical agency of each country and from UN Population Division (2005), which includes population projections out to 2050. Projections are based on the medium variant.

Table 2: Old-age Dependency Ratios
Population aged 65+ as a share of population aged 15–64

	2000	2010	2020	2030	2040	2050
Australia	20.4	22.3	29.0	36.5	41.0	43.5
Belgium	28.3	29.7	35.9	45.6	51.6	52.1
Canada	20.5	22.5	30.2	41.5	45.9	48.2
Denmark	24.1	27.7	33.7	39.2	44.2	41.7
Finland	24.7	28.4	40.0	48.1	49.2	50.4
France	27.9	28.5	37.1	44.9	50.5	52.4
Germany	26.3	33.5	36.7	48.4	55.9	55.0
Italy	29.3	35.0	42.1	53.3	71.2	75.9
Japan	27.6	38.0	51.6	56.8	69.5	77.8
Netherlands	21.9	24.6	32.8	42.4	49.9	47.6
NZ	20.4	22.1	28.6	37.8	42.4	43.2
Norway	26.1	26.5	32.9	39.8	46.4	45.3
Sweden	29.5	31.7	37.9	42.6	46.5	46.0
Switzerland	24.3	29.2	36.3	48.8	55.6	53.8
UK	26.9	27.4	31.8	38.4	42.7	42.3
US	20.9	21.3	27.1	34.2	35.9	36.8

Source: UN Population Division (2005)

been driven by common shocks, such as World War II and the post-war recovery. As such, the cross-country data are not independent observations, though there is of course country-specific variation in the data. Second, it may be misleading to link asset prices to domestic age distribution data in small open economies such as Belgium, Denmark and the Netherlands. This is because such countries now have a substantial share of foreign investors in their equity markets, so that it is unclear whether domestic demographic variables should have much impact on asset returns and asset values. Though this is certainly a consideration, one advantage of the long time-series data assembled here is that international capital flows were negligible for much of the sample period under study.

5. Empirical Specification

This section outlines an empirical specification that uses the cross-section dimension of the data to control for a global, long-run business cycle, reflecting the possible impact of events such as the Great Depression, World War II and the oil shocks in the 1970s and 1980s on financial markets and demographic developments. As the introduction argued, omitting such a cycle could result in spurious regression results, due to omitted variable bias. An alternative approach would be to follow Davis and Li (2003) who explicitly control for non-demographic fundamentals. In addition, the specification allows the entire age distribution to enter, unlike the existing literature which relies on standard demographic ratios such as the relative importance of the population aged 40–64. As noted above, such ratios have the disadvantage that they arbitrarily partition the age distribution into net savers and net dissavers, while the approach employed here takes a more agnostic approach and lets the data speak for themselves. The regression model can be written as:

$$y_{it} = \lambda_i + \beta_t + \alpha_1 p_{1it} + \alpha_2 p_{2it} + \ldots + \alpha_J p_{Jit} + u_{it} \tag{1}$$

where $i = 1, ..., N$ and $t = 1, ..., T$ index the cross-section and time-series dimensions of the data. y_{it} is the dependent variable, which could be real stock prices, real stock returns or the equity premium. λ_i is a country dummy; while β_t is a time dummy, which controls for the global cycle discussed above; and p_{1it}, p_{2it}, ..., p_{Jit} represent shares of the population in the J age groups as a fraction of the total population. Constraining the coefficients on the age shares to lie along a third-order polynomial (for example) means that they are constructed as:

$$\alpha_j = \gamma_0 + \gamma_1 j + \gamma_2 j^2 + \gamma_3 j^3 \tag{2}$$

The α_j must be restricted to sum to zero because the population shares sum to unity, and are thus collinear with the country and time dummies. Imposing the restrictions, Equation (1) can be rewritten as:

$$y_{it} = \lambda_i + \beta_t + \gamma_1 Z_{1it} + \gamma_2 Z_{2it} + \gamma_3 Z_{3it} + u_{it} \tag{3}$$

where

$$Z_{1it} = \sum_{j=1}^{J} j p_{jit} - \frac{1}{J} \sum_{j=1}^{J} j \tag{4}$$

$$Z_{2it} = \sum_{j=1}^{J} j^2 p_{jit} - \frac{1}{J} \sum_{j=1}^{J} j^2 \tag{5}$$

$$Z_{3it} = \sum_{j=1}^{J} j^3 p_{jit} - \frac{1}{J} \sum_{j=1}^{J} j^3 \tag{6}$$

Constraining the α_js in this way means that there are only three independent population coefficients to estimate (γ_1, γ_2 and γ_3). Although these coefficients have no direct structural interpretation, the implicit age distribution coefficients can easily be recovered and will capture the sensitivity of asset prices, returns and the equity premium to the age distribution.

Equation (3) is estimated by OLS. Likelihood ratio tests are performed to test for the appropriate polynomial order for the population shares. Estimation is on an unbalanced panel, to take advantage of the maximum amount of data across countries. To enable an easier comparison with the existing literature, estimations are also performed using conventional demographic variables. These are defined as shares of the total population (in per cent) accounted for by: people aged 0–14 (RAT0); people aged 15–39 (RAT15); people aged 40–64 (RAT40); and people aged 65+ (RAT65). Also included are the share of the adult (aged 20+) population aged 40–64 (RAT4020); the share of the adult population aged 65+ (RAT6520); and the average age of the adult population (AA20).

The first two of these variables capture the younger tail of the age distribution and are intended to explore the effects of changes in youth dependency on financial markets. Variations of the second two variables have been widely used in the existing literature, including in Brooks (1998), Poterba (2001, 2004a, 2004b) and Davis and Li (2003), to describe the importance of middle-aged and old cohorts in the population. The next two measures were used in Poterba (2004a, 2004b) to capture the relative importance of middle-aged and old cohorts in the adult population, while the last measure was proposed by Bakshi and Chen (1994) to describe the ageing of the adult population.

6. Results

Theoretical models, including those discussed above, show that when a large middle-aged cohort begins to purchase assets for retirement, it bids up asset prices. This implies both a positive return when this occurs, and a positive association between the level of asset prices and the relative importance of middle-aged cohorts in the age distribution. As a result, the existing empirical literature has focused on both asset prices and returns in its investigation of the financial market effects of demographic change. The advantage of looking at asset prices, rather than returns, is that they do not exhibit the same amount of volatility, which may obscure the ability to observe a link to slow-moving demographic change. The disadvantage is that both asset prices and demographics exhibit a high degree of persistence, raising the possibility that unit roots in both explanatory and dependent variables may bedevil the results. This paper uses both returns and asset prices to investigate a possible link between demographics and financial markets, with the understanding that regressions based on asset prices are likely to overstate the link, while data on returns are prone to understate it.

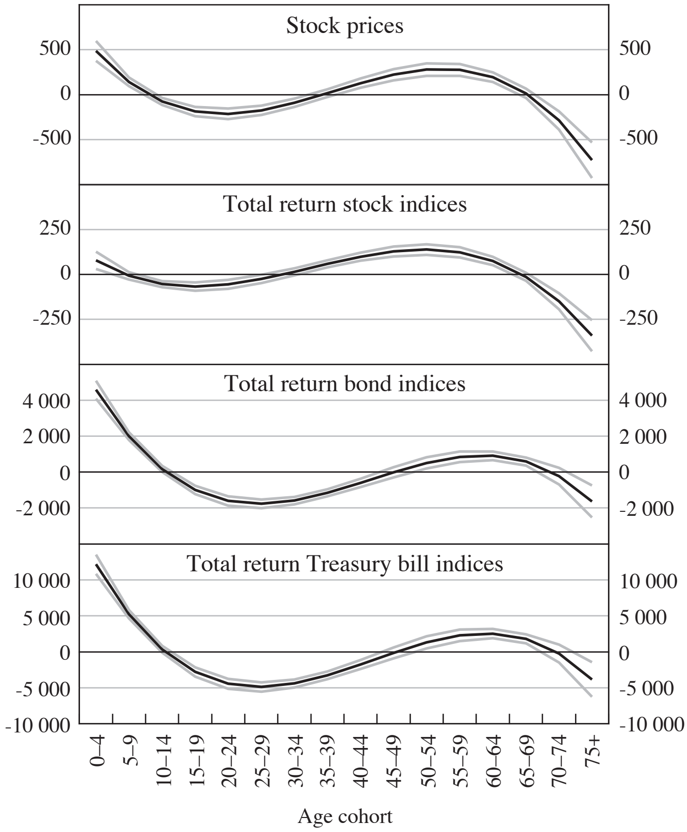
6.1 Asset prices and demographics

This section explores the link between demographics and real stock prices, real total return stock indices, real total return bond indices and real total return Treasury bill indices. The reason for looking at both stock prices and a total return stock index is that the former focuses on supply-demand mismatches that may result from demographic change, causing stock prices to rise or fall, while the latter focuses on the total return on equity, which better corresponds to the return to capital that is the focus of much of the theoretical literature.

This section begins by estimating a pooled version of Equation (3), where γ_1, γ_2 and γ_3 are constrained to be the same across the 16 countries in the sample. The implicit assumption is that the link between financial markets and demographics is the same across the 16 countries in the sample. Figure 3 shows the age coefficients (α's) for a third-order polynomial for real stock prices, real total return stock indices, real total return bond indices and real total return Treasury bill indices (all of which are normalised to 100 in 2005); error bands of two standard deviations on either

Figure 3: Estimated Impacts of Demography on Real Asset Prices

Pooled age coefficients



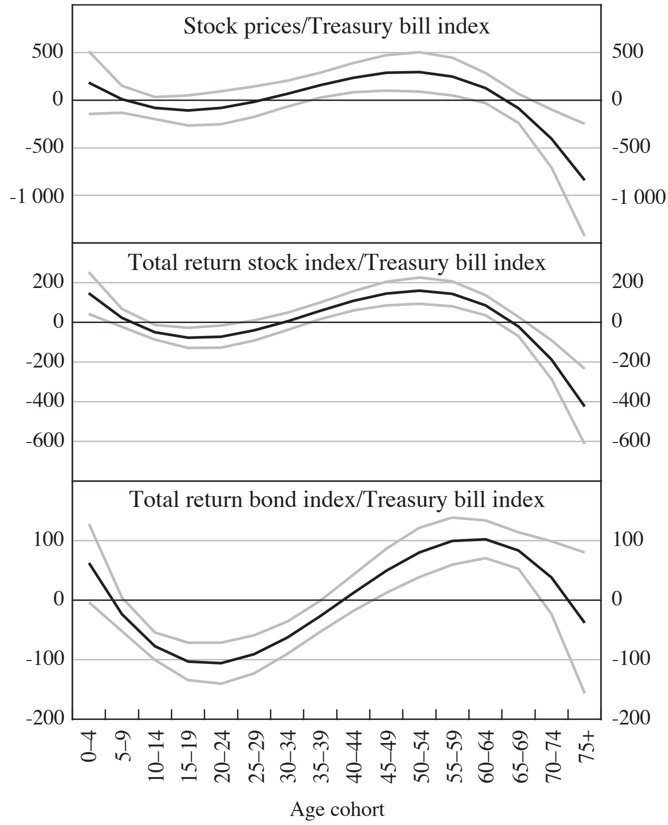
Note: Gray lines show error bands of two standard deviations around the point estimates.

Source: author's calculations

side are also shown.[3] Regressions are performed separately for each financial asset price series. Across all series, a clear pattern stands out: having a large proportion of the population in the younger parts of the age distribution (between 10–14 and 30–34) tends to be associated with significantly lower real stock, bond and Treasury bill prices, while large proportions of the total population in middle-aged cohorts (between 40–44 and 60–64) tend to be associated with significantly higher real financial asset prices. Finally, a large share of very old age groups tend to be associated with sharply lower real stock, bond and Treasury bill prices, consistent with the notion that older households run down their financial asset holdings in retirement, while very young age groups are associated with high real financial

3. Standard errors are White heteroskedasticity consistent. Likelihood ratio tests show that a third-order polynomial for the age coefficients best fits the data. Alternative specifications that were explored included second- and fourth-order polynomials.

Figure 4: Estimated Impacts of Demography on Relative Asset Prices
Pooled age coefficients



Note: Gray lines show error bands of two standard deviations around the point estimates.
Source: author's calculations

asset prices, possibly because parents are saving for housing or education. This finding has intuitive appeal as it suggests that middle-aged households accumulate financial wealth, only to decumulate it in retirement.

But what about relative stock and bond prices? Is there evidence that households shift their portfolio of financial assets from risky equity to less risky assets (such as Treasury bills) as they age? Figure 4 investigates this possibility, and finds that the relative price of stocks relative to Treasury bills falls as the importance of very old cohorts in the population grows. This pattern is also evident for the total returns for stocks relative to Treasury bills and for the relative price of bonds to Treasury bills.

These results are in line with regressions that use conventional demographic variables. Table A1 in the Appendix reports on regressions based on Equation (3) where the polynomial specification in the age distribution is replaced with the conventional set of demographic variables outlined above. It shows that the RAT40 variable is significantly and positively related to real stock prices and real total return stock indices, while the RAT65 variable is negatively and significantly related to real equity prices. In contrast, real bond and Treasury bill prices are negatively and significantly related to the RAT40 variable, while real Treasury bill prices are positively related to the RAT65 variable. These findings indicate that older investors may shift their financial asset holdings towards Treasury bills in retirement to reduce consumption risk. It is worth noting that the positive relationship between real financial asset prices and the relative importance of middle-aged cohorts does not emerge as clearly using these measures of the demographic structure, which are coarser and divide up the age distribution more arbitrarily. Table A1 also shows that the results for stock prices relative to Treasury bill prices are similar to Figure 4, as are those for the relative price of bonds versus Treasury bills.

As noted above, both the dependent and the explanatory variables in Equation (3) are slow moving, raising the possibility of spurious correlations. To address this concern, Table 3 reports a series of panel unit root tests for the regressions underlying Figures 3 and 4, where these tests are performed on the residuals of the regressions.[4] Across the board, these tests strongly reject the null hypothesis of a unit root in the residuals, providing evidence against the possibility that unit roots are driving the results.

This section now explores the robustness of these results across countries. It does this by allowing γ_1, γ_2 and γ_3 to be country-specific in Equation (3), by interacting the 16 country dummies with each of the demographic variables (Z_1, Z_2 and Z_3). This specification thus estimates 48 demographic coefficients (3 coefficients for each of the 16 countries) and allows the restriction that γ_1, γ_2 and γ_3 are the same across countries to be tested explicitly using likelihood ratio tests. If there is substantial heterogeneity across countries in the link between financial markets and demographics, the country-specific γ_1, γ_2 and γ_3 parameters will add significantly to the explanatory power of the model and the likelihood ratio test will reject the null hypothesis that these coefficients are the same across countries. It is important to note that this more general specification is not the same as country-by-country regressions, as the time dummies in Equation (3) control for a common factor.

Table 4 reports the likelihood ratio tests across the estimations underlying Figures 3 and 4. The likelihood ratio test is calculated as $LR = -2\times(\ln L_c - \ln L_u)$, where LR is the likelihood ratio test statistic, L_c is the likelihood for the model that constrains γ_1, γ_2 and γ_3 to be the same across countries, while L_u is the likelihood of the unconstrained model. This test statistic follows the chi-squared distribution with degrees of freedom equal to the difference in the number of parameters across the two specifications (45). Across specifications, the restriction that γ_1, γ_2 and γ_3 are equal across countries is soundly rejected, as the test statistics are substantially above critical values at standard levels of significance. There is thus evidence of

4. The tests are similar in spirit to the augmented Dickey-Fuller test, which is derived from a regression of the differenced residual on the residual without a constant and several lags of the dependent variable. For a survey of panel unit root tests, see Baltagi (2005).

Table 3: Panel Unit Root Tests

		Null: unit root (assumes common unit root process)		Null: unit root (assumes individual unit root process)	
		Levin, Lin & Chu *t*-statistic	Breitung *t*-statistic	ADF-Fischer Chi-square	PP-Fischer Chi-square
Real stock price	Statistic	–10.1	–6.5	163.2	133.7
	Probability	0.0	0.0	0.0	0.0
Real total return stock index	Statistic	–10.7	–3.1	203.8	174.2
	Probability	0.0	0.0	0.0	0.0
Real total return bond index	Statistic	–9.1	–5.8	153.1	100.9
	Probability	0.0	0.0	0.0	0.0
Real total return Treasury bill index	Statistic	–15.6	–9.2	632.3	106.8
	Probability	0.0	0.0	0.0	0.0
Stock price index relative to Treasury bill index	Statistic	–9.0	–7.2	142.7	163.2
	Probability	0.0	0.0	0.0	0.0
Total return stock index relative to Treasury bill index	Statistic	–10.2	–6.6	169.6	178.0
	Probability	0.0	0.0	0.0	0.0
Real total return bond index relative to Treasury bill index	Statistic	–5.9	–2.3	97.9	106.2
	Probability	0.0	0.0	0.0	0.0

Source: author's calculations

substantial heterogeneity across countries in the link between financial market outcomes and demographics.

Figure 5 shows the country-specific age coefficients (α's) based on a third-order polynomial and real stock prices. The results for real total return stock indices, real total return bond indices and real total return Treasury bill indices are qualitatively similar and are thus omitted for brevity. As above, error bands of two standard deviations are plotted on either side of the α coefficients. Table 5 shows the corresponding panel unit root tests, which again strongly reject the null of a unit root in the residuals. The striking result in Figure 5 is that equity-based, English-speaking economies, such as Australia, Canada, New Zealand, the UK and the US appear to have age coefficients that do not conform well to the life-cycle hypothesis. In each of these cases, the α's describe a U-shape, suggesting that lower real stock prices are associated with having a large proportion of the population in middle age, while

Table 4: Likelihood Ratio Tests

	Constrained log-likelihood	Unconstrained log-likelihood	*t*-statistic
Real stock price	–6 068	–5 610	916
Real total return stock index	–4 954	–4 604	701
Real total return bond index	–8 085	–7 700	769
Real total return Treasury bill index	–9 422	–8 923	997
Stock price index relative to Treasury bill index	–7 537	–6 788	1 499
Total return stock index relative to Treasury bill index	–6 011	–5 314	1 395
Real total return bond index relative to Treasury bill index	–5 384	–4 287	2 193

Source: author's calculations

higher real stock prices are associated with larger shares of those in later stages of middle age and in retirement. While this age profile may be counter-intuitive, it conforms well to survey-based evidence on wealth accumulation, which implies that financial asset holdings peak late in life with little evidence of decumulation in retirement (see Figure 2, for example). In contrast, the age coefficients for countries such as Italy, Finland, Sweden, Norway and Japan exhibit the more familiar pattern from the pooled regression, which suggests that a higher share of older cohorts are associated with lower real stock prices. However, as many of these countries have bank-based financial systems where equity market participation among households is relatively limited, this result casts some doubt over whether the age profile is capturing some omitted factors (rather than demographic effects).

Figure 6 contrasts the constrained and the unconstrained models in terms of the implications of projected demographic change for real stock prices, the real total return stock index, the real total return bond index and the real total return Treasury bill index in the US. Population projections are based on the medium-variant United Nations projections, which provide annual data out to 2050. The figure is based on extrapolating Equation (3), with error bands of two standard deviations around the point estimates. Unlike the constrained model, which is not supported by the data, the unconstrained model predicts that real financial asset prices will rise as the population ages, due to the U-shaped pattern of the US age coefficients. While this is evidence against the asset-price meltdown hypothesis, and is consistent with

Figure 5: Estimated Impacts of Demography on Asset Prices in Individual Countries

Age coefficients *(continued next page)*

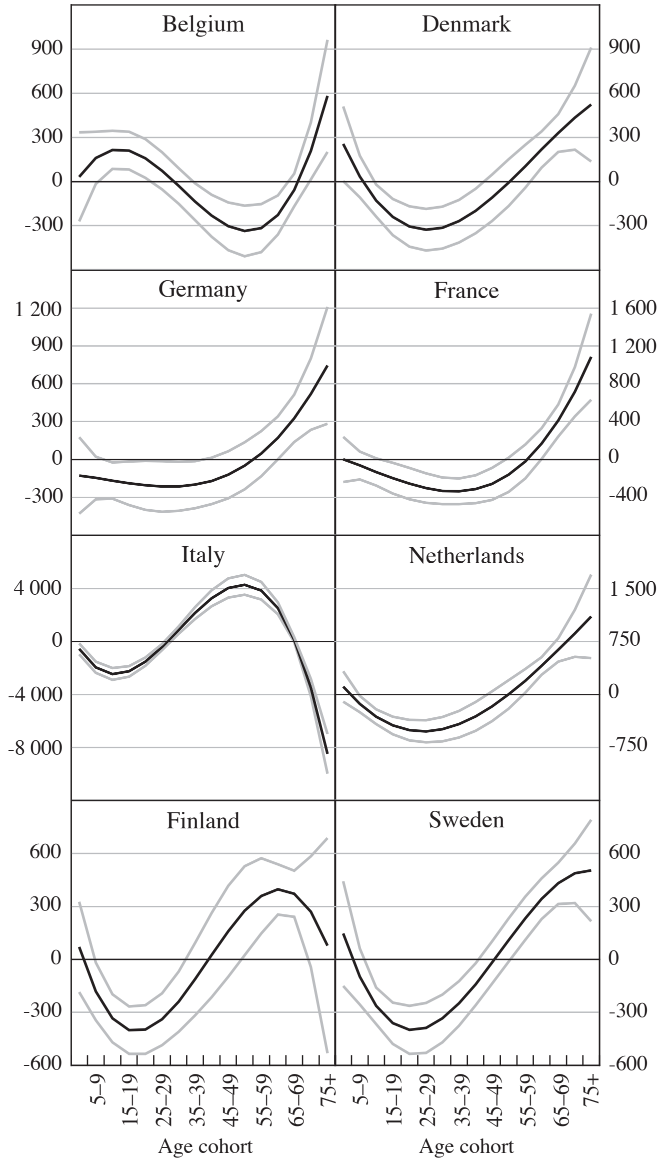
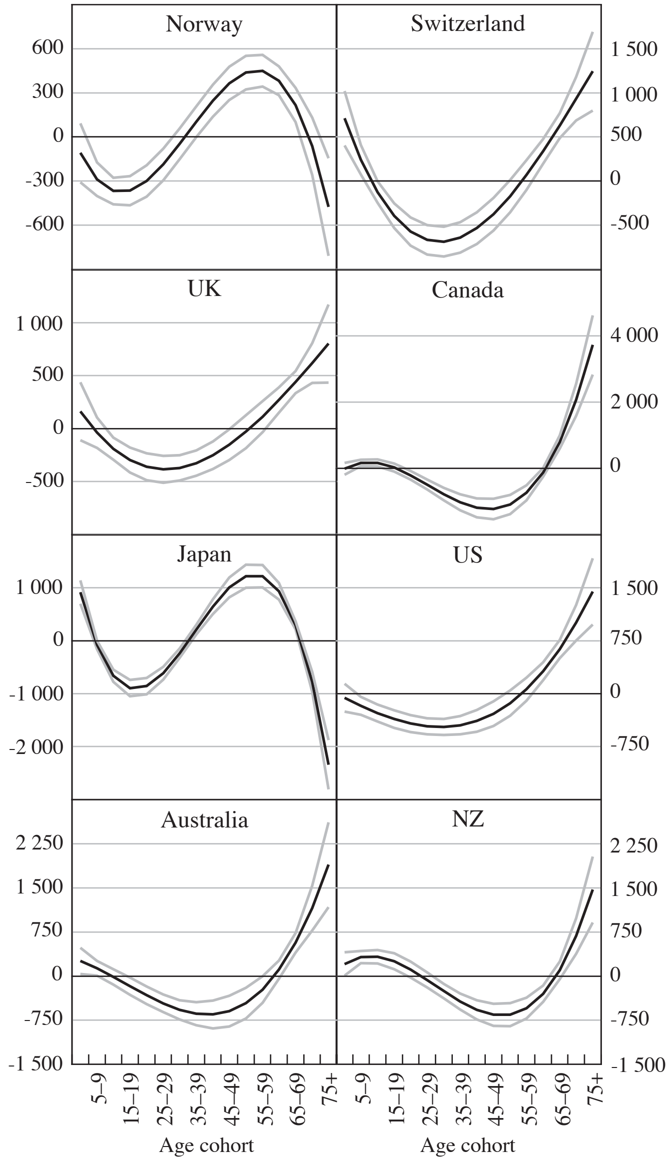


Figure 5: Estimated Impacts of Demography on Asset Prices in Individual Countries

Age coefficients *(continued)*



Note: Gray lines show error bands of two standard deviations around the point estimates.

Source: author's calculations

Table 5: Panel Unit Root Tests – Unconstrained Model

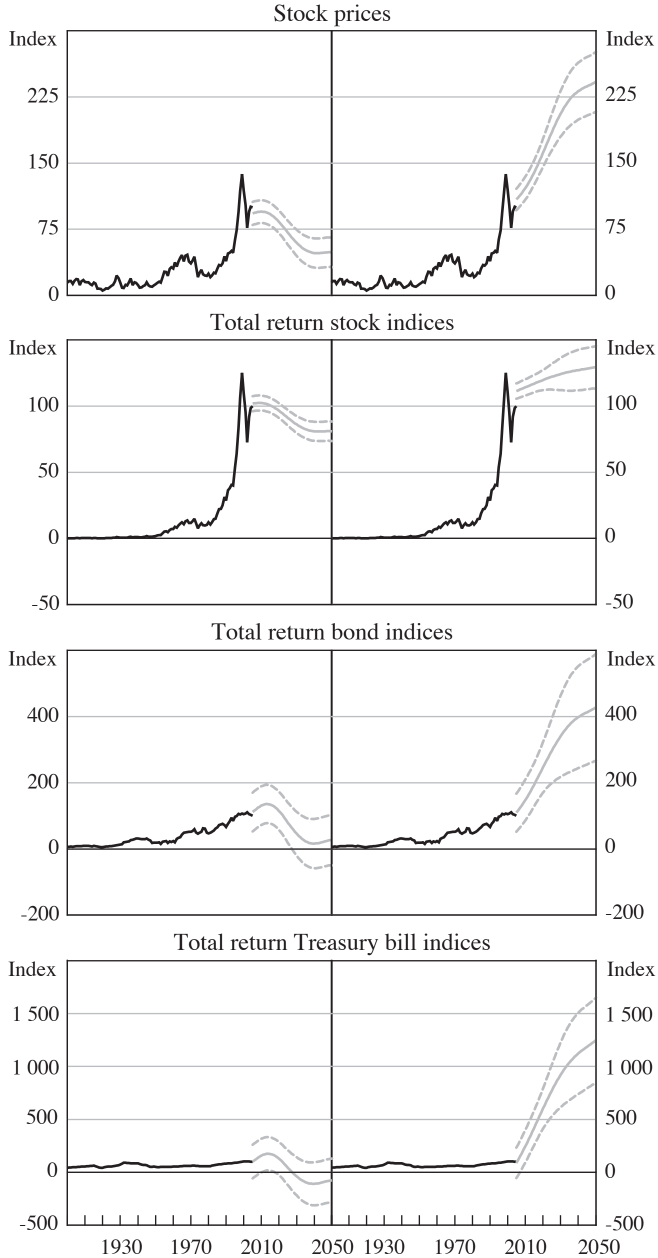
		Null: unit root (assumes common unit root process)		Null: unit root (assumes individual unit root process)	
		Levin, Lin & Chu *t*-statistic	Breitung *t*-statistic	ADF-Fischer Chi-square	PP-Fischer Chi-square
Real stock price	Statistic	–14.8	–11.3	271.1	235.2
	Probability	0.0	0.0	0.0	0.0
Real total return stock index	Statistic	–15.4	–7.6	320.4	254.9
	Probability	0.0	0.0	0.0	0.0
Real total return bond index	Statistic	–8.7	–6.6	139.5	125.2
	Probability	0.0	0.0	0.0	0.0
Real total return Treasury bill index	Statistic	–11.2	–8.5	217.9	116.2
	Probability	0.0	0.0	0.0	0.0
Stock price index relative to Treasury bill index	Statistic	–15.1	–12.8	270.6	309.4
	Probability	0.0	0.0	0.0	0.0
Total return stock index relative to Treasury bill index	Statistic	–14.7	–10.5	269.4	284.7
	Probability	0.0	0.0	0.0	0.0
Real total return bond index relative to Treasury bill index	Statistic	–12.0	–10.2	208.0	234.3
	Probability	0.0	0.0	0.0	0.0

Source: author's calculations

survey evidence for the US that points to a build-up in financial wealth well into old age, it needs to be interpreted with caution for several reasons. First, survey evidence may be contaminated by cohort effects, which may distort the age profile. Second, these projections assume that the coefficients, which are based on data back to the early 1900s, are stable going into the future, which is highly unlikely. Third, these projections ignore the general equilibrium interactions that will occur as the population ages. Nonetheless, these projections underscore that, based on the historical association between real financial asset prices and demographics, it is hard to make a case for the asset-price meltdown scenario.

Figure 6: Projected Real Asset Prices for the US

Constrained model (left panel) and unconstrained model (right panel)



Note: Solid gray lines show error bands of two standard deviations around the point estimates.

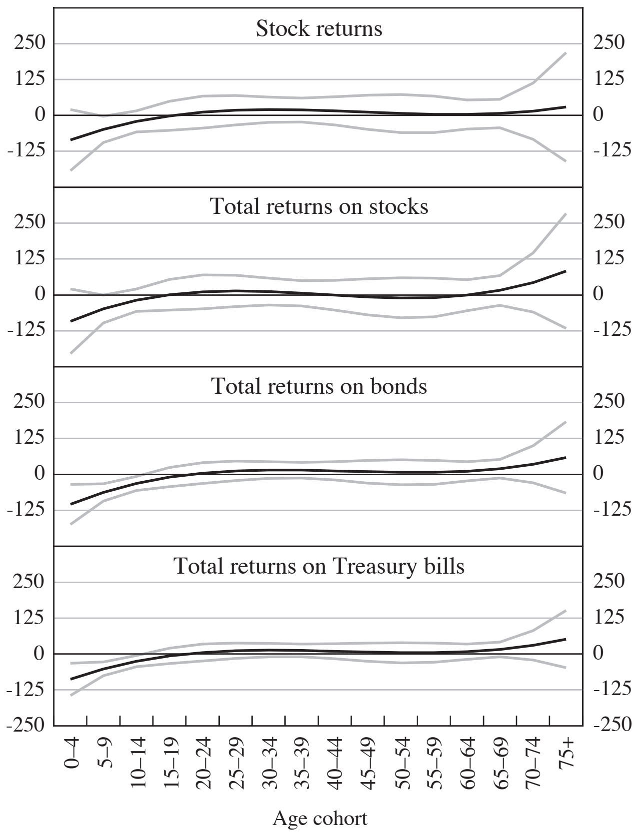
Source: author's calculations

6.2 Asset returns and demographics

Having dealt with asset prices, this section now turns to the question of asset returns. Figure 7 shows the age coefficients (α's) for a third-order polynomial for real stock returns, real total returns on stocks, real total returns on bonds and real total returns on Treasury bills, along with error bands of two standard deviations on either side. Real returns are computed as nominal returns minus CPI inflation. Regressions are based on Equation (3) and, as above, are performed separately for each series of financial asset returns. Across financial assets, there is little evidence of a link between demographics and financial markets.

Consistent with earlier findings, including Poterba (2001), evidence of a link between demographics and returns is strongest for bonds and Treasury bills, where volatility is lower than for equity returns. However, it appears that only a high share of very young cohorts (aged between 0–4 and 10–14) are associated with

Figure 7: Estimated Impacts of Demography on Real Asset Returns
Pooled age coefficients



Note: Gray lines show error bands of two standard deviations around the point estimates.

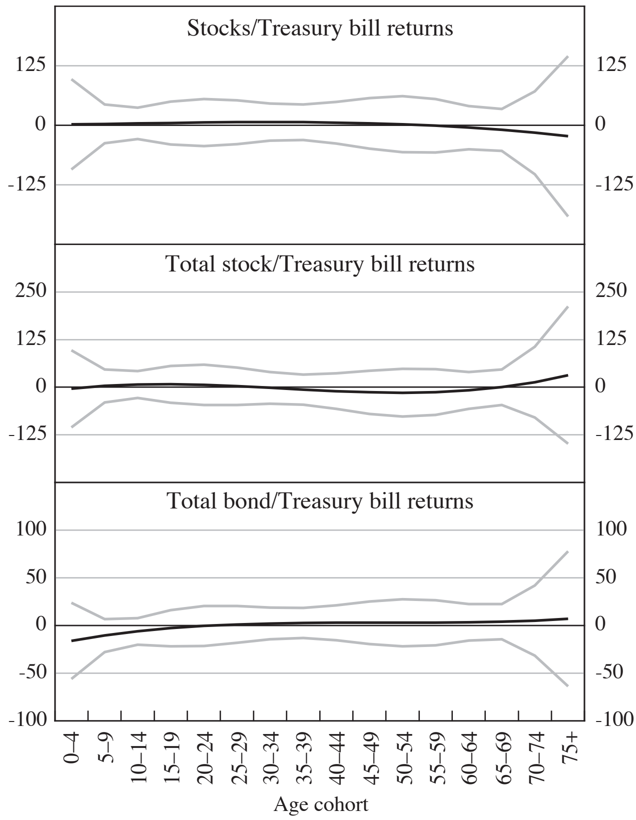
Source: author's calculations

significantly lower returns, while the association between returns and the rest of the age distribution is largely insignificant. In addition, there is little evidence that the equity premium and the premium on bonds over Treasury bills is significantly correlated with demographics, as can be seen from Figure 8, consistent with the generally weak evidence in favour of such a link in Ang and Maddaloni (2005).

These results contrast with Davis and Li (2003) who find that the relative importance of age groups 40–64 is positively and significantly correlated with changes in real stock prices, while it is negatively correlated with real bond yields. This finding could be due to the use of conventional demographic variables such as RAT40, which would suggest that the identified relationship is specific to that variable and not strong evidence in favour of a link between demographics and financial market returns.

Figure 8: Estimated Impacts of Demography on Relative Asset Returns

Pooled age coefficients



Note: Gray lines show error bands of two standard deviations around the point estimates.

Source: author's calculations

The results in Table A2 show that real stock returns are indeed positively and significantly associated with RAT40, consistent with the result in Davis and Li (2003). However, this link weakens when total real returns on stocks are considered, with the RAT40 coefficient no longer significant at conventional levels. Meanwhile, total returns on bonds and Treasury bills have a positive significant association with the RAT40 variable. Across stocks, bonds and Treasury bills, the most robust result that stands out is that RAT0 is significantly and negatively correlated with real returns, a possible indication that higher youth dependency is correlated with financial market declines. This result is worth noting because it also emerges from the more general specification for which results are reported above, where young cohorts are associated with significantly lower returns. Table A2 also shows that there is little indication that the equity premium or the bond premium exhibit a significant empirical relationship with conventional demographic variables.

Because the real return series are close to white noise, problems associated with unit roots are likely to be less important than for asset prices. As a result, panel unit root tests are omitted for brevity, as are regression results by country.

7. Conclusions

Empirical evidence does not point to a strong historical link between demographics and financial markets. While the existing literature has found that the relative importance of middle-aged cohorts tends to be associated with relatively high real stock and bond prices, this paper shows that this relationship does not hold for countries with strong equity market participation among households, such as Australia, Canada, New Zealand, the UK and the US. In these countries, higher real financial asset prices tend to be associated with a large share of the population in the old tail of the age distribution, consistent with survey evidence from the US that shows that households build up financial wealth well into old age and then do little to run it down in retirement. Taken at face value, this suggests that real financial asset prices in these countries will actually rise as the population continues to age, though a number of considerations – including the changing nature of markets over time and general equilibrium considerations – caution against drawing this conclusion. Nonetheless, this finding underscores that historical evidence provides little support for the hypothesis that asset prices and returns will fall abruptly when the baby boomers retire.

Appendix A

Table A1: Regression Results Using Conventional Demographic Variables

	RAT0	RAT15	RAT40	RAT65	RAT4020	RAT6520	AA20
Real stock prices							
Coefficient	0.95	–2.12	0.92	–1.93	1.91	–0.90	1.91
t-statistic	2.92	–4.99	2.44	–2.74	4.99	–1.55	2.13
R^2	0.55	0.56	0.55	0.55	0.56	0.55	0.55
Real total return stock indices							
Coefficient	–0.50	–0.38	1.25	–1.00	1.38	–0.90	0.92
t-statistic	–3.53	–2.05	7.79	–3.26	8.41	–3.57	2.34
R^2	0.83	0.83	0.84	0.83	0.84	0.83	0.83
Real total return bond indices							
Coefficient	24.70	–22.96	–15.24	–0.35	–3.80	10.47	9.43
t-statistic	16.39	–10.99	–8.11	–0.10	–1.92	3.56	2.05
R^2	0.45	0.39	0.36	0.33	0.33	0.33	0.33
Real total return Treasury bill indices							
Coefficient	64.89	–63.08	–39.72	5.52	–9.37	33.33	32.44
t-statistic	15.81	–11.18	–7.80	0.56	–1.75	4.20	2.61
R^2	0.45	0.40	0.37	0.34	0.34	0.35	0.35
Relative stock prices/Treasury bill indices							
Coefficient	–0.66	–0.48	2.32	–3.72	2.75	–2.04	1.67
t-statistic	–0.70	–0.39	2.12	–1.82	2.45	–1.22	0.64
R^2	0.56	0.56	0.56	0.56	0.56	0.56	0.56
Relative total return stock/Treasury bill indices							
Coefficient	–0.11	–0.70	1.13	–1.52	1.50	–0.80	1.30
t-statistic	–0.37	–1.76	3.22	–2.30	4.17	–1.49	1.55
R^2	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Relative total return bond/Treasury bill indices							
Coefficient	–0.51	–1.32	1.22	1.73	1.29	1.32	3.45
t-statistic	–2.66	–5.29	5.54	4.17	5.72	3.88	6.61
R^2	0.71	0.72	0.72	0.71	0.72	0.71	0.72

Source: author's calculations

Table A2: Regression Results Using Conventional Demographic Variables

	RAT0	RAT15	RAT40	RAT65	RAT4020	RAT6520	AA20
				Real stock returns			
Coefficient	–0.67	0.21	0.62	0.41	0.43	0.07	0.66
t-statistic	–2.21	0.52	1.76	0.63	1.20	0.13	0.79
R^2	0.37	0.37	0.37	0.37	0.37	0.37	0.37
				Real total stock returns			
Coefficient	–0.64	0.23	0.50	0.64	0.27	0.24	0.72
t-statistic	–2.00	0.54	1.34	0.92	0.72	0.42	0.81
R^2	0.36	0.36	0.36	0.36	0.36	0.36	0.36
				Real total bond returns			
Coefficient	–0.85	0.32	0.64	0.92	0.16	0.39	0.82
t-statistic	–4.28	1.20	2.74	2.11	0.65	1.09	1.49
R^2	0.36	0.35	0.35	0.35	0.35	0.35	0.35
				Real total Treasury bill returns			
Coefficient	–0.72	0.29	0.52	0.76	0.10	0.32	0.57
t-statistic	–4.51	1.37	2.81	2.18	0.50	1.13	1.29
R^2	0.29	0.28	0.29	0.28	0.28	0.28	0.28
				Stock returns – Treasury bill returns			
Coefficient	0.05	–0.08	0.10	–0.35	0.34	–0.25	0.09
t-statistic	0.19	–0.24	0.31	–0.60	1.05	–0.53	0.12
R^2	0.41	0.41	0.41	0.41	0.41	0.41	0.41
				Total stock returns – Treasury bill returns			
Coefficient	0.08	–0.06	–0.03	–0.12	0.18	–0.08	0.15
t-statistic	0.28	–0.17	–0.08	–0.19	0.52	–0.17	0.18
R^2	0.39	0.39	0.39	0.39	0.39	0.39	0.39
				Total bond – Treasury bill returns			
Coefficient	–0.13	0.03	0.11	0.15	0.06	0.07	0.25
t-statistic	–1.15	0.17	0.85	0.63	0.43	0.32	0.80
R^2	0.41	0.41	0.41	0.41	0.41	0.41	0.41

Source: author's calculations

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Discussion

1. Helmut Schwarzer

Robin Brooks presented an excellent paper, which stimulates discussion with original contributions and advances in relation to the previous state of the art.

An impressive feature of the paper is its use of an extended data set reaching to a period before World War II, to better capture the long-term relationship between demography and financial markets. However, as noted by the author himself, extending the observation period does not eliminate one of the problems affecting all of the literature on the likely impact of the baby boom on future financial market outcomes, which is that there has still been only one baby boom. But this fact does not invalidate the effort made. On the contrary, in Brazil we have a saying, 'if you don't have a dog, you chase with a cat'. The analysis provided by Robin highlights important trends and likely developments, providing some convenient rules-of-thumb to guide policy-makers in the future.

As a policy-maker, I don't look at Robin's paper, or indeed several other contributions prepared for this workshop, in search of mathematical precision. Rather I am interested in what hints or clues he can provide to people in my position, who ask pragmatically, what can policy-makers do right (or wrong) to manage the process of population ageing in the future? So, I do not want to discuss the model, its assumptions or other technical matters, because I think there are much more qualified experts from academia here who can comment on these issues.

One of the most important conclusions that I drew from this paper (along with several others submitted to this workshop) is that, despite demography being a 'slow-moving fundamental', it affects financial markets. As one of many forces acting on the same subject it implies a certain underlying trend, which should not be neglected. However, this influence will not necessarily lead to an 'asset-price meltdown' when relatively larger generations run down their accumulated stock of wealth to fund retirement consumption.

Another lesson drawn from the literature discussed at this, and previous, workshops – I remember especially Axel Börsch-Supan's contribution on the impact of ageing on labour, product and capital markets written for the 2004 G-20 seminar on Demography and Ageing held in Paris – is that good public policy may soften the demographic transition process, moderating its impact on labour, product and capital markets as well as on public finances (and, conversely, bad policies increase the likelihood of adverse outcomes).

Since the future is uncertain (remember that in the 1970s there was talk that high fertility rates would lead to a population explosion), it is likely that our thinking on how best to design institutions and rules to manage the process of demographic change will evolve in the coming decades. While it might seem an obvious point, I would like to stress the importance of comparing international experiences, policies and results across different countries to evaluate the success of alternative policy responses.

Continuing and deepening pension reforms, adjusting the parameters of public pay-as-you-go (PAYG) pension systems, streamlining their incentives and strengthening the supervision of private funded regimes are among the usual policy recommendations in response to the demographic transition. There is no once-and-for-all unique type of pension reform. Rather, it is a continuous process because social security is a social contract, which needs to be reformulated as society changes. Many countries will need to adjust their social security systems in the future. This includes Brazil, despite the approval of two relevant constitutional amendments in recent years.

Regarding pension reforms, we have already experienced a considerable learning process over the past two and a half decades, at least in Latin America. The original Chilean model – of replacing public PAYG pension schemes with privatised, fully funded (FF) retirement income provision – is now being re-examined. In particular, important questions have emerged over issues such as the fiscal costs of this type of reform. On the basis of the experiences of Latin America, and the discussions in this seminar, I feel that it would be unwise for countries to adopt systems which totally replace public PAYG schemes with private FF schemes. Instead, I would be inclined to support mixed models that supplement the public PAYG scheme with a private FF one. The latter could operate on a voluntary basis if the replacement of pre-retirement income from the first pillar is sufficiently large, or on a compulsory basis if the replacement rate of the first pillar is low and broad support for private retirement income options exists.

Conserving PAYG schemes as part of the social protection structure – provided they do not create adverse incentives for labour force participation – is important because, despite some of the criticisms they have suffered (many of which apply to FF systems as well), they are able to redistribute income and provide widespread coverage far more effectively than private FF schemes. Another advantage of PAYG systems is that they allow governments to adjust pension contributions and benefits in response to new demographic developments without disrupting financial markets. So, while building supplementary FF private pension systems and allocating capital reserves for public schemes (to soften the transition in the event of unfavourable demographic or economic outcomes) may be desirable, radical pension reforms like those seen in Chile or even Argentina in 1994 seem, to me, to be an overreaction.

Returning to Robin's paper, I would like to make two more remarks. First, I am pleased that the paper raises the issue of who actually saves – middle-aged individuals, as in the assumption of the life-cycle hypothesis, or older active workers who have raised children and finished paying off the mortgages on their own homes. This has important implications for the conclusions and for the policy recommendations implied by many models. Second, Robin reminds us that most models operate in closed economies. Given the substantial expansion of capital flows over the past few decades, international portfolio diversification could be an option for economies hoping to moderate the impact of demographic change. However, it is important to bear in mind that policies to stabilise international capital flows and foreign direct investment are required to guarantee that both net lending and net borrowing economies may benefit from those developments. Additionally, I would note that the benefits of international capital flows may be limited by the fact that developing countries are facing demographic transitions as fast as, or faster than, those facing developed countries.

Finally, Robin mentioned in his paper that historical events and other developments such as technical progress may moderate or even overwhelm the impact of 'slow-moving fundamentals' like demographic change. This is more than just a hypothesis – the history of the past two centuries provides many examples of what a powerful impact such events can have.

I would like to conclude by congratulating Robin for his contribution to this workshop and say that I think that his paper (and those of the other contributors to the workshop as well) represents a valuable resource for those of us who will have to develop the social policy responses to demographic change in the future.

2. General Discussion

Overall, there was broad agreement with Robin Brooks' conclusion that the ageing of the baby boomer generation may place some downward pressure on financial asset prices and returns, but that a dramatic 'asset-price meltdown' seems unlikely. Discussion focused on three topics: the empirical validity of the life-cycle hypothesis; the implications of asset accumulation in the form of residential housing; and policy responses to asset-price volatility.

Much of the discussion again focused on the usefulness of the life-cycle hypothesis as a link between demographic change and asset prices and returns. Participants compared the implied age coefficients from Robin Brooks' model with the life-cycle age-savings patterns observed in household survey data. A number of participants agreed that Robin Brooks' results are consistent with survey evidence for the United States, which suggests that households tend to run up financial wealth well into old age, then do little to run it down in retirement. Yet, while he finds a more conventional life-cycle pattern for Italy and Japan, this is less clear-cut in survey data for these countries. Another participant argued that the observation that the US households do not run down assets in retirement is not necessarily at odds with the life-cycle hypothesis; people accumulate assets through their working lives, then in retirement stop accumulating assets and live on the income generated by those assets. Participants highlighted that one advantage in using household survey data is that cohort effects can be identified; these effects are not controlled for in Robin Brooks' model. As an example of such a cohort effect, one participant suggested that increasing longevity might alter life-cycle patterns, as households are more likely to inherit later in life. However, participants also agreed that household survey data may understate life-cycle saving behaviour by excluding defined benefit pension and public pension assets. Similarly, a participant emphasised the importance of distinguishing between the equity holdings of households and institutional holdings, as the latter will follow life-cycle patterns by definition.

While Robin Brooks' paper focuses on stock and bond prices, participants also discussed the implications of ageing for housing prices, noting that in many countries the majority of people hold wealth, and leave bequests, in the form of residential housing. Some participants argued that, unlike other asset prices, for housing it may be important to consider the effect of population growth, as well as the effect of the changing age structure. That is, as the supply of land is often limited, shifts in demand for housing may have significant wealth effects; where housing prices increase, this will be a windfall gain to those who own property, and a windfall loss to those who do not. One participant remarked that the distinction between the effect of population growth and age structure may also apply to decisions about leverage, which are based on expected future prices; in a world of slower population growth, and hence weaker housing price growth, these decisions may need to be re-assessed.

Finally, whether triggered by the retirement of the baby boom generation or other factors, participants acknowledged that big swings in asset prices and returns will have implications for the adequacy of retirement incomes. A number of participants argued that this is exacerbated in many countries by increased emphasis on private saving for retirement, which has increased the exposure of households to these investment risks. Participants suggested that this reinforces the need for a mixture of public and private sources of retirement incomes.

How Will Ageing Affect the Structure of Financial Markets?

E Philip Davis[1]

Abstract

The ageing of the world population is an ineluctable process with major economic implications. Whereas there is extensive research on macroeconomic effects and on financial asset prices, there has been more limited systematic research into the impact of demographic changes on financial asset volumes and financial market structure more generally, as driven by age-related household saving and asset allocation decisions. Our empirical work based on the experience of 72 countries, viewed in the light of the existing literature, suggests that demographic changes have had a detectable impact on financial structure. Ageing tends to benefit bond markets relative to equity markets, while depressing private saving and external balances, albeit not sharply reducing the overall size of the financial sector. Continuation of such patterns during the coming period of ageing have wide-ranging implications for policy-makers and market participants.

1. Introduction

The ageing of the world population is an ineluctable process. It is anticipated that by 2050 one in four people will be aged above 65 at the world level (UN Population Division 2005). This pattern reflects both rising longevity and declining fertility rates over the long term, as well as the exceptional size of the post-war 'baby boom' generation. Such future trends will have major macroeconomic consequences.

The economic literature on demographics is in our view unbalanced. The link between changing demographic structure and conjunctural trends at a macroeconomic level has been widely studied (see for example, Kohl and O'Brien 1998; Turner *et al* 1998; McMorrow and Roeger 2003; Batini, Callen and McKibbin 2006). There is also an extensive literature on the impact of ageing on pension systems and public finance (see Dang, Antolin and Oxley 2001 and McMorrow and Roeger 2002 for recent examples). Researchers in the United States have put a considerable focus on links between demographic trends and financial asset prices (see Poterba 2004 for a recent survey; also Davis and Li 2003 and Brooks, this volume). There has also been work on demographic impacts on saving (see the review in Bosworth, Bryant and Burtless 2004). However, there has been more limited systematic research

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into the impact of demographic changes on individual financial asset volumes and financial market structure more generally.

Accordingly, in this paper we seek to fill the gap by reviewing the literature and undertaking further investigation of the link between demographics and financial market structure.[2] The paper is structured as follows. After assessing a number of stylised facts on financial structure, we attempt to address the issue of the impact of ageing on a number of levels.

First, we use *a priori* economic reasoning in terms of the life-cycle theory of saving, bearing in mind likely developments in ageing. Second, we review the existing literature on demographics and saving, to assess likely changes in financial asset demand and asset prices (including the possible effect of pension funding). Third, we seek to assess econometrically, using cross-country data for up to 72 countries, the impact of ageing on existing financial systems in terms of the volume of assets as well as private saving over the past 40 or so years. This assessment employs the World Bank Financial Structure Database, for both advanced and emerging-market economies (EMEs). We seek to control for a number of factors affecting financial structure (such as pension systems and the level of economic development) in detecting demographic effects without 'omitted variable bias'. In a final section, we estimate equations for demographic effects on external balances using our panel dataset. Policy aspects are highlighted in the conclusion.

2. The Evolution of Financial Systems

As background to assessing the impact of population ageing, it is essential to consider how financial structures evolve as countries develop, and factors that influence such development. It is important to understand what such normal financial development entails so we do not mistake it for an effect of demographic developments, perhaps due to omitting key variables from the econometric specification.

There is a widespread perception, backed by empirical observation, that financial systems go through stages of development. For example, Rybczynski (1997) suggests that one can distinguish bank, market and securitised phases. In the bank phase, all finance is directed through banks, whereas securities markets and institutional investors start to develop in the market phase and become dominant in the securitised phase. Most EMEs are still in the bank phase, although the most advanced – such as South Korea – are moving to a market phase (Davis 2005). Advanced economies are either in the market or securitised phase (where 'securitised' implies a growing importance of securities finance generally rather than just the packaging of loans in the form of securities).

2. Financial market structure can be viewed from several angles, namely in terms of overall size, by institutional sectors (for example, household, corporate, banks and institutional investors) and by instrument (for example, bonds, equities and deposits), as well as on a domestic and international level. A complication is that detailed 'national-balance-sheet' data on all of these aspects is only available for a small number of advanced economies. However, a wider range of countries are covered by the World Bank Financial Structure Database, notably in terms of volumes of equities, bonds and bank assets that we utilise here.

Stylised facts drawn from empirical observation suggest a somewhat more complex pattern (see Allen and Gale 2000), although the idea of these phases remains helpful. On average, as shown by Demirguc-Kunt and Levine (2000), banks, non-banks and stock markets are larger, more active and more efficient in richer countries. This is confirmed by background data on financial structure provided in Tables 1 and 2 for EMEs and advanced economies, respectively. Table 1 shows that for EMEs on average, private credit amounts to the equivalent of 46 per cent of GDP, while stock market capitalisation is equivalent to 44 per cent of GDP, private bond stocks 16 per cent, and public bond stocks are 25 per cent. In contrast, in advanced economies (Table 2) the private credit ratio is 118 per cent of GDP, stock market capitalisation 72 per cent, and the outstanding stocks of both private and public bond markets are equivalent to roughly 50 per cent of GDP.

A further division is between countries at a similar level of development that are market-oriented and those that are bank-dominated (see Table 3). Underlying the relative importance of markets and banks are aspects relating to the role of public information in markets as opposed to private information held by banks, as well as banks' role in corporate governance. The classic distinction is between the US and the United Kingdom on the one hand, and most continental European countries and Japan on the other. In this context, developed economies are themselves bimodal in their financial structure, with the market-oriented Anglo-Saxon countries having larger-than-average securities markets and bank-dominated countries having dominant banking sectors.

Country status in terms of bank or market focus may be partly endogenous; Demirguc-Kunt and Levine (2000) show that in developed economies, stock markets become more active and efficient relative to banks, and that there is some tendency for financial systems to become more market-oriented as countries become richer. On the other hand, Schmidt, Hackethal and Tyrell (1999, 2001) argue that there is path dependence, meaning that a bank-based system such as Germany will not automatically develop into a market-based system, owing to the institutional and legal structure that in a sense cements the bank-based structure in place.

A role for legal traditions in financial development and its link to market or bank orientation has been considered by recent empirical work on law and finance. This aspect appears to affect the relative size of banks and securities markets separate from the stage of economic development. A classification of countries by legal origin is also given in Table 3. La Porta, Lopez-de-Silanes and Schleifer (1999) show that countries with a Common Law tradition, protection of shareholders' rights, detailed accounting, low corruption and no explicit deposit insurance tend to be market-based – and have large institutional investor sectors – whatever their income level. In contrast, countries with a French Civil Law tradition, poor protection of the rights of shareholders and creditors, poor contract enforcement and accounting standards, restrictive banking regulation, high corruption and inflation tend to have underdeveloped banks, markets and institutional investors. The few countries with a German law tradition, which offers strong protection for creditors, tend to have strong bank-based systems, with small institutional investor sectors.

Table 1: Financial Structure within EMEs – 2003

Country	Private credit by deposit money banks and other financial institutions to GDP	Concentration (commercial bank assets, share of top 3)	Net interest margin	Stock market capitalisation to GDP	Private bond market capitalisation to GDP	Public bond market capitalisation to GDP
Argentina	0.118	0.468	0.052	0.624	0.100	0.056
Bolivia	0.486	0.511	0.056	0.173	na	na
Brazil	0.332	0.467	0.120	0.362	0.097	0.426
Bulgaria	0.224	0.468	0.044	0.063	na	na
Chile	0.750	0.591	0.051	0.864	0.194	0.274
Colombia	0.227	0.379	0.061	0.150	0.003	0.253
Costa Rica	0.287	0.591	0.081	0.111	na	na
Czech Republic	0.295	0.702	0.020	0.183	0.072	0.515
Dominican Republic	0.354	0.716	0.139	na	na	na
Ecuador	0.245	0.695	0.074	0.073	na	na
Estonia	0.292	0.982	0.036	0.021	na	na
Fiji	na	na	na	0.342	na	na
Honduras	0.380	0.489	0.081	na	na	na
Hong Kong, SAR	1.519	0.703	0.027	3.733	0.189	0.097
Hungary	0.378	0.540	0.056	0.174	0.034	0.409
Indonesia	0.219	0.534	0.048	0.204	na	na
Kazakhstan	0.189	0.632	0.057	na	na	na
Malaysia	1.327	0.429	0.025	1.414	0.530	0.363
Mexico	0.181	0.590	0.068	0.181	0.025	0.203
Pakistan	0.270	0.551	0.033	0.190	na	na
Panama	na	0.347	0.029	0.235	na	na
Peru	0.213	0.820	0.100	0.244	0.038	0.035
Philippines	0.349	0.430	0.033	0.396	0.001	0.280
Poland	0.281	0.419	0.040	0.153	na	0.291
Russian Federation	na	0.225	0.057	0.411	na	0.020
Singapore	1.132	0.964	0.012	1.360	0.231	0.389
Slovak Republic	0.350	0.674	0.034	0.071	na	na
Slovenia	0.392	0.606	0.032	0.207	na	na
South Korea	1.199	0.478	0.027	0.479	0.504	0.183
Sri Lanka	0.276	0.683	0.037	0.119	na	na
Thailand	0.957	0.522	0.026	0.564	0.156	0.210
Ukraine	0.197	0.490	0.053	0.075	na	na
Uruguay	0.503	0.661	0.066	0.017	na	na
Average	**0.464**	**0.574**	**0.052**	**0.440**	**0.155**	**0.250**

Source: World Bank Financial Structure Database

Table 2: Financial Structure within Advanced Economies – 2003

Country	Private credit by deposit money banks and other financial institutions to GDP	Concentration (commercial bank assets, share of top 3)	Net interest margin	Stock market capitalisation to GDP	Private bond market capitalisation to GDP	Public bond market capitalisation to GDP
Australia	0.953	0.664	0.021	0.937	0.341	0.156
Austria	1.037	0.798	0.021	0.172	0.368	0.373
Belgium	0.757	0.830	0.022	0.501	0.394	0.971
Canada	0.989	0.543	0.027	0.885	0.214	0.561
Denmark	1.483	0.852	0.038	0.485	1.193	0.481
Germany	1.174	0.637	0.030	0.370	0.426	0.378
Iceland	1.000	0.975	0.021	0.748	1.326	0.158
Italy	0.825	0.405	0.026	0.375	0.439	0.847
Japan	1.046	0.331	0.017	0.601	0.444	1.207
Netherlands	1.515	0.833	0.018	0.876	0.566	0.446
New Zealand	1.136	0.608	0.024	0.361	na	0.278
Norway	0.952	0.919	0.021	0.368	0.242	0.173
Portugal	1.476	0.838	0.034	0.340	0.282	0.464
Spain	1.113	0.729	0.028	0.714	0.240	0.445
Sweden	1.022	0.967	0.031	0.776	0.401	0.411
Switzerland	1.559	0.903	0.015	2.080	0.403	0.287
United Kingdom	1.413	0.427	0.028	1.199	0.389	0.276
United States	1.736	0.311	0.039	1.175	1.126	0.443
Average	**1.177**	**0.698**	**0.026**	**0.720**	**0.517**	**0.464**

Source: World Bank Financial Structure Database

Table 3: Characteristics of Financial Systems

Country	Legal origin[(a)]	Bank-based[(b)]	Market-based[(c)]	Anti-director rights[(d)]
Argentina	F	1	0	4
Australia	CL	0	1	4
Austria	G	1	0	2
Belgium	F	1	0	0
Brazil	F	0	1	3
Canada	CL	0	1	5
Chile	F	0	1	5
Denmark	SC	0	1	2
Finland	SC	1	0	3
France	F	1	0	3
Germany	G	1	0	1
Greece	F	1	0	2
Hungary	G	1	0	3
India	CL	1	0	5
Ireland	CL	1	0	4
Italy	F	1	0	1
Japan	G	1	0	4
Malaysia	CL	0	1	3
Mexico	F	0	1	1
Netherlands	F	0	1	2
New Zealand	CL	1	0	4
Norway	SC	1	0	4
Portugal	F	1	0	3
Singapore	CL	0	1	4
South Africa	CL	0	1	5
South Korea	G	0	1	2
Spain	F	1	0	4
Sri Lanka	CL	1	0	3
Sweden	SC	0	1	3
Switzerland	G	0	1	2
Thailand	F	0	1	2
Turkey	F	0	1	2
United Kingdom	CL	0	1	5
United States	CL	0	1	5

(a) F: French; G: German; SC: Scandinavian; CL: Common Law

(b) 1 = bank-based financial system

(c) 1 = market-based financial system

(d) An index aggregating the shareholder rights, formed by adding 1 when: (i) the country allows shareholders to mail their proxy vote; (ii) shareholders are not required to deposit their shares prior to the General Shareholders' Meeting; (iii) cumulative voting is allowed; (iv) an oppressed minorities mechanism is in place; or (v) when the minimum percentage of share capital that entitles a shareholder to call for an Extraordinary Shareholders' Meeting is less than or equal to 10 per cent (the sample median). The index ranges from 0 to 5.

Source: Impavido *et al* (2003)

As regards historical trends, Rajan and Zingales (2000) show that financial development has not been monotonic. The major OECD countries were on some measures more financially developed in 1913 than 1980, with a significant reversal in financial development and financial integration taking place between 1913 and 1950. A tightening of regulation in the inter-war period led to a decline in the size and importance of the financial sector relative to GDP. The imposition of such 'structural regulation' implied that the service provided to the non-financial sector was sub-optimal and economic growth was hindered, with, for example, low deposit rates and rationing of credit to households and small companies. This illustrates the danger of complacency by law-makers in respect of financial development. Meanwhile, financial liberalisation in the 1980s and 1990s has of course tended to improve financial sector efficiency in securities and banking, also leading to increased household borrowing, implying a cost in terms of risk.

With this section as background we now turn to an assessment of the impact of ageing on financial structure.

3. The Likely Impact of Ageing on Total Financial Assets

The main focus of ageing has to be on the relation between ageing and financial asset demand for the personal sector, which is the ultimate holder of financial claims, if one abstracts from foreign claims. Theory suggesting a link between an individual's age, consumption and saving decisions originated with the permanent income hypothesis (Friedman 1957), and the later life-cycle hypothesis (Modigliani and Brumberg 1954; Ando and Modigliani 1963). For an overview of this literature, see Deaton (1992). Saving patterns will in turn affect the aggregate size of the financial system, which is also affected by features such as the presence of pay-as-you-go pension systems.

The permanent income hypothesis, while not explicitly basing saving on age, has the insight that an individual's consumption is likely to depend on permanent rather than current disposable income. People will only consume additional income if they believe it will be sustained. Consequently, if increases in their income are expected to be temporary, they will save rather then increase their consumption. The underlying assumption is that people seek to avoid fluctuations in their consumption when income fluctuates. Furthermore, when actual income is below permanent income, that is, in retirement, they may decumulate wealth.

Following this insight, the life-cycle hypothesis of consumption suggests that, early in one's life, consumption may well exceed income as individuals may be making major purchases related to buying a new home, starting a family and beginning a career. At this stage in life, individuals may borrow based on their expected labour income in the future (human wealth), if financial markets are sufficiently developed and liberalised. In mid-life, these expenditures begin to level off while labour income increases. Individuals at this point will repay debts and start to save for retirement in equities, bonds, pension schemes, etc. At retirement, income normally decreases, and individuals may start to dissave. This involves selling off some of their financial assets, including pension fund decumulation.

Both theories of optimal consumption imply consumption will be smoothed out through an individual's lifetime, with corresponding accumulation and decumulation of financial assets. In the context of ageing, the life-cycle hypothesis is a crucial background as it implies that personal saving will rise when the high-saving age group grows, then fall as the population ages, and a larger proportion of individuals enter the low- or negative-saving age groups.

As regards empirical evidence, at a macroeconomic time-series level Disney (1996) notes that, consistent with the life-cycle hypothesis, saving rates tend to decline in countries where there are a larger proportion of retired people. The changes in saving rates lead to changes in demand for financial assets. Econometrically, a strong effect of demographics on private saving is found by many studies. Pioneering work in this area was by Fair and Dominguez (1991); Attfield and Cannon (2003) apply their work to the UK using a vector-error-correction approach. Masson, Bayoumi and Samiei (1995) find the total dependency ratio to have a significant negative effect on private saving in a panel of both advanced and developing countries, with an elasticity of –1. Later work by Loayza, Schmidt-Hebbel and Servén (2000) suggests that this estimate is lower at around –0.2. McMorrow and Roeger (2003) find an average elasticity of –0.75 across existing studies.

Modigliani (1986) shows life-cycle savings follow a hump-shaped pattern where an investor's asset holdings increase with age and decline after retirement. Higgins (1998) estimates demographic effects via a third-order polynomial in age and finds strong demographic effects; a similar exercise by Bosworth and Keys (2004) finds a peak impact on saving from the age 40–55 cohort and a negative effect from cohorts aged over 70. Al-Eyd, Barrell and Davis (2006) test for demographic effects on consumption over and above the standard determinants (that is, income and wealth), using the age cohorts 20–39, 40–64 and 65+ relative to the population in 15 countries (EU excluding Luxembourg plus US). They find a strong positive effect on consumption from the 20–39 cohort, but no differential between the middle-aged and elderly as would be expected if the latter draw down savings to pay for retirement. This in turn may reflect pay-as-you-go pension schemes in most of Europe.

Whereas the above work focuses on time-series macroeconomic data, there is also a large literature on life-cycle household saving using cross-sectional survey data, notably in the US (see the survey in Bosworth *et al* 2004). A significant number of these studies find that retired cohorts do not have negative saving. There is an apparent contradiction between micro and macro evidence which would affect strongly the predictions about personal saving when ageing and asset accumulation takes place.

Poterba (1998) suggests the life-cycle hypothesis cannot be proven by focusing on average cross-section-based asset accumulation profiles for three reasons. First, average figures are distorted by the wealthiest 10 per cent of households, who hold approximately 70 per cent of financial assets. If equities are included, this will raise the number to 90 per cent (see Poterba and Samwick 1995). Second, micro data typically omit social security wealth and wealth in defined benefit pension funds, which are important aspects of asset accumulation and decumulation from the point of view of individual households. Third, there is a problem in using cross-section data to evaluate the life-cycle hypothesis or project asset demands, in the style of Yoo (1994) and Bergantino (1998) since they mix age and cohort effects, as discussed by Poterba (2001). The associated problems can be described using Equation (1) where $A_{\alpha t}$ is individual asset holdings of age α at time t:

$$A_{\alpha t} = \alpha_a + \beta_t + \delta_{t-a} \tag{1}$$

α_a is the age-specific asset demand at age a, β_t is the time-period-specific shift in asset demand and δ_{t-a} is the cohort-specific effect for asset demand for those born in the period *t–a*. 'Cohorts' are a linear combination of age and time. With panel or repeated cross-section data, it is possible to estimate two effects, but it is impossible to estimate all three effects.

Poterba and Samwick (2001) estimate the effects of ageing using the US *Survey of Consumer Finances* data and allowing for this critique. They find a hump shape for net worth but not for net financial assets, which level off in old age. The levelling off of net financial assets could reflect precautionary saving or a bequest motive (Hurd 1987; Bernheim 1991). On the other hand, Bosworth *et al* (2004) suggest there may be intergenerational interactions missed by even such micro studies, and problems of heterogeneity leading to difficulty in aggregating micro studies.

Whereas our main focus is on personal saving and the related accumulation of financial assets, it is important to add that as the population ages, the public sector will tend to lower its saving, other things equal. This will in turn help to drive external balances as discussed in Section 8. Such trends in public saving are largely driven by the scale of the public pension system in light of ageing and the means of financing adopted (for example, taxation versus debt finance). Recent estimates include those in Dang *et al* (2001) and McMorrow and Roeger (2002). Debt finance would imply a greater fall in public saving. Rapid increases in the proportion of the population over 65 (the dependency ratio) combined with generous social security pension schemes are particularly threatening. It is this aspect which is encouraging governments to scale down public pension commitments and switch to funding.

4. The Likely Impact of Ageing on Demand for Financial Assets

While the life-cycle hypothesis focuses on overall household asset demand, empirical evidence also suggests that households' desired portfolios of specific asset classes would vary with age, which in turn would have a major effect on financial structure. Hence, further work has related to the changing demand for financial assets over the life-cycle. One underlying aspect of this relates to implications for asset holdings of the life-cycle pattern of borrowing and repayment, as well as pension accumulation. Another aspect of the underlying theoretical view is that risk aversion may vary over the life-cycle, with individuals seeking lower risk late in life (that is, shifting from equities to bonds). Complementing this, the duration of assets would appropriately change over the life-cycle, with long duration assets such as equities being more appropriate for young workers saving for pension claims far in the future, and shorter duration assets such as bonds being more relevant for older workers (Blake 1997). This would be particularly the case when (private) pensions are paid out as annuities, which are generally backed by bonds. Note that such effects relate on the one hand to directly-held assets but on the other to assets held indirectly via pension funds. They may be partly offset if, as in many EMEs, households are multigenerational, with labour income from younger households in effect supporting pensioners.

Bergantino (1998), looking at cross-sections derived from the US *Survey of Consumer Finances*, finds that young households under 40 usually draw credit from the financial markets by taking out mortgages for buying houses. Bergantino shows that households aged 40–60 tend to provide credit to financial markets, via employer and personal pension accounts. Those households which are over the age of 60 tend to withdraw from the financial markets as a result of using accumulated assets to fund consumption at retirement. Mankiw and Weil (1989) show that housing demand is high for those aged 25–40. Thus, again, their borrowings tend to exceed their purchases of financial assets.

Goyal (2001), using aggregate stock market data, looks at the effect of cohort size on outflows from the US equity market, defined as the difference between the value-weighted stock market return (NYSE, AMEX and NASDAQ), including dividends, and the percentage increase in stock market capitalisation. He finds that outflows are related to a rise in the size of the cohort aged 65 and over, and inflows are linked to the size of the cohort aged 45–64, suggesting that a rise in the over-65 cohort will reduce the net supply of equity finance.

Yoo (1994), using survey data, finds that demand for risky assets, bonds and equities increases with age and decreases after individuals retire. Bergantino (1998) shows that households with heads under the age of 35 generally have near-zero ownership of bonds and stocks. However, he finds a divergence in stock and bond holdings among older households. Ownership of stocks for those over 55 tends to decrease more rapidly than for bonds. He attributes this to possible cohort effects and risk aversion. It is also noteworthy that financial assets make up only 37 per cent of households' total assets, of which 15 per cent are held directly in stocks. Thus, total household assets are mostly non-financial assets, such as primary residences and vehicles, which are not the focus of our current work.

These estimates are subject to the critique pointed out above of mixing cohort and age effects for estimates of the life-cycle based on cross-sectional data. On the other hand, Poterba (1998) shows that holdings of equities decline in old age even allowing for age and cohort effects. Ameriks and Zeldes (2000), who also correct for age and cohort effects using data from the US pension fund TIAA-CREF, note a rapid increase in the proportion of households owning equities, from 33 per cent in 1989 to 49 per cent in 1998, as the baby boom generation increased in size. This is consistent with high equity holdings by the high-saving middle-age group. But they also note that half of Americans do not hold any wealth in the stock market.

Bodie and Crane (1997) look at the total asset holdings of individuals both inside and outside retirement accounts and find that behaviour is in line with economic theory and the 'best advice' of investment professionals. They hold a proportion of cash that declines with wealth and a proportion of equities that declines with age and rises with wealth. Consistent with this, Brooks (2000) suggests that given the need to finance annuities, demand for equities will fall more than demand for bonds as the population ages.

5. Impacts on Financial Asset Prices

A number of authors have sought to assess whether asset prices will also be put under downward pressure in coming decades by declining saving in advanced economies implicitly affecting the real interest rate or the risk premium. Particular focus has been put on the concept of a 'meltdown' of equity prices when the baby boom generation retires. The underlying issue for this paper is the balance between price and quantity effects of changing demands for financial assets. Arguably, in an efficient market excess demand for a certain type of financial asset will lead initially to price rises, but in the longer term to balance sheet adjustments that entail higher issuance of associated claims.

Schieber and Shoven (1994) suggest that given the correlation of ageing in OECD countries, and the likely decumulation of defined benefit pension fund assets, there could be widespread falls in asset prices, and associated high real interest rates. Supporting this, Erb *et al* (1997) find a positive correlation in the US between stock returns and the fraction of the population aged 25–45 and 65+ (that is, a negative effect on prices), while those aged 45–65 have a negative effect on returns. Looking at a range of OECD countries and EMEs, they find a positive relation between stock returns and the average age of the population. On the other hand, Brooks (this volume), using an econometric approach, shows estimates suggesting at most a modest decline in equity prices and possibly no decline at all.

Poterba (2001, 2004), although he acknowledges that standard models suggest that equilibrium returns on financial assets will vary in response to changes in population age structure, argues that the rapid meltdown hypothesis is inconsistent with empirical survey data. Consumers decumulate assets at a less rapid rate than the life-cycle hypothesis suggests. This is because the life-cycle model takes no account of the bequest motive and lifetime uncertainty. Hence, although asset demands rose to fuel the 1990s boom, future declines will be modest. However, Abel (2001) using a rational expectations model which takes account of the bequest motive, finds that stock prices are still expected to fall when baby boomers retire, despite high projected asset demands owing to shifts in the supply of capital in response to changes in its price.

Davis and Li (2003) give econometric evidence that demographics have had a significant impact on US, panel and aggregated international stock prices and bond yields, even in the presence of standard additional independent variables. As noted by Poterba (2004, p 15), the Davis and Li study '... moves beyond most of the previous work in including control variables for non-demographic factors that may affect asset prices, such as the rate of economic growth, the inflation rate, and the recent volatility of the equity market. The findings are robust to the inclusion of these control variables'. In this context, the age 40–64 cohort has a strong positive influence on equity and bond prices, a support that would be removed as its share of the population declines.

Rather few studies have looked at relative demand for different assets with ageing and its impact on prices. One exception is Brooks (2000) who, using a theoretical overlapping generations model, focuses on the relation between ageing and the demand for equities and bonds, and suggests that there will be excess demand for bonds and excess supply of equities in coming decades, with a modest decline in the returns on the retirement savings of baby boomers. He finds that the bond yield rises from 4.5 per cent to 4.8 per cent as the baby boomers buy equities, then falls to 4.1 per cent as they retire.

Consistent with the point we made above, Neuberger (1999) argues that the increase and subsequent decrease in flows during ageing will be balanced by rises and falls in equity issues, with little effect on prices and returns. This suggests that there could nevertheless be a substantive impact on financial structure.

6. Impacts of Pension Funds on Financial Structure

As noted above, growth of pension funds is likely to accompany ageing and hence, there is an important issue of whether pension reform more broadly affects financial structure. An impact on saving, and hence financial asset volumes, separate from demography would have to rely on the inability of the household sector to offset forced saving via pension funds (for example, due to credit constraints), and also – at a national level – that any rise in personal saving is not offset by falling public saving.

As reviewed in detail in Davis (2005, 2006) and Davis and Hu (2006), there is evidence that pension fund growth raises personal saving, but not one-for-one, as households reduce discretionary saving to offset growth in pension claims. Effects on saving are particularly marked where credit markets are imperfect (limiting borrowing) or for lower-income individuals who are less creditworthy or who do not have other assets to decumulate. Meanwhile, public dissaving may partly or wholly offset rises in personal saving at a national level, especially if the transition from pay-as-you go to funding is financed by debt issuance as opposed to higher taxes. On the other hand, Lopez Murphy and Musalem (2004) using a panel of 43 industrial and developing countries, find evidence suggesting that the accumulation of pension fund financial assets might indeed increase national saving, when these funds are the result of a mandatory pension program. The boost to personal saving is thus greater than the dissaving of the public sector due to reform. By contrast, national saving might be unaffected, when pension funds are the result of a public program implemented to foster voluntary pension saving.

Meanwhile, at the level of demand for individual financial assets, there is evidence that growth of pension funds accompanies equity market development (Catalan, Impavido and Musalem 2000), as well as entailing rises in the stock of private and public bonds (Hu 2005; Impavido *et al* 2003). In terms of asset prices, pension fund growth accompanies a decreased dividend yield and increased price-to-book ratio, as well as lower equity price volatility implying a drop in the cost of capital (Walker and Lefort 2002).

7. Econometric Analysis of the Impact of Demographics on Financial Structure

In light of the work cited above, in this section we undertake new tests of the hypothesis that ageing affects financial structure. We assess demographic impacts both for aggregates and also for ratios of financial assets. Data are for up to 72 countries from 1960–2002, of which 23 are OECD (that is, advanced) economies, 36 are EMEs and 13 are transition economies.[3] Countries covered are listed in Appendix A.

We use GLS panel techniques with fixed effects. We follow authors such as Walker and Lefort (2002) by adding extra explanatory variables such as inflation, per capita income, urbanisation and openness (average of the ratios of imports and exports to GDP) to estimate equations for financial structure and financial development, so as to avoid the possibility of omitted variable bias boosting the effect of the demographic variables. Openness we consider to be of particular interest, given that it proxies the degree to which a country is integrated in the global economy, which may in turn impact on the effect demographics has on the domestic financial system.

On the other hand, following Arestis, Luintel and Luintel (2004) we do not include some of the standard variables typically entered in cross-sectional cross-country growth regressions such as years of schooling, as well as corruption, social capital, inequality and the rule of law. We consider using panel data with fixed effects will capture any relevant differences in financial structure across countries. We estimate for all economies together, then for the EMEs and advanced economies separately (transition economies are included with EMEs).

The dependent variables are firstly size variables, namely the ratios of bank loans to GDP, M3 to GDP, equity market capitalisation to GDP and bond market capitalisation to GDP, as well as the sum of loans, and bond and equity market capitalisation to GDP (overall size indicator). This aggregate provides a rough total of domestic financial assets, which are held by households either directly or indirectly via financial institutions. Unfortunately, data on bond market capitalisation are not widely available, so the observations for that variable and the total size aggregate are limited. Note also that the equity market capitalisation variable (and to a lesser extent the bond market capitalisation variable) mix price and volume effects of ageing, as the data do not distinguish rises in capitalisation due to new issues from those due to revaluations. Furthermore, we do not have data on housing wealth for a wide range of countries, yet that may be an important complement and determinant of financing patterns that can vary with age.

3. Data are largely from World Bank's *World Development Indicators* and the Financial Structure and Economic Development Database. I am indebted to Yu-Wei Hu for use of the data he has collected.

We also assess a number of financial structure ratios, namely the economy-wide loan to equity ratio, debt (loans plus bonds) to equity ratio and loan to securities (bonds plus equities) ratio. Following the point made above, the loan to equity ratio has the most observations. Finally, we consider two flow ratios, namely the private saving to GDP ratio and (reported in the next section) the external balance to GDP ratio.

Table 4 records results for size variables for the full sample of up to 72 countries. From the coefficient estimated on GDP per capita it is evident that most of the size variables are correlated with economic development – countries with higher living standards also have larger financial sectors, banking assets and liabilities, and equity markets. Only the bond market result is opposite to this. Equally, urbanisation tends to accompany financial development, although the coefficient for equities is insignificant. Inflation is clearly inimical to bond issuance, as would be expected, but not to overall financial sector size or bank loan volume. More open economies tend to have larger banking sectors and equity markets, although the overall size effect is insignificant. Note that the overall size and bond results are based on quite small samples (37 countries and around 400 observations instead of 65 and over 1000 for the others) and hence may be less well-determined than the bank and equity results.

Turning to the demographic effects, a common feature is that the share of the over-65 cohort is significantly positively related to all the size variables. We need to infer causality with caution however, as it may link partly to the fact that countries with higher living standards have relatively larger populations of pensioners. The relative magnitude of the coefficients on the age 40–64 and 65+ variables is of interest. For bonds, it is the over-65 cohort that is most favourable to bond market development, consistent with the idea of greater risk aversion of older people in work cited above. On the other hand, for equities it is the age 40–64 cohort that is most favourable, consistent with higher demand for equities among those in peak years of saving for retirement. The coefficients for M3 and bank lending are similar for the two cohorts. Meanwhile, the age 20–39 cohort is insignificant or negative for most of the equations, consistent with low or negative financial saving by this cohort, but a high demand for bank loans in the form of mortgages, where the lending equation coefficient is positive.

To check for robustness, we add two lagged financial development variables, the pension fund to GDP ratio and the bank lending to the private sector to GDP ratio (Table 4). Most of the demographic coefficients are unchanged. Especially, the bulk of the coefficients on the over-65 cohort variables are still positive and significant, and the pattern for the age 40–64 cohort relative to the over-65s for equities and bonds is as cited above. The exception is that the lending equation has a negative sign for the younger cohorts with the extra variables. Pension funding is shown to entail a larger stock of bonds and equities, and a smaller banking sector, but a larger financial sector overall. Bank lending to the private sector is positively related to overall size (with a smaller coefficient) while there is also, unsurprisingly, a positive relationship with the banking sector variables (where it is more or less a lagged dependent variable).

Table 4: Estimates of Demographic Effects on Financial Structure – Size Variables

	All countries					All countries with financial development variables				
	SIZE	LOANS	M3	EQUITIES	BONDS	SIZE	LOANS	M3	EQUITIES	BONDS
GDPPC	**0.099**	**0.0176**	**0.003**	**0.0084**	**–0.0058**	**0.079**	**0.0072**	**–0.0046**	0.0038	–0.005
	(7.8)	(11.5)	(2.4)	(2.1)	(1.8)	(5.5)	(5.2)	(3.3)	(0.8)	(1.3)
INFLATION	**0.018**	**0.0031**	0.00031	–0.002	**–0.0059**	0.0074	0.00006	–0.00072	–0.0019	**–0.0063**
	(2.0)	(2.6)	(0.4)	(0.6)	(2.5)	(0.9)	(0.1)	(1.2)	(0.6)	(2.7)
URBAN	**0.048**	0.0014	**0.0038**	0.0017	**0.0012**	0.0081	**0.0024**	**0.0036**	–0.0001	**–0.0069**
	(4.2)	(1.6)	(6.0)	(0.6)	(2.4)	(0.6)	(3.4)	(5.6)	(0.1)	(2.1)
OPEN	0.0025	**0.0053**	**0.0044**	**0.0092**	0.0014	0.0045	**–0.0014**	0.0006	**0.0094**	**0.0026**
	(0.7)	(8.4)	(10.3)	(6.8)	(1.6)	(1.4)	(2.8)	(1.5)	(6.1)	(3.0)
20–39	**–0.093**	**0.0056**	0.0014	–0.0063	–0.0062	**–0.06**	**–0.0014**	0.00004	–0.0002	0.0072
	(4.1)	(2.7)	(1.0)	(1.0)	(1.1)	(2.6)	(2.8)	(0.1)	(0.1)	(1.2)
40–64	–0.036	**0.021**	**0.025**	**0.064**	**0.014**	**–0.037**	**–0.0059**	**0.012**	**0.048**	**0.018**
	(1.5)	(7.7)	(14.2)	(8.5)	(2.3)	(6.3)	(2.5)	(6.1)	(5.6)	(2.6)
65+	**0.156**	**0.039**	**0.027**	**0.025**	**0.081**	**0.15**	**0.019**	**0.018**	–0.0082	**0.076**
	(5.2)	(8.4)	(6.9)	(2.1)	(10.3)	(5.2)	(5.6)	(5.0)	(0.7)	(9.7)
PFAGDP(–1)						**1.5**	**–0.011**	**–0.23**	**0.98**	**0.38**
						(6.3)	(3.2)	(6.2)	(9.5)	(6.4)
BANKGDP(–1)						**0.5**	**0.91**	**0.53**	0.057	0.047
						(3.5)	(43.0)	(27.4)	(0.9)	(1.3)
R^2	0.93	0.8	0.87	0.71	0.97	0.95	0.93	0.93	0.77	0.97
Countries	37	71	65	66	37	35	68	62	63	35
Observations	395	2 468	2 160	1 246	419	365	1 937	1 684	1 069	380

Notes: SIZE – loans plus bonds plus equities as a per cent to GDP; LOANS – ratio of loans to GDP; M3 – ratio of M3 to GDP; EQUITIES – ratio of stock market capitalisation to GDP; BONDS – ratio of bond market capitalisation to GDP; GDPPC – real GDP per capita; INFLATION – annual percentage change in the GDP deflator; URBAN – urbanisation ratio; OPEN – average of the export and import to GDP ratios; 20–39 – share of 20–39 age group in total population; 40–64 – share of 40–64 age group in total population; 65+ – share of age group over 65 in total population; PFAGDP(–1) – ratio of pension fund assets to GDP lagged one year; BANKGDP(–1) – ratio of bank credit to GDP lagged one year. Coefficient estimates in bold are significant at the 5 per cent level. *t*-statistics are shown in brackets.

Table 5: Robustness Check Using 5-year Averages and Lags – Size Variables
All countries

	SIZE	LOANS	M3	EQUITIES	BONDS
GDPPC (–5)	**0.00004**	**0.00002**	**0.000004**	**–0.00002**	–0.000003
	(2.5)	(13.5)	(3.0)	(3.6)	(0.7)
INFLATION (–5)	–0.00002	–0.00001	**–0.00001**	–0.00002	–0.000008
	(0.3)	(0.9)	(2.0)	(0.7)	(0.6)
URBAN (–5)	**0.082**	0.00041	**0.0032**	0.00007	–0.0015
	(7.4)	(0.5)	(5.4)	(0.1)	(0.5)
OPEN (–5)	**0.007**	**0.0086**	**0.0053**	**0.016**	–0.00044
	(1.8)	(13.1)	(12.0)	(12.1)	(0.4)
20–39 (–5)	**–0.13**	0.0032	**0.0035**	0.007	–0.00056
	(5.8)	(1.6)	(2.6)	(1.2)	(0.1)
40–64 (–5)	–0.04	**0.029**	**0.034**	**0.086**	**0.019**
	(1.3)	(10.3)	(17.9)	(9.8)	(2.5)
65+ (–5)	**0.19**	**0.026**	**0.025**	**0.077**	**0.089**
	(5.0)	(5.1)	(6.0)	(6.3)	(9.8)
R^2	0.98	0.85	0.9	0.83	0.99
Countries	35	71	65	65	35
Observations	236	2 092	1 748	963	272

Notes: See Table 4; also (–5) indicates a lag of five years

A further robustness check was to change the specification to one where the dependent variable is a five-year average and the lagged variables are the 'initial conditions' at the beginning of each 5-year period (Table 5). We find that the demographic results are remarkably similar. Notably, we again find the relatively greater effect of the age 65+ generation on bonds and the 40–64s on equities, consistent with risk aversion effects. The signs on most of the non-financial variables are also robust.

As regards the size estimates for the EME and advanced economies (Table 6), results are similar despite the differing living standards and levels of financial development, which underpins the results for the full sample of countries. There remain some differences, however. For EMEs, GDP per capita is favourable for financial development except for bond markets, while for the advanced economies there is a negative-sign relationship between GDP per capita and the size of equity markets, possibly reflecting high living standards in some 'bank dominated' countries. Bond market development for advanced economies is not affected by GDP per capita, the level of which is of course fairly common across advanced economies. In this context, note that in advanced economies, the correlation between bonds and government debt is closer than in EMEs, where much of government debt is a bank asset.

Urbanisation is positive and significant for all of the EME equations, but only for overall size for the advanced economies. Again, urbanisation is comparable across the advanced economies. Openness has a positive effect on financial development

Table 6: Demographic Effects on Financial Structure – Size Variables

	EMEs					Advanced economies				
	SIZE	LOANS	M3	EQUITIES	BONDS	SIZE	LOANS	M3	EQUITIES	BONDS
GDPPC	**0.11**	**0.021**	**0.012**	**0.041**	**–0.023**	**0.1**	**0.018**	**0.006**	**–0.014**	–0.00001
	(2.7)	(6.1)	(5.2)	(5.1)	(3.1)	(5.2)	(8.8)	(3.2)	(2.3)	(0.1)
INFLATION	**0.025**	**0.0028**	0.00025	–0.0023	**–0.0055**	**–0.036**	0.05	–0.072	**–1.7**	**–1.1**
	(2.6)	(2.4)	(0.3)	(0.9)	(3.0)	(3.8)	(0.4)	(1.0)	(3.2)	(4.1)
URBAN	**0.07**	0.00074	**0.0021**	0.0053	**0.0092**	**0.036**	**–0.0075**	**–0.0015**	–0.0059	**–0.009**
	(2.9)	(0.7)	(3.0)	(1.6)	(2.1)	(2.6)	(3.6)	(1.7)	(1.1)	(2.1)
OPEN	–0.004	**0.0067**	**0.0053**	**0.0095**	**0.0024**	0.0065	**0.0025**	–0.0011	**0.011**	**–0.005**
	(0.9)	(9.4)	(11.5)	(7.7)	(2.8)	(0.9)	(1.9)	(0.9)	(3.0)	(2.5)
20–39	**–0.08**	**0.019**	**0.0093**	0.0018	**–0.017**	**–0.17**	0.002	**–0.012**	–0.0012	–0.0027
	(1.9)	(6.9)	(5.1)	(0.3)	(2.2)	(4.2)	(0.5)	(4.3)	(1.0)	(0.2)
40–64	**–0.17**	**–0.0068**	**0.01**	**0.015**	–0.004	–0.077	**0.045**	**0.024**	**0.14**	**0.041**
	(2.8)	(1.8)	(4.1)	(1.8)	(0.4)	(1.1)	(8.5)	(7.1)	(8.6)	(2.1)
65+	**0.61**	**0.041**	**0.037**	0.023	**0.13**	**0.092**	**0.049**	**0.034**	–0.018	**0.069**
	(3.8)	(4.9)	(6.6)	(0.9)	(4.4)	(2.8)	(8.0)	(6.8)	(1.1)	(6.8)
R^2	0.93	0.68	0.83	0.79	0.91	0.92	0.83	0.91	0.66	0.95
Countries	15	48	48	43	15	20	22	16	22	20
Observations	160	1 560	1 562	714	167	227	900	590	524	244

Note: See Table 4

for both sets of countries, although for the overall size regression in EMEs and for overall size and M3 regressions in the advanced economies the coefficients on openness are insignificant, and for the advanced economies the coefficient for the bond market is negative – possibly reflecting lesser fiscal discipline in the more closed economies. Inflation appears to have a more consistent negative effect on financial development in the advanced economies, where it has – for example – a significant negative effect for bonds, equities and overall size. In contrast, it is positive for overall size and loans in EMEs.

In terms of the demographic variables, the age 65+ cohort has a positive and significant effect throughout, except for equities where it is insignificant for both subsets of countries.[4] This is a more telling result than for the full set of countries, given that the advanced economies and EMEs separately have more similar age distributions than when they are pooled together. It suggests that there may indeed be a positive effect of the elderly on the size of financial markets other than equities, consistent with a pattern whereby they switch from equities to safe assets, but the decline in net financial assets is not a sizeable one due to precautionary saving or bequests as also suggested by Poterba and Samwick (2001).[5]

Consistent with this suggestion, the dichotomy of results for equity and bond markets across the age 40–64 and 65+ cohorts again applies, with only the 40–64 coefficient being significant (and positive) for equity market development in both country groups. For the bond market regression, the coefficient on the 40–64s cohort variable is insignificant for EMEs while the coefficient on the 65+ cohort variable is significant for both EME and advanced economy groups. The results confirm that again, there is implied to be a relative switch by the elderly from equities to bonds. Meanwhile, especially for the advanced economies, the coefficients of these sub-groups are comparable (positive and significant) for M3 and bank lending, suggesting that liquid asset holding needs do not change with retirement. Meanwhile the 20–39 cohort is shown to have a negative impact on M3 for the advanced economies, but a positive effect on M3 and borrowing in the EMEs. The contrast for M3 may reflect greater liquidity constraints in the EMEs. Finally, the 20–39 cohort has a negative effect on overall size in both cases, as do the 40–64s for EMEs.

Turning to estimates for financial structure ratios (Table 7), the loan-equity equation has the most countries (67) and observations (1 219). This shows that economic development accompanies growth in securities markets relative to banks, as witnessed by a negative sign on the GDP per capita and on urbanisation. This is consistent with a shift to market orientation as economic development proceeds, as discussed in Section 1. More open countries also have a larger stock of equity funding relative to bank lending, consistent with internationally integrated securities markets. Inflation is inimical to equities as opposed to bank lending. The demographic variables are all negative for this equation, but with the largest value for the 40–64 cohort, consistent with larger relative demand for equities rather than bank liabilities for this group.

4. We note that the lack of significance of equities for the over-65 variable rules out the possibility that results for EMEs are driven by a correlation of longevity with overall development.

5. Of course, the foreign sector may also be an important concurrent investor in these assets, notably in small open economies.

Table 7: Estimates of Demographic Effects on Financial Structure – Ratio Variables

	All countries			All countries with financial development variables		
	LOAN/ EQUITY	LOAN/ SECURITY	DEBT/ EQUITY	LOAN/ EQUITY	LOAN/ SECURITY	DEBT/ EQUITY
GDPPC	**–0.0033**	–0.0008	–0.4	**–0.0069**	0.011	–0.47
	(2.3)	(0.3)	(1.6)	(3.7)	(0.4)	(1.4)
INFLATION	**0.0054**	**0.086**	0.25	**0.0043**	**0.062**	0.13
	(4.7)	(5.3)	(1.4)	(3.9)	(4.8)	(0.7)
URBAN	**–0.0052**	–0.031	–0.21	**–0.0041**	**–0.052**	–0.46
	(5.0)	(1.5)	(0.9)	(3.5)	(2.1)	(1.6)
OPEN	**–0.0018**	**–0.028**	**–0.38**	**–0.0029**	**–0.033**	**–0.42**
	(3.4)	(4.5)	(5.4)	(5.1)	(5.2)	(5.6)
20–39	**–0.0046**	0.018	**1.0**	**–0.0067**	0.012	**1.23**
	(2.1)	(0.4)	(2.2)	(2.8)	(0.3)	(2.7)
40–64	**–0.016**	0.032	**1.6**	**–0.017**	–0.028	**1.61**
	(6.0)	(0.7)	(3.3)	(5.6)	(0.6)	(2.7)
65+	**–0.011**	–0.055	–0.61	**–0.0077**	–0.056	–0.45
	(2.6)	(1.0)	(1.0)	(1.7)	(1.0)	(0.7)
PFAGDP (–1)				**–0.172**	–0.27	2.25
				(4.5)	(0.6)	(0.4)
BANKGDP (–1)				**–0.178**	**0.99**	**5.6**
				(7.7)	(3.5)	(1.7)
R^2	0.71	0.61	0.41	0.73	0.63	0.41
Countries	67	36	36	63	35	35
Observations	1 219	395	395	1 059	365	365

Notes: See Table 4; also, LOAN/EQUITY – ratio of loans to stock market capitalisation; LOAN/SECURITY – ratio of loans to bonds plus equities; DEBT/EQUITY – ratio of loans plus bonds to equity; all ratios expressed in per cent

Meanwhile, for the loan-security ratio there are no significant demographic effects, and for the debt-equity ratio the younger cohorts are shown (on the smaller sample) to favour the development of debt markets (loans and bonds). The equations with the financial development variables show similar patterns for the demographic effects. A large pension fund sector is shown to accompany a larger stock of equities relative to bank loans, as, interestingly, does a larger banking sector. On the other hand, a larger volume of bank loans to the private sector accompanies a higher loan-security ratio and economy-wide debt-equity ratio.

Looking at the ratio results for the separate country groups (Table 8) briefly, the loan-equity ratio is reduced strongly in advanced economies by the high saving 40–64 cohort, who as shown in Table 7 encourage the development of equity markets more than bank loans. In the EMEs it is the 20–39 and 65+ cohort that drive a fall in the loan-equity ratio – the result for all countries in Table 7 was a mixture of these effects.

Table 8: Demographic Effects on Financial Structure – Ratio Variables

	EMEs			Advanced economies		
	LOAN/ EQUITY	LOAN/ SECURITY	DEBT/ EQUITY	LOAN/ EQUITY	LOAN/ SECURITY	DEBT/ EQUITY
GDPPC	–0.00021	–0.025	–0.35	–0.0007	–0.009	**–0.39**
	(0.4)	(0.2)	(0.3)	(0.5)	(0.7)	(2.5)
INFLATION	**0.0054**	**0.071**	0.27	**0.44**	**0.027**	**20.0**
	(4.3)	(2.9)	(1.0)	(3.2)	(4.5)	(2.7)
URBAN	**–0.0073**	**–0.137**	0.13	0.0003	0.012	–0.095
	(4.5)	(2.2)	(0.2)	(0.2)	(1.4)	(0.8)
OPEN	**–0.0015**	**–0.028**	**–0.54**	**–0.003**	**–0.018**	**–0.14**
	(2.3)	(2.4)	(4.1)	(3.2)	(4.1)	(2.7)
20–39	**–0.0071**	0.17	**2.6**	–0.0004	0.016	0.027
	(2.0)	(1.6)	(2.1)	(0.1)	(0.6)	(0.1)
40–64	0.0011	**0.43**	**4.2**	**–0.029**	–0.029	0.1
	(0.2)	(2.8)	(2.4)	(7.0)	(0.7)	(0.2)
65+	**–0.05**	**–1.1**	–7.3	–0.0007	–0.011	–0.22
	(4.0)	(2.6)	(1.6)	(0.2)	(0.5)	(0.9)
R^2	0.69	0.57	0.33	0.78	0.83	0.77
Countries	44	15	15	22	20	22
Observations	696	160	160	515	227	227

Note: See Tables 4 and 6

We finally highlight some results for private saving using demographic effects, as shown in Table 9. Note that this includes corporate as well as household saving. Given this area has been widely researched (see Section 5), we do not put a major emphasis on these results. Nevertheless, it is notable that strong and consistent demographic effects are detected for all countries and both subgroups, with a range of financial structures. The results are in turn consistent with the life-cycle hypothesis (although the results do not *prove* the life-cycle pattern holds for each individual cohort, since the aggregate macro data show the average age behaviour of a range of cohorts).

In each case, the coefficients on the 20–39 and 40–64 cohort variables are positive for private saving, and the 40–64 cohort always has a larger coefficient. For EMEs, the coefficient on the 20–39 cohort variable is positive and significant (and also for all countries) but in the advanced economies, the 20–39 cohort variable is insignificant, which may reflect heavy borrowing in financially liberalised economies, while the 20–39s face liquidity constraints in EMEs. Meanwhile, the over-65 cohort has a consistently negative and significant impact on saving, across all country groups. The contrast with some of the positive results for financial asset accumulation may reflect the existing stock of wealth that this cohort has built up, and positive revaluations that will not be reflected in private sector saving. Finally, whereas the size of the pension sector has no effect on private saving, there is a tendency for countries with large bank lending to the private sector to have lower private saving also.

Table 9: Estimates of Demographic Effects on Financial Structure – Flow Variables

	Private saving/GDP				External balance/GDP			
	All countries				All countries			
	(1)	(2)	EME countries	Advanced countries	(1)	(2)	EME countries	Advanced countries
GDPPC	0.0006	0.00075	**0.0068**	–0.00023	**0.3**	**0.24**	**0.14**	**0.24**
	(0.8)	(0.8)	(3.8)	(0.5)	(9.5)	(4.9)	(1.7)	(7.5)
GROWTHPC	**0.0008**	**0.0006**	0.00031	**0.0026**	**–0.059**	**–0.056**	**–0.09**	**0.09**
	(2.8)	(2.0)	(0.8)	(6.9)	(2.9)	(2.4)	(3.6)	(2.1)
INFLATION	0.00043	0.0001	0.00046	**0.063**	0.028	0.03	0.023	**–0.074**
	(1.5)	(0.3)	(1.3)	(3.1)	(1.0)	(1.1)	(0.7)	(3.8)
URBAN	**–0.00095**	–0.00067	**–0.0015**	0.0005	0.021	–0.0026	0.039	–0.014
	(2.4)	(1.3)	(2.6)	(1.1)	(1.1)	(0.1)	(1.5)	(0.5)
OPEN	**0.001**	**0.0019**	**0.00072**	**0.0015**	0.019	0.013	–0.011	**0.15**
	(4.4)	(6.2)	(2.3)	(4.9)	(1.4)	(0.7)	(0.7)	(7.2)
20–39	**0.0045**	**0.0023**	**0.0052**	0.00064	0.0033	0.045	–0.0047	–0.048
	(5.5)	(2.2)	(3.5)	(0.8)	(0.1)	(0.8)	(0.1)	(0.7)
40–64	**0.0067**	**0.0048**	**0.0094**	0.0019	**0.021**	**0.029**	**0.37**	0.056
	(4.9)	(2.6)	(3.7)	(1.6)	(3.5)	(3.4)	(3.8)	(0.6)
65+	**–0.011**	**–0.0079**	**–0.022**	**–0.0046**	**–0.59**	**–0.35**	**–0.63**	**–0.41**
	(5.3)	(3.3)	(4.4)	(3.5)	(5.8)	(2.8)	(3.2)	(4.3)
PFAGDP (–1)		0.021				–0.22		
		(0.9)				(0.2)		
BANKGDP (–1)		**–0.031**				**–1.65**		
		(2.5)				(2.1)		
R^2	0.6	0.62	0.53	0.76	0.57	0.6	0.56	0.55
Countries	59	53	35	22	71	68	48	22
Observations	1 398	1 103	830	560	2 600	1 950	1 663	928

Notes: See Table 4; also, GROWTHPC – annual growth rate of GDP per capita

Overall, we conclude from this preliminary empirical work that there are indeed detectable demographic effects on financial structure, which can be expected to have important implications for the future. Among other things, there is a switch from equities to bonds between the 40–64 and 65+ cohorts, as well as a positive impact of the older cohorts on banking and overall size of the financial sector. Saving regressions show a strong positive effect for the 40–64 cohort and negative for the 65+ one, consistent with other work in this area. So in an ageing economy, a financial system may well become more bond- as opposed to equity-based, and somewhat larger overall, while also facing declining inflows of saving.

This is an area which clearly warrants further research. Further work could assess different specifications, notably using lagged dependent variables for the financial structure variables, which would in turn necessitate using the Generalised Method of Moments method for estimation.

8. Impacts of Ageing on Cross-border Financial Claims

In open economies, ageing will also impact on the external balance, depending on the path of investment. In this context, most studies suggest that investment rates will fall with ageing, which would temper the increase in external deficits from lower saving. For example, Cutler *et al* (1990) suggest that total investment may fall with ageing, given the reduced need for capital with a smaller workforce; they also envisage a fall in the rate of return on capital from 6.7 per cent in 1990 to 3.5 per cent in 2025. Disney (1996) shows a significant negative relationship between the elderly dependency ratio and fixed capital growth over 1977–1992 in 24 OECD countries. Blommestein (1998) again sees falling investment as likely to occur as the labour force shrinks and the capital-labour ratio rises, depressing returns to new investment. Higgins (1998) estimates that the cohort aged 15–24 has a peak positive effect on investment earlier than the peak positive effect on saving due to the 30–45 aged cohort.

Bikker (1996) focuses directly on balance-of-payments effects of ageing and finds that the effects in OECD countries may be to move the current account towards a surplus as long as national saving is boosted by ageing, which seems possible as long as the 'baby boom' generation remains at work. But once people in this generation retire and begin to dissave, this could turn around.

In the light of this work, we undertook panel estimates for the external (current account) balance, bearing in mind that it is a product of public as well as private sector behaviour, and of investment as well as saving. These are also reported in Table 9. Looking first at the non-demographic effects, higher GDP per capita tends to push countries' current accounts towards surplus, in the full group as well as the EMEs and advanced economies separately. Rapid income growth tends to reduce current account balances, but interestingly not for the advanced economies, where high inflation pushes countries towards external deficits. As regards demographic effects, the 20–39 cohort is not in any case a significant influence on the external position. The 40–64 cohort tends to encourage a surplus position, albeit not significantly for the advanced economies. This is plausible in the light of high saving by this group, and also a likely beneficial effect on government saving (higher tax receipts than expenditure needs). The 65+ generation is associated with a tendency to deficit in the external position in all cases, consistent with lower private saving as discussed above as well as pension and health expenditures by government with less offsetting tax inflows. Finally, whereas the pension sector has no effect on the external position, there is a tendency for countries with large bank lending to the private sector to have deficits. This may of course reflect private investment financed by such lending, as we now go on to discuss.

On balance, our results suggest that the pattern of ownership of financial claims will shift relatively from advanced economies towards EMEs as the former age more rapidly, although later ageing of the EMEs will tend to redress the balance. These suggestions are supported by various macroeconomic projections as summarised below.

9. Global Macroeconomic Projections

Illustrating the overall outcome of these ageing patterns, and giving further clues about changes in financial structure with ageing, Turner *et al* (1998) provided a simulation of the global effects of population ageing (focusing both on changing population growth and age structure), using the OECD's international dynamic general equilibrium macro-model MINILINK. Reflecting the declining labour supply with ageing, economic growth is forecast to decline to 0.25 per cent per annum in Japan, 1 per cent in Europe and 1.4 per cent in the United States by around 2030. The slowdown in growth reduces investment needs directly. Furthermore, a decline in the weight of the OECD in the world economy tends to shift OECD current accounts towards a surplus (and hence saving-investment balances) as non-OECD imports rise faster than OECD import demand. The US, Europe and Japan all generate current account surpluses of 2–3 per cent of GDP up to 2025, as saving is initially boosted by the high proportion of high-saving age groups while growth potential and hence investment weaken, thus building up net external assets which help to buttress GNP. They thus build up ownership of global financial claims, including those on EMEs.

On the other hand, eventual downwards pressures on public and private saving are greater in the OECD than elsewhere, generating – in combination with exchange rate appreciation – current account deficits for the three OECD regions after 2025. The balance of ownership of global financial assets would tend to switch at this point from OECD countries to EMEs. As world investment in this simulation falls less than saving, world real interest rates are expected to rise slightly, reinforcing the decline in investment. Reflecting differing returns to capital, interest rates are higher in EMEs than in the OECD. The authors note that higher saving in OECD countries could generate quite different results, with lower real interest rates and consequently higher investment and capital-labour ratios. There would also be greater net external assets, boosting OECD GNP via inflows of interest, profits and dividends.[6]

6. The return on such investments will depend on factors such as labour and product market reforms in the EMEs as well as the overall size of such flows from the OECD (if the flows are sizeable enough, they will depress the return to capital in the EMEs).

McMorrow and Roeger (2003) concur that the EU and Japan will run current account surpluses for some time, but expect the US to run ongoing deficits, reflecting growth differentials and an assumption that the absorptive capacity of slow-ageing EMEs is limited. Their projection, unlike that of Turner *et al* (1998) thus implies that the bulk of cross-border claims will remain within the OECD region during that region's ageing phase. They also note that such a continued concentration of capital flows within the OECD is more likely to generate downward pressure on rates of return and a risk of bubbles.

Finally, Batini *et al* (2006), using a dynamic intertemporal general equilibrium model, again find slower growth and a current account deterioration for the developed economies as the elderly run down assets in retirement. Interestingly, more rapid productivity growth (in terms of catch-up with the US) can markedly reduce the loss in growth from ageing, and related current account balances.[7]

10. Conclusions

Summarising the paper, we noted initially that financial structure is intimately related to the stage of development and legal structure of an economy. We then highlighted that, in line with the life-cycle hypothesis, overall personal saving is likely to rise then fall as ageing proceeds, thus impacting on the size of financial claims and overlaying standard patterns of financial development. Existing work also shows that ageing tends to accompany an initial shift into securities followed by a relative shift from equities to bonds, as well as a fall in household debt. There has been extensive work on securities prices and ageing, much of which suggests that ageing will depress equity prices, albeit modestly. Finally, most analysis suggests that ageing will accompany rising current account surpluses in the advanced economies followed by deficits, largely driven by changes in saving albeit also affected by demographic effects on investment.

Our own empirical work suggests that demographic changes have had a detectable impact on financial structure in both advanced economies and EMEs and will continue to do so in the future if current relationships continue to hold. The similar results for the two subgroups suggest that this may indeed be the case (as advanced economies can be viewed as akin to EMEs at a later stage of ageing and economic growth). Ageing tends initially to benefit equities (as the 40–64 cohort grows) but then as the 65+ cohort becomes predominant, it will benefit bond markets relative to equity markets. Banking tends to benefit from large cohorts aged 40–64 and 65+. Finally, a rise in the 65+ cohort also tends to depress private saving and external balances, albeit not reducing the overall size of the financial sector.

Policy-relevant issues, also necessitating further research, that are raised by the effect of ageing on financial market structure include the following:

- What will be the balance between price and quantity effects on financial markets as the asset demands of the household sector evolve with ageing? If there is a

7. See Davis (2006) for a review of existing work and new estimates of the impact of age structure on productivity, as well as that of pension funding.

'meltdown' will there be pressure on governments to accept some of the burden of adjustment which would otherwise fall directly on holders of defined contribution pension funds?

- How should government financing evolve to meet the changing demands of the household sector in terms of asset risk? Should they issue bonds linked to longevity to overcome uncertainty over demographic changes?
- How will companies cope with the changing demand for bonds and equities from the household sector during ageing? Will there be an initial fall in debt-equity ratios followed by a rise – leading to heightened bankruptcy risk at a time when economic growth may also be sluggish? Or could asynchronous demand for bonds and equities by advanced economy and EME households flatten out this pattern?
- Saving has seen a decline in many advanced economies after financial liberalisation, as household sectors have undertaken heavy borrowing and relied on rising asset prices (notably house prices) to maintain wealth-income ratios. Can this continue as the population ages, and how will ageing, borrowing and house prices interact?
- Is it plausible that banking sectors will be relatively unaffected by ageing, as implied by the empirical results?
- Will there be difficulties in dealing with major cross border flows, initially from advanced economies to EMEs and later reversed, which are also likely to drive shifts in exchange rates and even financial instability (Davis 2002). Why are such flows not occurring now? In other words, why are EMEs financing the advanced economies via foreign exchange reserves? Can EMEs absorb the potential volume of advanced economy claims in the short term (McMorrow and Roeger 2003) and what are the economic and political implications of major shifts later by EMEs into creditor status, when their economic development will be much more comparable to that of the advanced economies than it is now? Will cross-border EME asset demand help attenuate any pressures cited above for changes in asset prices and composition of assets in advanced economies?
- How should financial regulation adapt to the changing patterns of financial stocks and flows foreshadowed in this work?
- How will the changing structure of finance interact with growth in conjunction with ageing? There is an extensive literature on finance and growth (see Beck and Levine 2004 and Davis and Hu 2004 for example), while there is also emerging evidence that ageing may affect growth (such as Davis 2006 who looks at a possible impact on total factor productivity).
- Will past patterns, which were estimated over periods when pension systems were more pay-as-you-go-based, change as pension funding becomes more important? Will the switch from defined benefit to defined contribution pension funds change saving, and its composition between debt and equity claims (for example, as risk-bearing households under defined contribution schemes become more cautious)?

Appendix A: List of Countries Utilised in Econometrics

EMEs	Transition economies	Advanced economies
Algeria	Bulgaria	Australia
Argentina	China	Austria
Bolivia	Croatia	Belgium
Brazil	Czech Republic	Canada
Chile	Hungary	Denmark
Colombia	Kazakhstan	Finland
Costa Rica	Latvia	France
Dominican Republic	Poland	Germany
Ecuador	Romania	Greece
Egypt	Russian Federation	Iceland
El Salvador	Slovak Republic	Ireland
Fiji	Ukraine	Italy
Honduras	Vietnam	Japan
Hong Kong, SAR		Luxembourg
India		Netherlands
Indonesia		New Zealand
Israel		Norway
Jordan		Portugal
Malaysia		Spain
Mexico		Sweden
Morocco		Switzerland
Nigeria		United Kingdom
Pakistan		United States
Panama		
Paraguay		
Peru		
Philippines		
Singapore		
South Africa		
South Korea		
Sri Lanka		
Thailand		
Tunisia		
Turkey		
Uruguay		
Venezuela		

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Discussion

Richard T Freeman

I have heard it said that the intersection of demography and economics is a rich area for theorists, but much less so for econometricians. That observation highlights the fact that, while demographic variables are among the most reliable in many respects, econometric analysis of their effects often has to be filtered through economic frameworks where longer-run stability can be questionable. Given enough time, seemingly solid constants and supposedly stable relationships may be on unsteady ground. Some so-called 'fundamentals' even turn out to be partially endogenous.

Against that background, Philip Davis has done a nice job of surmounting many of the hazards of econometric work in this area by effective use of a very broad cross-country panel. It is reassuring that the findings on the whole tend to confirm theory (specifically the life-cycle hypothesis) across a wide range of financial structures and cyclical circumstances. The paper has a lot of good ideas, raises some important issues and adds to our understanding of some of the potential impacts of demographic change. The paper also raises some intriguing questions about how the growth of pension systems might contribute generally to financial development and, in turn, to real economic growth. My comments have to do mainly with how we might use the findings to draw out some broader implications – especially with regard to how saving may evolve over time and affect financial markets as global ageing advances.

Structural change in financial markets

My first point has to do with the interactions of ageing populations and structural change in financial markets. A noteworthy trend observed in the 1980s (and emphasised yesterday) was the widespread decline in household saving rates in major industrial countries that has been attributed, among other factors, to improvements in financial technology. At that time, more efficient structures arose for smoothing consumption and achieving life-cycle objectives. Opportunities for saving expanded. Potentially, such changes can operate in competing directions, but on balance households lowered saving rates – in fact, they lowered saving rates significantly in some countries where rates had been thought to be permanently entrenched at high levels.

This raises the question: should we expect something equally dramatic as engineering of financial instruments and frameworks for retirement-related needs continue to evolve and spread globally? Ongoing structural innovations could make the process of saving for retirement more efficient and, thereby, lower saving rates. But steps being taken in many countries to shift the burden of risk to individuals (moving them off defined benefit plans, for example) could work in the opposite direction. The net effect of these and other foreseeable structural changes is hard to pin down, and there may be many such changes in store. Of course, these changes not only have immediate impacts on saving and spending behaviour when they occur, they also change the entire incentive structure faced by the population as it ages over a period of indefinite duration. Accordingly, the responsiveness of saving to ageing populations, and the impact on financial markets, could be quite different from what has been revealed by the sample.

Home and property ownership

The papers presented so far at this workshop have been heavily focused on the provision of income for retirement via pensions and other essentially financial arrangements. But another key objective for household saving – and one we know to be importantly affected by demographic developments – is home and property ownership, which is the basis for my second point. In the United States, in interpreting movements in spending recently, we have seen the importance of households' capacity to extract income from housing assets as house prices rose to high levels. My reason for mentioning this is that home ownership is an alternative avenue for building up assets, and withdrawals from home equity could operate to smooth consumption over time for older cohorts as well. This is likely to be occurring to some extent already, through downsizing in housing and other such steps; the smoothing would be even more apparent if reverse mortgages and other similar instruments were more prevalent.

In cross-country data, a noticeable feature is how widely the share of home ownership in household wealth varies. That share is high here in Australia, for instance, and surprisingly low in countries like Switzerland. Such differences could arise in a number of ways, but one wonders about the extent to which home ownership may interact with decisions related to life-cycle saving. A broad comment that I might offer is: in this research, and in general in our discussions, impacts on saving and, thus, on financial markets through housing deserve more attention – especially if this is a sensitive margin across which individuals shift their personal saving portfolio.

Globalisation

The third area that I want to spotlight is globalisation. From our discussions, a basic point (in effect, nearly an axiom) seems to be: impacts of national demographic developments on local markets will be greater to the extent that an economy conforms to the closed model. As an economy becomes more globalised and open, the impacts of local 'shocks' – including those related to ageing – get dispersed into global markets and are thereby buffered; by the same token, external demographic shocks start to matter more locally.

If we ask what we can expect going forward, it seems safe to assume that globalisation will continue. But globalisation as it relates to ageing could mean changes across a variety of economic measures – and what particular aspects of globalisation should be stressed most are debatable. In fact, the degree to which the basic axiom holds up may vary, depending on our focus. Three aspects of globalisation or openness seem pertinent. At perhaps the level of greatest generality, openness might mean the extent to which a country is able to run an imbalance in its current account, with the gap financed by capital inflows or outflows. Analysis at this level, of course, links directly to broad, national measures of saving and investment, and in turn to how ageing might affect cross-country patterns of external imbalance. The paper by Philip includes a control variable that measures openness at this level of aggregation, in effect, as the share of trade in GDP. But openness at this level of generality may not capture well the aspects of globalisation that are most relevant to detecting how ageing populations might affect financial markets.

A somewhat narrower, more focused notion of openness refers to the degree to which flows in specific (but still fairly broad) compartments of financial markets can move across borders freely. To the extent that some financial markets (say, fixed-income securities and some stocks) are more subject to global arbitrage than others, local and global impacts of ageing populations will be felt differently across market sectors. And, of course, the margins of substitution that underlay such relationships could well shift over time.[1]

Finally, perhaps most narrowly, globalisation could refer to the extent to which particular institutions involved in intermediating intergenerational flows become more globalised themselves – either by wider portfolio diversification or by cross-border operations. Changes in the rules or practices governing these aspects of globalisation also could importantly affect how demographic developments get transmitted into local financial markets. Many pension portfolios already are widely diversified internationally, but the degree of diversification is uneven. In the United States, for example, there is a considerable range of variation in foreign asset shares. Rough calculations suggest that there still is scope for further decline in '*pension-sector home-bias*' in many cases. I suspect that such estimates for other countries might lead to a similar conclusion.

In general, a trend toward wider global diversification likely would be a positive development, as well-managed, globally diversified portfolios offer potential for improved risk-return trade-offs. But there are some hazards as well. Lately, concerns have been expressed about pension funds becoming prominent investors in financial markets with high volatility, especially during the recent low-interest-rate period. We generally assume that pension providers are not high-risk investors, have effective governance structures in place and perform sufficient due diligence with respect to risk management. But these are assumptions for which it is worth reserving final judgment, and these concerns are a reminder of the need to have adequate supervisory safeguards in place as financial structures and strategies evolve.

Reference

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1. A theme of the recent compendium produced by the members of the G-20 on 'Economic Reform in the Era of Globalization' was the positive effects of openness on domestic financial development more generally (G-20 2003). Arguably, greater openness is likely to contribute to a more efficient, better-managed financial environment with improved options for meeting age-related investment demands.

Financial Innovation for an Ageing World

Olivia S Mitchell, John Piggott, Michael Sherris and Shaun Yow[1]

Abstract

Over the last half-century, around the world, many nations have seen plummeting fertility rates and mounting life expectancies. These two factors are the engine behind unprecedented global ageing. In this paper, we explore how this demographic transition may influence financial markets and, in turn, how financial market innovation might help to resolve concerns flowing from global ageing trends. We first provide context by reviewing the economics, finance, and insurance-related literature on how global ageing patterns may influence capital markets. We then turn to insurance markets, and discuss a range of products and policies, including both retail and wholesale financial offerings for various forms of life annuities, long-term care benefits, reverse mortgages, securitisation of longevity risk, inflation-protected assets, reinsurance, guarantees, derivative contracts on residential property price indices, mortality swaps, and longevity derivative contracts. We also indicate how new public-private partnerships might be beneficial in enhancing the future environment for old-age risk management.

Introduction

> *Representing two-thirds of the world's population, and with its unique mix of systemically significant industrial and emerging market economies, the G-20 is a useful forum in which to develop a shared understanding of the implications of demographic change, and to consider responses to the associated economic and social challenges.* (G-20 2005, p 4)

Understanding how economies and financial markets will respond to global population ageing is an area of extraordinary policy and research interest. In recent years, substantial attention has been drawn to the macroeconomic implications of

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population ageing; thus after its 1997 Denver Summit, the BIS offered an extensive review of the impact of ageing on fiscal stability (G10 1998) and Davis (2004) addressed the implications of global ageing for financial and monetary stability. Recent high-level G-20 meetings, including this year's meetings in Australia, again underscore policy-makers' concerns at the highest level. The problem is simply put: over the past half-century, around the world, many nations have seen plummeting fertility rates and mounting life expectancies. These two factors are the engine behind unprecedented global ageing. In this paper, we explore how the demographic transition may influence financial markets and, in turn, how financial market innovation might help resolve concerns flowing from global ageing trends. We also indicate how new public-private partnerships might be beneficial in enhancing the future environment for old-age risk management.

Our approach is to assess what the economics, finance, and risk-management literature offers by way of insight, to help us evaluate how global ageing may spur demand for new financial products useful in helping to mitigate and insure against key old-age risks. We begin by providing an overview of relevant demographic trends and patterns of retirement wealth, and reviewing the literature on the effect of population ageing on capital markets and asset prices. We then turn to insurance issues, and point to the need for more complete insurance of risks which are disproportionately borne by the old, focusing especially on products associated with uncertain mortality and morbidity – longevity insurance, and insurance against long-term care costs. Along the way, we identify a range of products and policies that could be imagined to help manage these risks. For instance, these could include both retail and wholesale financial offerings for life annuities, long-term care benefits, reverse mortgages, inflation-protected assets, reinsurance, guarantees, derivative contracts on residential property price indices, mortality swaps, and securitisation of longevity risk. We also discuss ways in which public-private partnerships might be beneficial in enhancing the environment for old-age risk management, including ways in which national and international government organisations could help to identify, regulate, and possibly develop markets to finance these risks.

In what follows, we begin with a sketch of some relevant demographic trends and review what is known about the resources that older households take into retirement. Next we explore what is known about the impact of global ageing on asset markets. We then focus on the possible impacts of population ageing on insurance markets. Finally we discuss product developments in both the retail and institutional markets for longevity products.

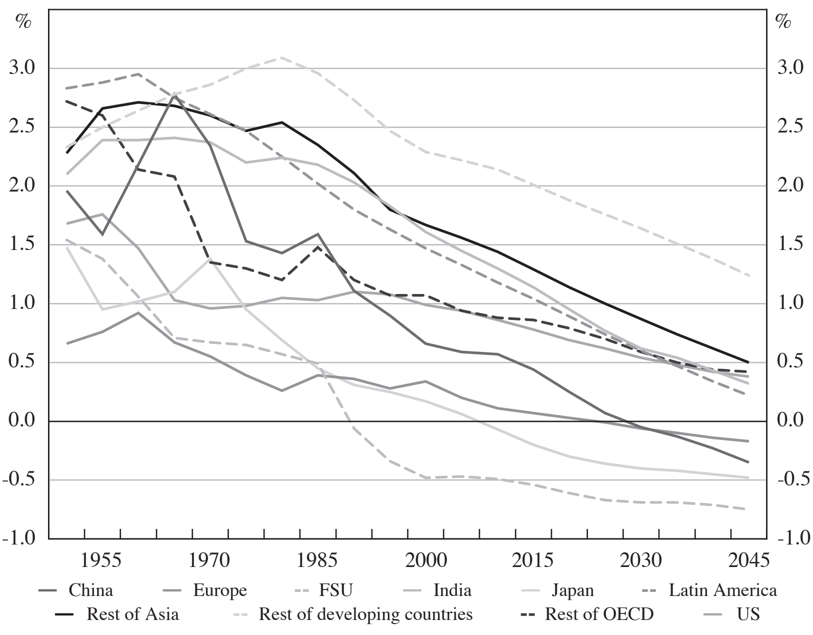
1. The Ageing World

The reality of population ageing is now widely discussed, though the underlying dynamics are sometimes less clear. For this reason, we briefly review how population ageing is occurring. There are two main sources of this change: first, older cohorts of individuals are living longer than ever before in human history, and second, younger cohorts are having fewer children. An example offers a sense of the quantitative magnitude of the change in longevity. In 1975, there was a 38 per cent chance that at least one member of a married couple aged 65 and 60 would still be alive at age 90 (the age at which the female member would be now). For the same couple aged 65 and 60 in 2005, that probability is approximately 57 per cent. Further projections reveal that this last survivor probability increases significantly to 64 per cent in 2025 and 71 per cent in 2045.[2] Population ageing is already being experienced in many countries and this demographic transition is expected to become more pronounced over the next 40 years.

When these two effects interact with roughly constant retirement ages, the aged dependency ratio increases.[3] Of course, it is important to distinguish between increasing longevity and an increasing aged dependency ratio. The first gives a sense of the increase in aggregate size of the retired population; the second gives a sense of fiscal capacity to support the retired population (in the presence of constant retirement ages). It is also worth noting that these dynamics are occurring at different times and at different rates across countries and regions (Figures 1 and 2). Data on projected increases in the number of people aged over 65 by region show the most dramatic increase in Asia: by 2050, more than 910 million Asians will be older than

Figure 1: Population Growth Rates

Per cent per year



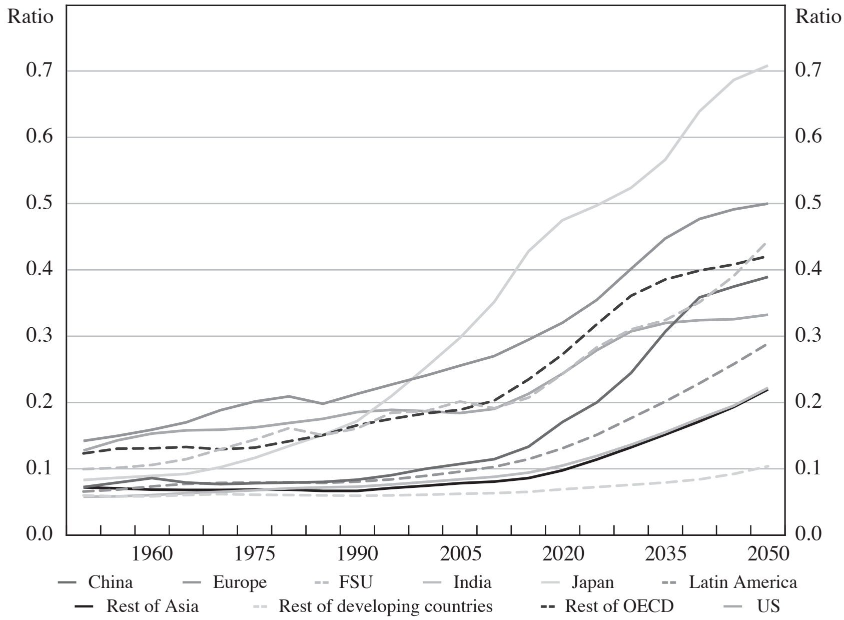
Notes: Dates refer to the beginning of the 5-year window. Data after 2005 are based on projections.

Sources: McKibbin (2005); UN Population Division (2005)

2. These estimates are based on Australian longevity but may broadly be generalised across all developed economies.
3. Indeed in many nations, the average age of retirement has actually declined, though this trend may now be flattening.

Figure 2: Elderly Dependency Ratios

Persons 65+/persons 15–64



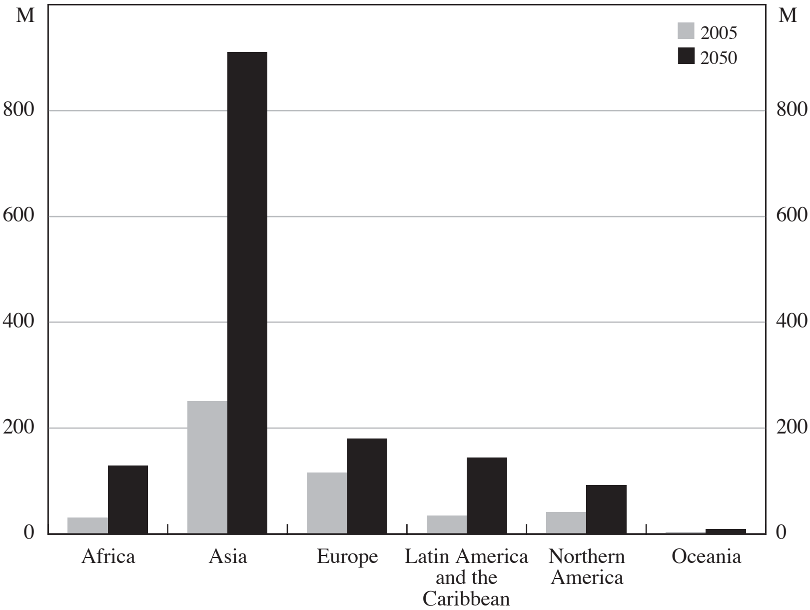
Note: Data after 2005 are based on projections.

Sources: McKibbin (2005); UN Population Division (2005)

65, up from 250 million today. The fertility decline in China in the past 20 years has been very dramatic; Japan, the world's most rapidly ageing country, with low fertility and negligible immigration, faces far heavier aged dependency than Asia in general. On the other hand, Sweden enjoys fertility close to the replacement rate, while Spain's rate is one of the world's lowest. But the largest percentage increase in the aged dependency ratio occurs in Europe, due primarily to reduced fertility and not increased longevity.

Generally, fertility differentials across countries are believed to be associated with differences in per capita wealth; differences in culture and attitudes; and differences in policies and infrastructure. Poor countries tend to have higher fertility than rich countries because children are seen as an investment, rather than requiring investment as in rich countries. Cultural differences are exemplified in the US, where the Hispanic population has a fertility rate of 2.5 children per woman, compared with a rate among Caucasians of 1.8 among women aged 40 to 44 in 2000 (Bachu and O'Connell 2001). And policy and infrastructure can lead to major differences – if women can return to work after having children without losing status or income, fertility tends to be higher. If countries mandate ceilings on the number of children, as with China's one child policy, then fertility falls dramatically. In addition, changes in fertility occur at different times. Japan is the world's most rapidly ageing country because the baby boom there ended in the early 1950s, whereas in most developed economies it continued until the early 60s. Similarly, the rate of increase in longevity

Figure 3: Population Aged 65+



Source: UN Population Division (2005)

is now far higher in Asia than in Europe and the US, where the benefits of good nutrition and health services are already reflected in current longevity patterns.

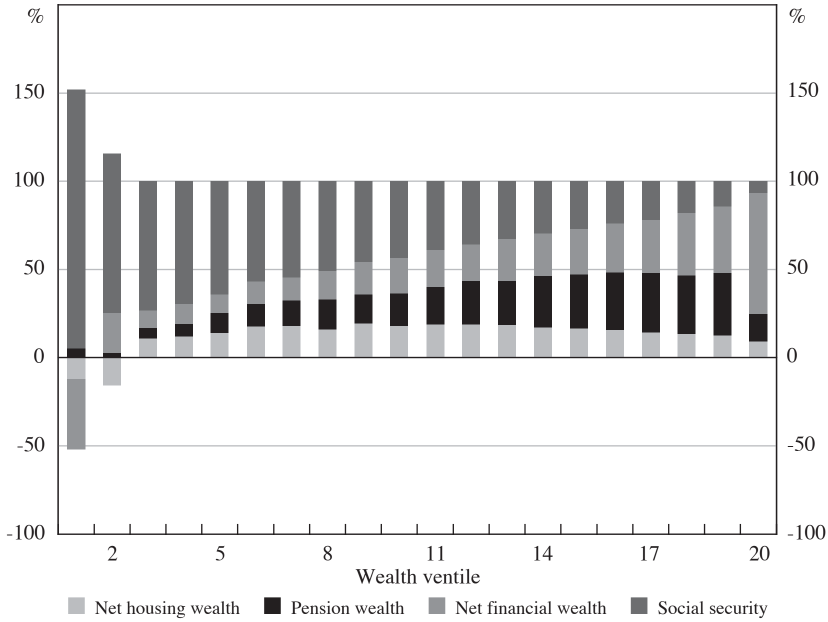
Because of these regional and national differentials in population ageing, there is reason to believe that the impact of ageing on financial markets may also occur at different rates over time (see Figure 3). Capital movements across national boundaries, and between regions, are likely to be partly demographically driven in the future, along with associated exchange rate adjustments. This generates opportunities for financial products which can to some extent facilitate these exchanges.

2. Ageing and Retirement Resources

In the developed world, most retirees rely heavily on public retirement benefits, loosely referred to here as social security benefits, funded corporate or state-run pensions, and owner-occupied housing. For this reason, understanding retirement resources and old-age financial vulnerability requires understanding older persons' rights to pensions and social security as well as home ownership patterns.

One way to see this is to examine US data, drawing on the most comprehensive survey of retirement wealth known as the Health and Retirement Study (HRS). Looking across a nationally representative sample of US households on the verge of retirement (age 51–61), researchers found that median retirement wealth was about US$340 000 (in 1992) while the average wealth stood at US$500 000 (Mitchell and Moore 1998; Moore and Mitchell 2000). Yet they also noted large differences across

Figure 4: US Distribution of Financial Resources by Source
Persons aged 51–61, 1992



Source: Moore and Mitchell (2000)

households, in that those in the 90–95 per cent ventile had 19 times the wealth of those in the 5–10 per cent ventile. Additional analysis explored the composition of retirement wealth, summarised in Figure 4. For the typical US household, financial assets comprise a relatively small portion of retirement wealth, whereas owner-occupied housing and funded pensions amount to 40 per cent of retirement wealth, and social security benefits constitute another 40 per cent of old-age consumption financing. This underscores the need for strong pension and social security systems, as well as the potential importance of a reverse mortgage market, in enhancing additional consumption for near-retirees and retirees of the future.

In other economies, government policies may differ regarding retirement support, and this in turn can influence the level, and composition, of retirement saving (see Tables 1 and 2). Results for New Zealand, for instance, show that housing wealth constitutes almost 30 per cent of retirees' assets, and government benefits almost 50 per cent. Very few in Europe hold any financial assets at all.[4]

Another interesting contrast is presented by Australia, one of the few OECD countries to have introduced a mandatory-funded defined contribution pension system. This is known as the Superannuation Guarantee Scheme, and it involves

4. These comparisons are for the whole population, not just the aged, but they nevertheless highlight the generous social security promises that have been made in many continental European economies.

Table 1: Comparison of Sources of Pre-retirement Wealth: US and New Zealand

	Total	Net housing	Pension	Net financial	Social security
		Per cent			
US	US$400K	18	20	20	41
NZ	NZ$454K	29	0	14	48

Note: For US – household head aged 51–61 in 1992; for NZ – household head aged 45–55 in 2001

Sources: Moore and Mitchell (2000); Scobie and Gibson (2003)

a mandatory contribution by workers of 9 per cent of their pay toward a funded pension each year. These benefits can be accessed between ages 55 and 60 depending on the date of birth. In addition, elderly who are poor are entitled to a means-tested benefit called the age pension, available from age 65, set at 25 per cent (40 per cent) of average male full-time earnings for singles (couples). As the age pension is an entitlement, independent of work history, the fact that it is means-tested on both assets and income means that over 80 per cent of those aged over 65 receive some amount of age pension. Because the Australian Superannuation Guarantee Scheme is still relatively young, accumulations are still low for many, and naturally they are much lower for those currently retired than for those still working. An average super plan balance for those aged 50–69 is A$83 000, while for retirees in their early 60s, the balance is A$68 000. Similar to the US, owner-occupied homes are also a key retiree asset, with average home equity values for those aged 50–69 worth A$223 000 in 2001.[5]

Table 2: Composition of Household Wealth – Japan, Europe and US
2002

	Japan	Europe	US
Financial wealth per household (€)	180 967	119 985	270 986
Financial wealth as a percentage of disposable income	439.0	338.0	405.0
Financial liabilities as a percentage of disposable income	99.9	86.5	89.8
Retirement wealth – pensions and social security (per cent)[(a)]	73.0	133.0	45.0
Residential property as a percentage of financial wealth	67.0	87.8	38.3

Notes: Price conversion at purchasing power parity, end 2002
(a) Estimates refer to 1995

Source: Babeau and Sbano (2003), Tables 3, 4, 28 and 38

5. These values are for people who were working one year previously. The values represent about 95 per cent of gross home value – on average, mortgage debt was about 5 per cent of the value of the asset for this group.

3. Population Ageing and Capital Markets

Predicting how population ageing might influence capital markets in the future, and retirement risk, might be expected to map fairly directly from life-cycle patterns of wealth accumulation and decumulation. That is, economists are fond of noting that the theory of life-cycle saving postulates that individuals save during their working lives so they can draw down this wealth in retirement. This approach might be thought to imply that population ageing will result in asset sales by the elderly, raising the supply of stocks and bonds relative to demand. Accordingly, some pundits have concluded that as populations age, the new waves of retirees will cause a 'market meltdown'. In particular, this term has been defined as a sharp decline in asset prices expected when ageing baby boomers (persons born from about 1946–1964) sell off their assets to pay for retirement consumption. On the other hand, other commentators suggest that inasmuch as capital markets are global, demand for assets from emerging economies (some of which are experiencing slower (or no) population ageing) may help offset sales of assets by economies with older populations.

In this section, we seek to assess the importance of such effects by drawing on theoretical and empirical literature in the economics and finance fields. While theoretical studies tend to be fairly inconclusive, and the empirical research linking changes in demographic structure to capital market performance is contradictory, we believe that the weight of the evidence suggests there will be no great impact on financial markets of baby boomers ageing. That is, international stock and bond markets appear to have already incorporated existing information regarding population ageing. Accordingly, unless there were some dramatic and unexpected shift in demographics beyond that which is currently predicted, continued population ageing is unlikely to have dramatic effects on global capital markets. There could, however, be local effects, to be discussed below.

3.1 Theoretical analysis of ageing and capital markets

A simple yet useful theoretical model linking capital prices and population age structure is developed by Poterba (2001). He posits two hypothetical groups of people, young and retired. The young workers (of whom there are N_y) work and earn a normalised wage of 1 per period; they also save at rate s. The supply of capital is given (exogenously) by K, and the price of a unit of capital p will adjust to satisfy demand, in equilibrium:

$$p * K = N_y * s$$

Accordingly, when the number of young workers rises, the price of capital will rise. By contrast, when a 'pure' baby boom occurs, a large birth cohort is then followed by a much smaller cohort. In this framework, asset prices will rise when the large cohort is of working age, and fall when it retires. Though the predictions from the model are consistent with an 'asset-price meltdown', Poterba points out that the formulation does not take into account several important real-world conditions. These include heterogeneous saving rates across different groups of people, the fact that capital is not fixed in supply, the fact that there are capital flows between open economies, and other possible effects of population ageing such as productivity changes, which could override the depressing demographic effects on asset returns.

A more sophisticated theoretical framework designed to address some of these issues is provided by Abel (2001). His view is that, even if asset demand does not decline in old age, the price of capital may still fall because of changes in the supply of capital. He therefore constructs a two-period overlapping generations (OLG) model that includes both variable capital supply and a bequest motive. This formulation relates the supply of capital to the price of capital in the previous period, and workers gain utility from leaving bequests to their children. This model implies that the dynamic behaviour of the price of capital follows a stationary autoregressive (AR-1) process, assuming the price of capital has a long-run unconditional mean. His simulation of the impact of the US baby boom then produces a short-term increase in the price of capital, followed by a reversion of capital prices to their long-run unconditional means. Abel further concludes that the presence of a bequest motive does not prevent the fall in capital prices when a variable supply of capital is introduced.

A more elaborate OLG approach is developed by Brooks (2002), who uses a four-period model to determine the quantitative impact of the US baby boomers on stock and bond returns. His important innovation is to assume that agents can shift their asset holdings from stocks to bonds as they age: this reflects the view that retirees face more consumption risk than workers, and since the return to capital is more volatile than to bond returns, they prefer to hold the risk-free asset. His model has a Cobb-Douglas production function. He simulates changes in population size of the magnitude of the US baby boom. As a large cohort lends to a small cohort of borrowers as baby boomers retire, the capital-labour ratio is then driven up 15 per cent above equilibrium by 2020, pushing returns down. Brooks' results suggest a fall in stock and bond returns of 92 and 82 basis points respectively (over 2000–2020). The model also predicts that baby boomers will earn 100 basis points less than previous smaller generations, over their lifetimes.

An even more complex OLG model is derived by Geanakoplos, Magill and Quinzii (2004). This formulation includes variable capital supply, bequests, dependency by both the young and retirees, and a tax-financed pay-as-you-go (PAYG) social security system. The authors note that the US stock market experienced a bull market (1945–1964) followed by a bear market in the 1970s, and a bull market in the late 1980s and early 1990s. They also point out that three 20-year periods coincide with alternating periods of low and high birth rates: the Great Depression, the baby boom of the 1950s, and the 'baby bust' of the 1970s. Accordingly, they model a world in which agents live for three periods (young, middle-aged, and retired); along the way they can invest in equity and bonds and they seek to maximise utility over their lifetimes. When small cohorts are middle-aged, equity prices are low. By contrast, when a large cohort becomes middle-aged, it bids up equity prices to double the original level, and later equity prices fall as workers retire and sell equity to a smaller cohort of young investors. The authors label this as the 'favoured cohort effect', where small cohorts do better than large cohorts in terms of lifetime consumption streams. The inclusion of a bequest motive with a variable supply of capital somewhat mitigates, but does not fully attenuate, the decline in equity prices when the large cohort reaches retirement (a similar result to Abel 2001). The authors also argue that the actual amplitude of the cycle in equity prices (for the period 1965–2004) is twice as large as can be explained by demographic cycles, with other explanations including oil shocks.

The models surveyed to this point take a 'closed economy' perspective, whereas Brooks (2003, this volume) focuses on a multi-regional approach. His OLG models simulate the effects of population ageing in an international context, assuming free international capital flows drive equalisation of capital returns across countries. His results suggest that, when a population ages, savings will come to exceed investment and produce a decline in capital returns. Consequently a region with an ageing population will become a capital exporter to regions with younger demographic structures and higher returns to capital. Open economies with international capital flows will therefore experience less of a fall in capital returns as a result of an ageing population. In practice, this means that the rapidly ageing European Union and US will become capital exporters to developing countries such as Latin America and Africa, until around 2020. Beyond that, baby boomers drawing down their wealth will produce large current account deficits in the European Union and the US, which must be financed by capital inflows from emerging economies such as Latin America. Africa will continue to be a capital importer due to its high population growth, while Japan will continue to be a capital exporter till 2040 due to its rapid population ageing.

Siegel (2005), like Brooks (2003), agrees that international capital flows will attenuate the anticipated fall in stock market returns. Describing this as the 'global solution', he contends that ageing countries will sell off capital to developing countries in exchange for goods and services. Using UN population data, Siegel measures the burden of ageing populations according to the retirement age required to support retirees (under existing pay-as-you-go pension arrangements). He predicts that an increase in labour productivity in emerging economies of 6 per cent, by 2050, would be sufficient to allow retirement ages in ageing countries to rise only marginally, by 2 years (to 64). The alternative scenario, of no productivity growth, results in a need to raise retirement ages to 76 in the developed world. Other policies are also suggested, including higher taxation and easier immigration, but these seem to be politically delicate and possibly less effective suggestions. Higher taxes will discourage the small proportion of the working population just at the time when more labour is needed. The impact of immigration would probably not be of sufficient magnitude to offset the needed increase in retirement age. These findings are therefore similar to those of Geanakoplos *et al* (2004).

3.2 Empirical analysis of demographics and capital market outcomes

Several analysts have sought to measure the empirical effect of population ageing on capital market outcomes, though again mostly with US data. As there has been no previous demographic shift of the magnitude that the nations with older populations confront, it must be noted at the outset that predictions are 'out of sample' forecasts.

Two studies by Poterba (2001, 2004) analyse the empirical relationship between US population ageing, and prices and returns for US stocks, bonds, and Treasury bills. To explore age patterns of asset ownership, he uses the *Survey of Consumer Finances* (SCF), which is a periodic cross-section survey on US asset ownership. This approach allows the identification of both age and cohort effects on asset holdings by regressing the value of assets held by the i^{th} individual at time t, A_{it}, on age AGE_{ijt} and cohort dummies $COHORT_{it}$:

$$A_{it} = \sum \alpha_j * AGE_{ijt} + \sum \gamma_c * COHORT_{it} + \xi_{it}$$

His results indicate that equity holdings do display an age pattern: they peak at US$32 500 for people aged 55–59 and then they fall to about US$25 000 by age 75. It is interesting that overall net financial assets show almost no decline in old age; thus holdings peak around ages 65–69 and remain fairly constantly at age 75+. On this basis, Poterba concludes that there will be no rush to sell financial assets as US baby boomers reach retirement. In other words, there will be no 'asset-price meltdown' in 2020–2030, as people will continue to hold considerable wealth up to the time of their deaths.

Poterba also links demographic measures to measures of the return to capital in regression models of the following sort for asset returns, R_t, and the aggregate price-dividend ratio $(P/D)_t$:

$$R_t = \alpha + \beta * \left(DEMOGRAPHIC\ VARIABLE\right)_t + \xi_t \tag{1}$$

$$\left(P / D\right)_t = \alpha + \beta * \left(DEMOGRAPHIC\ VARIABLE\right)_t + \xi_t \tag{2}$$

Several demographic variables are tested, including: the number of people over age 20; the percentage of the population between ages 40–64; and the ratio of people aged between 40–64 to the population over 20. The majority of demographic variables in Equation (1) show no evidence of correlation with any of the asset returns. In Equation (2), the price-dividend ratio is related to only a few of the demographic variables, and when the variables are differenced, the coefficients become statistically insignificant. Poterba also repeats the analysis for the United Kingdom and Canada, where results are similar: there is little evidence of a relationship between demographic variables and asset prices and returns.

Finally, Poterba develops a projected asset-demand variable constructed from SCF information which he also uses as an explanatory variable in the returns and price-dividends models:

$$R_t = \alpha + \beta * \left(PROJECTED\ ASSET\ DEMAND\right)_t + \xi_t \tag{3}$$

$$\left(P / D\right)_t = \alpha + \beta * \left(PROJECTED\ ASSET\ DEMAND\right)_t + \xi_t \tag{4}$$

Only a weak link is seen between asset returns and projected asset demand. However, Equation (4) provides statistically significant results (albeit at only the

90 per cent confidence level). Poterba suggests that as baby boomers retire, asset prices will not decline because retirees in fact do not draw down all their wealth in old age.

An alternative empirical strategy is offered by Geanakoplos *et al* (2004) who construct a '*MY* ratio' (the ratio of middle-aged to young persons) as a measure of demographic structure. This is linked to the price-earnings ratio PE_t as follows:

$$PE_t = \alpha + \beta MY_t + \zeta_t \tag{5}$$

Using US data, their results suggest that stock prices are positively correlated with the *MY* ratio: in fact, they predict that equity prices will decline until 2020, in line with the projected fall in the *MY* ratio. They also posit that returns on equity are influenced by capital gains or losses, which are in turn influenced by changes in equity prices. Therefore, they regress equity returns on the differenced *MY* ratio:

$$X_t = \alpha + \beta \Delta MY_t + \zeta_t \tag{6}$$

They find that the differenced *MY* ratio is positively correlated with equity returns, explaining 14 per cent of the variability. Also, the *MY* ratio is negatively correlated with equity risk premiums and uncorrelated with interest rates. The authors also consider international evidence, regressing stock market indices for France, Germany, Japan, and the UK ($INDEX_t$) on the *MY* ratio in each country:

$$INDEX_t = \alpha + \beta MY_t + \zeta_t \tag{7}$$

There is only weak international evidence of a similar relationship between the *MY* ratio and equity prices, as in the US, though Japan presents a stronger positive correlation between equity prices and the *MY* ratio. The inclusion of immigration in this model does not alter the *MY* ratio findings.

In sum, available evidence suggests that equity prices will fall to some degree as baby boomers approach retirement and sell assets to smaller 'baby bust' cohorts. On the other hand, bequests can attenuate this effect, and international capital flows will moderate them even more, particularly if developing countries with higher birth rates and younger population age structures can purchase assets from more rapidly ageing countries. Empirical studies are mainly limited to US data and tend to report only a modest inverse link between ageing and equity prices or returns.[6] Of course, it must be remembered that the empirical projections are fragile, given that the world has not yet experienced the consequences of such a dramatic change in the population age structure.

6. Davis (this volume) and Brooks (this volume) estimate similar models using international data and come to much the same conclusion.

4. The Impact of Population Ageing on Housing Markets

Many analysts have sought to evaluate the possible implications of ageing populations on housing markets. Ageing is expected to have similar implications to those noted above for equity and bond prices: that is, if baby boomers sell their houses ('downsize') in retirement, this could trigger a substantial fall in house values. In what follows, we discuss what is known about the relationship between the population age structure and housing demand, the efficiency of the housing market, and housing prices.

Turning first to theoretical studies, the evidence indicates that population ageing can have a deeply depressing impact on housing prices if the housing market is inefficient. Mankiw and Weil (1989) model housing demand as a positive function of rental prices and the number of adults in the population of house-buying age. The authors simulate their model under two alternative conditions. The first assumes that investors have perfect foresight of the baby boom. In this case, the arbitrage equation suggests that expected capital gains on housing, P, will be the difference between the user cost of owner occupation rP and the rental price $R(h)$:

$$P = rP - R\left(h\right) \tag{8}$$

In the second case, the arbitrage condition assumes that investors display myopic behaviour and believe the price of housing will remain the same in the following period. In other words, expected capital gains are zero:

$$P = \frac{R\left(h\right)}{r} \tag{9}$$

In practice, the effect of a baby boom followed by a bust is simulated as a 2 per cent annual increase in the adult population from 1970–1979, falling to 1 per cent annually thereafter. Under the perfect foresight condition, the authors show that US housing prices would have been predicted to rise 3 per cent between 1969–1970, rise another 1 per cent between 1970–1975, and then fall back to original levels after 1975. If investors had perfect foresight, price changes would pre-empt the fall in housing demand as baby boomers age. Conversely, if investors display myopic behaviour, the simulation results would more closely match the actual US housing market experience. In particular, housing prices were slow to react to the baby boom news, and prices did not rise until 1970. Over the 1970–1980 period, housing prices grew by 14 per cent, twice as fast as what would have been expected under perfect foresight. Given that the second model tracks actual housing prices better, Mankiw and Weil conclude that the US housing market is inefficient.

4.1 Empirical evidence for the United States

Most statistical analysis of theoretical models of the effect of population change on house prices relies on US data. As noted earlier, Mankiw and Weil's (1989) work used US Census data 1970–1980 to track housing expenditures by age over time. The analysis regresses the value of the housing property on the individual households' age controls. They conclude that in the US, the 'typical' house-buying age is between ages 20–30, and demand declines by 1 per cent per year after age 40. The authors then take these estimated age-based housing demand coefficients (α_i) and simulate changes in aggregate demand using Census population data for 1947–1987 using the following equation:

$$D_t = \sum_i \alpha_i N\left(i,t\right) \tag{10}$$

Demand D_t for housing at time t depends on the number of people aged i at that time, $N(i,t)$, multiplied by the estimated age-demand coefficients α_i. The results show that the emergence of the baby boom cohort is associated with substantial increases in aggregate housing demand during the 1970s, and the growth rate peaks at 1.66 per cent annually in 1980 when baby boomers are at their maximal house-buying age. Mankiw and Weil's forecasts suggest housing demand will then decline substantially from 1990 to 2010, with annual growth falling to only 0.6 per cent over this period.

One limitation of this model is the fact that it assumes that the age structure of housing demand remains constant over a very long period (1947–1987). Poterba (2001) tries to test for this using repeated cross-sections to construct the age structure of capital demand. The results indicate that the risk aversion of the representative consumer declines as the fraction of the population over 55 increases. Poterba concludes that it is difficult to find a significant relationship between housing demand and age structure for the US population over a 70-year period.

Green and Hendershott (1996) have an even more sophisticated approach, by using a hedonic pricing model to show how age, income and education affect demand for a constant quality house. Their age effects enter two ways, in both the total age derivative (where other variables are allowed to vary), and the partial age derivative (where other variables are held constant). They find that lower levels of education and income explain the observed lower demand for housing among older age groups, and that demand for housing is not affected significantly by age, but it is influenced by education and income. Assuming that the baby bust generation will have higher levels of both education and income than the previous cohort, this is predicted to attenuate the age-driven decline in housing demand.

Using their estimate of age-based housing demand to construct aggregate housing demand, Mankiw and Weil (1989) analyse the relationship between ageing and housing prices in the following regression model:

$$\ln\left(P_t\right) = \alpha + \beta_1 t + \beta_2 \ln\left(D_t\right) + \beta_3 \rho_t + \xi_t \tag{11}$$

Here the dependent variable is the log of the price of housing P_t, housing demand is D_t, t is a time trend, and ρ_t is an error-correction term. Results indicate a strong positive correlation between the demand for housing and housing prices: that is, a 1 per cent increase in housing demand results in a 5.3 per cent increase in prices. The projected effect of the ageing of the baby boom generation is a 3 per cent annual decline in real housing prices, producing what became a notoriously large 47 per cent predicted fall by 2007 – a prediction that is now seen as unlikely to come true.

This extraordinarily large predicted effect of population ageing on future housing prices ignited a vigorous debate regarding its plausibility and robustness. Among the critics is Hendershott (1990), who questions the forecasting power of the model and the quality of the data. Using the same US Census data, Hendershott re-estimates the model using subsets of the data and then estimates in-sample forecasts (from 1970–1987). He reports that the forecasted values fit actual housing price trends badly (with an R-squared of 0.03) and argues that weak in-sample forecasting power undermines the credibility of the out-of-sample forecast. He then offers several additional regression equations which boost the model's explanatory power. One includes the real after-tax interest rate, *RAT*, which improves the fit of the model (with an R-squared value of 0.38). A different model allows for a shift in the constant and coefficient on the housing demand variable between the periods 1948–1969 and 1970–1987, and also includes gross national product GNP_t, which enhances the R-squared to 0.69.[7]

Other studies have also added variables whose omission, they argue, biases estimated parameters. Holland (1991) includes the rent-price ratio *R*/*P* which then reduces the significance of housing demand in the housing price equation. Hamilton (1991) also posits that rental prices and housing prices should move in opposite directions, as renting and owner-occupation can be seen as substitutes. Therefore he prefers a different dependent housing price variable, namely the rental price component from US consumer price index (CPI) data, which he uses in a variant of Mankiw and Weil's Equation (11). Since all the coefficient estimates become insignificant, he concludes that this is proof of omitted variable bias. Hamilton and Hendershott also conclude that the negative coefficient on the time trend variable in the Mankiw and Weil regression is a model misspecification. The negative coefficient on the time trend variable forces the coefficient on the housing demand variable to be large and positive, simply to offset the negative time trend. Hendershott suggests that other factors should be controlled for, including labour force participation and productivity growth. Holland also shows that the earlier results are not robust since housing price and housing demand prove to be cointegrated.

4.2 Evidence for other countries

Relationships between population ageing and housing markets outside the US have also been studied. For instance, Engelhardt and Poterba (1991) adopt the Mankiw and Weil (1989) approach but use housing data from Statistics Canada. The researchers report that, though Canada and the US experienced similar population ageing, their housing market experience has differed sharply. Canadian housing prices rose rapidly in the 1970s and declined sharply in 1985; by contrast, US housing prices rose in the mid 1970s and declined little in the early 1980s. As a result, the coefficient on

7. The extended model is expressed as:

$$\ln\left(P_t\right) = \alpha_{48-69} + \alpha_{70-87} + \beta_1^{48-69}\ln\left(D_t\right) + \beta_1^{70-87}\ln\left(D_t\right) + \beta_2\Delta RAT + \beta_3 RAT + \beta_4\Delta\ln\left(GNP_t\right) + \xi_t$$

the housing demand variable is positive using US data and negative when using Canadian data. Engelhardt and Poterba conclude that movements in housing prices cannot be explained by demographic factors in the Canadian housing market.

Ageing's impact on the British housing market is taken up by Ermisch (1996), who uses cross-sectional data from the Joseph Rowntree Foundation Housing Finance Survey 1988–1989. Here *HCi*, the housing consumption variable, is measured as the value of the house purchased divided by a hedonic housing price index. Housing consumption is then regressed on the marginal cost of housing MCH_i, current net household income I_i, housing structural variables H_i, and the age of the head of the household AGE_i:

$$\ln\left(HC_i\right) = \beta_0 + \beta_p \ln\left(MCH_i\right) + \beta_I \ln\left(I_i\right) \\ + \beta_{a1}\left(AGE_i\right) + \beta_{a2}\left(AGE_i^2\right) + \beta$$

Ermisch models the underlying demand for owner occupation and the desire to move as part of a correction for sample selection bias. His results indicate two positive age effects on demand for housing. The 'household formation' effect is strongest among young workers with newly-purchased homes. The 'household income' effect is strongest among older individuals who have increased levels of wealth and consume higher-quality housing. The model suggests the formation effect is strongest, and it implies that population ageing will produce a projected halving in the growth of aggregate housing demand, from 0.65 per cent in the late 1980s to 0.35 per cent in 2000. The price and income elasticity of housing demand are estimated at –0.4 and 0.5 respectively. In other words, as baby boomers age, fewer new UK households will be formed, while the average amount spent on housing will increase. Though the author acknowledges the need to integrate housing supply as well, his study focuses mainly on the demand for housing.

To summarise, this literature suggests that housing prices are likely to decline somewhat as baby boomers reduce their housing demand. However, the impact will likely be far smaller than Mankiw and Weil's dramatic predicted drop of 47 per cent by 2007. Furthermore, there is reason to believe that the effect of ageing on housing prices could be neutral or even positive, if positive income and education effects on housing demand offset population ageing.

5. The Impact of Population Ageing on Insurance Markets

Global population ageing will also mean that more people are confronting longevity risk and health shocks. In turn, these facts raise questions about society's ability to sustain a rising and perhaps increasingly destitute share of very old retirees.

5.1 Longevity risk

This concern is focused on the worry that people may outlive their wealth, which can happen if they save too little, retire too early, and/or spend too quickly in retirement.

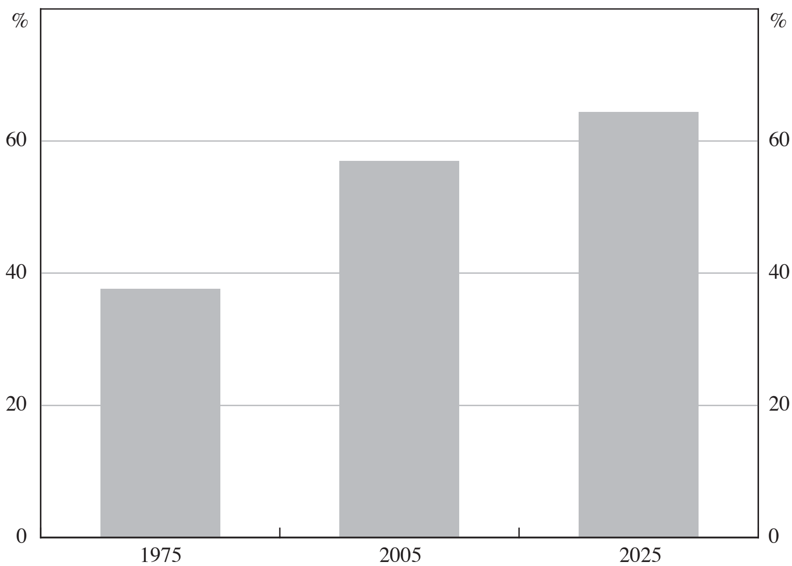
Systematic increases in longevity over time have been dramatic. There is a better-than-even chance that at least one partner in a conventional couple aged 65/60 today, will be alive at age 90. A generation ago, this probability was only a little better than one in three (see Figure 5).

The longevity problem has been exacerbated as firms and governments have phased out defined benefit (DB) pensions, and instead given increasing emphasis to defined contribution (DC) plans. This trend suggests that private insurance markets are likely to become increasingly important as populations age. Nevertheless, there is some consensus that annuity markets are not yet adept at helping individuals to manage longevity risk. In what follows, we discuss the risks faced by both providers and purchasers of insurance that may have contributed to longevity insurance market failure and review a range of possible solutions.

The traditional way to insure against outliving one's assets is to purchase an annuity, which is a financial product guaranteeing a lifelong stream of payments in exchange for an initial premium. Despite the initial appeal of annuity products, participation in such markets has been relatively thin in many countries, with the UK and the US being moderate exceptions. A possible explanation suggested by Brown *et al* (2001) is that people behave myopically and focus on the risk of dying too soon rather than the risk of living too long. Another explanation is that annuity prices may be too high due to adverse selection. This latter point is explored by

Figure 5: Increases over Time in Survival Probability to Age 90 for at Least One Member of Couple

Male 65/female 60



Note: Calculations based on mortality rates and 100-year improvement factors reported in Australian Life Tables 2000-02

Sources: Australian Government Actuary; authors' calculations

McCarthy and Mitchell (2002) who measure adverse selection in annuity markets in Japan, the UK and the US by comparing mortality tables used in pricing annuity products against mortality tables from a baseline population. Their Actual/Expected (A/E) ratio is defined as:

$$A/E = \frac{\sum_x w_x q_x^*}{\sum_x w_x q_x}$$

where q_x^* is the probability that an individual aged x dies in the next year corresponding to the annuity mortality table, q_x is a similar probability of death corresponding to the baseline population mortality table, and $w_x = (1-q_{x-1})w_{x-1}$ and weights are set so that $w_{65} = 100$.

Their results show that adverse selection is strongest among voluntary annuitants in all countries. Male voluntary annuity purchasers display significantly lower mortality than the baseline population of the US male age 65 group: the A/E ratio is only 67.5 per cent in the UK, 65.3 per cent in the US, and 81.8 per cent in Japan. Female annuitants display 73 per cent of baseline mortality overall, with the exception of Japan where annuitants are found to have roughly the same mortality as the baseline population (though it appears this better result is a statistical fluke).

Various approaches have been tried to encourage retirees to spread their resources over their remaining life span. These can be thought of as products which provide some coverage against some retirement-related risks, while leaving some exposure to other risks. Table 3 provides a schematic representation of the relationship between different kinds of retirement products and insurance coverage for the major financial risks confronted by the retired. These include, besides longevity and inflation risk, investment risk (return and volatility), replacement risk (the risk that post-retirement income will not adequately replace wages) and annuity rate risk (the possibility that interest rate expectations change over time, so that the annuity price at the point of mandatory purchase will vary). This last risk poses a significant problem. The price of non-indexed annuities in particular can move significantly in quite short periods of time, since the nominal long-term rate of interest has much higher

Table 3: Coverage against Income Uncertainty Offered by Alternative Annuity Designs

Annuity type	**Type of risk**				
	Longevity	Investment	Inflation	Replacement	Annuity rate
Immediate term-certain fixed	Medium	High	Low	Low	Low
Immediate-life indexed	High	High	High	Medium	High
Pooled fund	High	High	Medium	Low	Low
Phased withdrawal	Medium	Low	Medium	High	Medium

Source: authors' calculations

volatility than the real rate. This is especially true in countries with a high variance of inflation rates over time.

The first two annuity products identified in Table 3 are well known. The third, a pooled annuity fund, is a device which allows the separation of idiosyncratic from systematic longevity risk. Since annuitants are predominantly concerned with idiosyncratic risk, while insurers are concerned with systematic risk, a product which separates these risks has potential appeal, in that it becomes possible to direct risk to stakeholders in the contract for whom the risk is less costly. The division is achieved through mechanisms which adjust the annuity payout in light of evolving mortality experience.

Another product which may be unfamiliar to some is a phased withdrawal plan, which provides coverage for a specified period, usually life expectancy, along with higher returns (and a standard annuity) and some exposure to investment risk. Phased withdrawals are popular in some emerging economies; they are also popular in Australia, where mandatory DC plans provide an accumulation at retirement for investment (Dus, Maurer and Mitchell 2005). Also, it would be possible, and in some cases desirable, to have financial products that would combine a phased withdrawal with a deferred annuity (Horneff *et al* 2006). These would provide financial insurance for later life, in exchange for a relatively modest sum at retirement. While such a combination has much to commend it, we are unaware of it on offer in the marketplace. Nevertheless, these new product designs may well have a future market, as the need for longevity insurance becomes clearer to consumers, governments and industry.

Friedberg and Webb (2006) adopt a simulation approach to quantify the aggregate mortality risk faced by an annuity provider. Using a Lee-Carter model to forecast mortality trends, they find annuities contribute significantly to the risk of insolvency. For example, an insurer selling joint life and survivor annuities to couples can reduce its probability of insolvency from 5 per cent to 1 per cent by increasing premium loadings from 3.78 per cent to 5.37 per cent. These results suggest there is a clear need for improvements in the way that insurers manage mortality risk.

It has often been suggested by actuarial theorists that life insurance and annuity products could be perfect hedges for each other: that is, life insurance which covers death could be used to hedge the longevity risks associated with offering annuity products to people who live too long (McCarthy and Mitchell, forthcoming). Yet in practice, adverse selection means that the mortality risks are not the same for both life insurance and annuity purchases, which limits the feasibility of natural hedging. Cox and Lin (2004) evaluate the possibility for natural hedging of life and annuity mortality risks by regressing the price of annuities, *PRICE*, on the extent of natural hedging within the company. Here *RATIO* is the log of the ratio of annuity reserves to total life and annuity reserves:

$$PRICE = \alpha + \beta RATIO + \gamma X + \delta D$$

where X is a vector of control variables, and D is a vector of year effects. The authors conclude that insurance companies who offer both life insurance and annuity products can benefit somewhat from natural hedging. Accordingly, a benchmark insurer with 95 per cent of its business in life insurance and 5 per cent in annuity products, would pay out US$765 per month on its single-premium immediate annuity (sold to a 65-year-old male with US$100 000 to invest). By contrast, a company which took full advantage of natural hedging with a *RATIO* of 50 per cent could afford to increase monthly payouts by US$24 to US$789. Insurers who take advantage of natural hedging will be more competitive in annuity markets.

In practice, of course, it may not be possible for insurers to frequently alter their portfolios to fully realise the benefits of natural hedging. Instead, Cox and Lin (2004) propose mortality swaps as a way to achieve dynamic natural hedging. Assuming no counterparty risk, the mortality swap proposed takes place between a life insurer and an annuity provider. After agreeing that the present value of future cash flows are equal for the two products, the annuity provider will pay a floating benefit based on the number of deaths incurred by the life insurer in exchange for the premiums of the surviving cohort. These payments will be paid to an intermediary who facilitates the arrangement and only net payments need to be transacted. The authors suggest a forward-pricing model to determine the corresponding payments implied by the mortality swap. To account for adverse selection, Cox and Lin use a stochastic transformation to account for the risks of mortality improvement once a given mortality table is used in pricing annuities. The result is that, for every life insurance contract with a face value of US$1 million, the mortality swap can be made for annuity payments of US$267 for males and US$195 for females. Of course the market for mortality swaps is currently underdeveloped, requiring further innovation and research to help facilitate and price such contracts.

Other ways to help annuity providers manage longevity risks include the use of survivor bonds (also referred to as longevity bonds), as suggested by Blake and Burrows (2001) and Friedberg and Webb (2006). Payouts on these bonds increase as mortality improves, where mortality is measured by some pre-specified systematic mortality index. These authors contend that the absence of an instrument to help hedge against longevity risk is a key reason for underdeveloped annuity markets. To illustrate the significance of longevity risk on annuity products, they present a simple annuity-pricing model that relates the price P to mortality improvements through the adjustment factor f^x, as follows:

$$P = \sum_{T=1}^{\infty} \left[\frac{d}{r} \left[1 - \left(1 + r\right)^{-T} \right] \right] * q_{T+x_0}^{0} f^{T} \prod_{x=x_0}^{x_0+T-1} \left(1 - q_x^0 f^{x-x_0}\right) \qquad (12)$$

where d is the coupon rate, r is the discount rate, q_x^0 is the unadjusted mortality rate, and x_0 is the age of the person when buying the annuity. Equation (12) shows that errors in estimating future mortality trends, f^x, will complicate the appropriate pricing of annuity products. MacDonald (1997) shows that assuming an adjustment factor of 0.8, forecast errors for mortality rates of 65-year-old males are 10 per cent over a 10-year period. So for a male aged 65, the probability of surviving to age 85 ranges from 0.337 to 0.438, and for survival to age 95, probabilities range from 0.053 to 0.153. The result is that insurance companies price these mortality risks into cost loadings and consequently offer annuity rates that appear expensive.

The survivor bond proposed by Blake and Burrows would allow insurers to hedge aggregate mortality risks. They are structured so that future coupon payments depend on the share of the whole population of retirement age, in the year of the issue of the annuity, who survive to the date of payment. Blake and Burrows also suggest a role for the government, which would be able to issue these bonds at the lowest price by spreading aggregate risk across the population. Survivor bonds would be useful in lowering the price of privately-sold annuities and facilitate the transition from public to private pension systems. One shortcoming of the plan is that existing tax systems do not spread tax burdens equally among households, so if the purchasers of annuities were mainly rich households, then the poor would effectively be subsidising the retirement of the wealthy. Another concern is that survivor bonds are not currently available on a large scale, so that techniques for designing appropriate hedges are underdeveloped.

Supply-side problems of adverse selection are the focus of Creighton *et al* (2005) who show that this phenomenon results in annuitants receiving only 80 cents per dollar of annuity product purchased. They propose as a solution, the establishment of a pooled annuity fund (termed Group Self-Annuitisation or GSA), where benefits each period are contingent on the number of people remaining in the insured cohort. The authors develop a case where annuity benefits, y_t, defined as:

$$y_{t+1} = y_t * \left(1+\pi_t\right) * \left(\frac{1+R_t^M}{1+AIR}\right) * \left(\frac{{}_1p^*_{x+t-1}}{{}_1p_{x+t-1}}\right) \tag{13}$$

are related to inflation π_t, and a mortality experience adjustment (which arises from the difference between expected returns and mortality R_t^M and ${}_1p^*_{x+t-1}$, and actual returns and mortality AIR and ${}_1p_{x+t-1}$). The notion of the GSA is to share the benefits and costs of longevity changes among surviving group members: explicitly, individual annuitants bear cohort risk, while insurers take on idiosyncratic risk. In this way, longevity risk is shared between both the insurer and the insured, helping insurers to manage longevity risk and thus offer products at lower prices.

5.2 Protecting against health shocks

In view of the catastrophic nature of nursing home or long-term care (LTC) costs, it is surprising to many that the private insurance market plays such a small role in covering these risks. For instance, Garber (1996) argues that the 'most striking feature' of the US health care system is its failure to develop much of a private LTC insurance sector. Only one in five married couples deemed to be able to afford private LTC insurance in the US is adequately protected against this risk in retirement (Merlis 2003). Many attribute this shortcoming to the pervasive influence of public programs such as Medicare and Medicaid, which tend to crowd out privately-provided LTC insurance (Doerpinghaus and Gustavson 2002; Finkelstein and McGarry 2003). The wealthy tend to self-insure, leaving the middle-class as the group potentially most interested in private LTC coverage. It is widely believed, however, that this middle-group thinks that their LTC costs will be met through Medicare (which it does not), so hence do not purchase individual policies. Better marketing on the insurers' part could correct this misinformation, yet this has not yet gone very far.

Pauly (1990) highlights the appeal of LTC to elderly customers as being an important factor influencing demand. These customers prefer low-cost substitutes for LTC (provided as an institutionalised product). The medical literature provides contrasting conclusions, suggesting that home care is not an effective substitute for nursing home care. One well-designed experimental program in the US, known as the Channeling Demonstration project, showed that assigning expert case managers to help frail customers remain in the community increased costs and patient satisfaction, but did not forestall health deterioration, nursing home admission, or death (Garber 1996, p 148). Economic studies of individual preferences for quality reveals a lower price elasticity of demand the longer the length of the stay (Garber and MaCurdy 1990).

The Japanese LTC market, like the US, is characterised by significant growth although on a small scale. LTC contracts have more than doubled over 2000–03 (JILI 2003). Typical providers of LTC contracts include: private life insurance companies (for example, Nippon Life Insurance Company); private property and casualty insurance companies; the National Mutual Insurance Federation of Agricultural Cooperatives (Zenkyoren); and the Postal Life Insurance Service of the Japan Post system.

Several factors are likely to influence demand for LTC in future years. These include developments in health care and technology, and changes in the length of time during which the elderly population experiences periods of frailty. Their net impact on LTC demand is difficult to predict. Perhaps the greatest unknown is how attitudes will continue to evolve, given what is widely recognised as a fundamental change in society's approach to caring for the elderly. On the one hand, establishing an entitlement-oriented LTC program makes it possible for older persons to accept services without social stigma. On the other hand, demand for LTC may not grow as quickly as the elderly population. This is what has occurred in the US due to falling disability rates in the older population. Indeed, reduced elderly morbidity may mean that more people are able to care for their spouses in a non-market setting, thus reducing the demand for institutional LTC (Lakdawalla and Philipson 2002). In addition, levels of wealth will surely influence the demand for care, by directly shaping older consumers' ability to pay for care, and indirectly by influencing younger workers' ability to pay for rising premiums associated with any national mandatory system.

With regard to supply, one important aspect influencing private LTC costs is adverse selection. Garber (1996) suggests privatisation of underwriting reduces the costs of adverse selection, but it is important to note that the assessment technology remains in its infancy. Of course, mandating LTC coverage mitigates the problem of adverse selection in the purchase of the insurance, but it does not help in terms of service utilisation. Recent research by Finkelstein and McGarry (2003) finds no positive correlation between LTC insurance purchase and the probability of entering a nursing home. In fact, those who purchased LTC insurance in the US were more cautious and less likely to go into a nursing home, than those without coverage. This suggests that LTC insurance prices may not be unduly influenced by actuarially unfair selection, which eases the policy concerns about market failure.

There may also be other explanations for why insurers have only slowly moved into the LTC marketplace in the developed world. Uncertainty regarding the future paths of diseases, medical breakthroughs, and technological advances could dramatically change future life expectancies, years in frail condition, and consequently LTC costs. Also the mere existence of LTC insurance can potentially make it easier for families to 'unload' their relatives to nursing homes, which would fit with the concept of 'social hospitalisation' mentioned in the Japanese context above (Mitchell, Piggott and Shimizutani 2006). Both factors help to explain why private LTC policies in the US have had daily and lifetime (and sometimes financial) caps on coverage offered. In the past, many private policies did not guarantee renewability either, though this may be changing of late. And researchers have noted that private LTC policies are often not price-indexed, meaning that the consumer remains at risk for out-of-pocket expenses over the long term. Perhaps most importantly, private policies have tended to be silent regarding what they will pay if the government were to dramatically change its policies regarding medical care coverage, out-of-pocket requirements, spend-down policies, and the like. Such uncertainty on the consumer's part regarding the ultimate value of the private insurance surely serves to depress demand.

It is worth noting that government providers in other countries have often underestimated the demand for subsidised care when launching new long-term-care systems. For instance, Pratt (1999) points out that when the US Government established public support for LTC under the Medicare and Medicaid programs, it assumed that utilisation rates would continue at historical rates. In fact, demand proved to be far greater than anticipated. If rationing continues to be a problem, it seems that either the government will have to raise mandatory premiums or other taxes to pay for enhanced benefits, or the market for private LTC insurance will have to be opened up.

To this end, some have proposed the development of private LTC insurance policies sold through benefit plans offered by employers. In the past, US employers have exhibited little interest in subsidising this form of insurance directly (Wiener, Hixon Illston and Hanley 1994), but the 1996 *Health Insurance Portability and Accountability Act* (HIPAA) allows employer-paid premiums to be excluded from workers' salaries for tax purposes, and benefits are non-taxable up to a limit of actual LTC expenses (Rappaport and Stanger 1997). Additionally, US legislators have recently introduced bills to make LTC insurance premiums tax deductible to employees who purchase the private insurance via an employer-based flexible benefits or 'cafeteria' plan. These are plans where workers are granted a fixed dollar amount by their firms which they can then allocate across a range of benefit offerings. The proposed bill would grant a tax credit of US$3 000 per year to families who provide LTC services to relatives. Both provisions have an estimated revenue cost to the government of US$30 billion over the next decade (Rovner 2003). Whether that or another legislative initiative will pass is unclear, but it does seem that tax subsidies for LTC purchase are likely in the future.

Another approach that would use the workplace as a nexus for LTC provision would be to permit workers to use their mandatory LTC premiums to purchase private coverage, perhaps of a catastrophic-only sort. Contracting out in this fashion would give workers the responsibility of shopping around for LTC coverage, and it would also offer the advantage of lower costs and more competitive products for those of working age.

One concern with tax incentives for LTC is that they might be insufficient to induce low-wage workers to purchase enough LTC coverage. Nevertheless, rising costs of government-financed care have prompted a move to private market provision of care in several countries, including Australia, Germany, Sweden, and the UK (Go 2003). Though not-for-profit providers have traditionally dominated the market in Europe, LTC services are being increasingly provided by for-profit companies as in the UK and the US.

A proposal receiving attention in many ageing nations is to combine private LTC insurance with annuity products, which would potentially boost the market for both annuities and LTC cover. For instance, Warshawsky, Spillman and Murtaugh (2002) and Murtaugh, Spillman and Warshawsky (2001) propose an arrangement whereby a privately-sold life annuity product provides monthly payments that rise in the event that the insured party is certified as chronically and permanently disabled. The proposal's appeal is that the two-tiered coverage – longevity protection due to the annuity, plus a step-up in cash benefits if disabled – may attract more buyers than would a simple life annuity or a simple LTC scheme. This would be expected to reduce the potential for adverse selection which otherwise has been seen as a major obstacle to annuity sales (Brown *et al* 2001).

Alternative approaches include mandating that younger generations bear a larger share of LTC costs among the elderly. Lee (2003) reports China, New Zealand, and Singapore, have adopted this approach. Singapore has also bundled private insurance coverage with this scheme. In the extreme case of population ageing, as in Japan, Campbell and Ikegami (1998) suggest risk-pooling as a solution, requiring all workers to pay mandatory LTC premiums. This scheme places a burden on younger cohorts; for instance, US data reveal that 89 per cent of people aged 40–44 could meet LTC underwriting criteria, but only 68 per cent of those aged 70–74 are healthy enough to meet the screens (Merlis 2003).

The reverse mortgage (RM) market, about which we say more below, may offer an indirect method to fund LTC. Allowing elderly homeowners to borrow against owner-occupied housing, provides a means of utilising the full potential of an individual's retirement resources. There is evidence to suggest that a significant proportion of retirement wealth is tied up in owner-occupied homes, particularly in Japan where housing equity is 50 per cent larger than in the US.

6. Ageing and the Wealth Decumulation Process

As populations age, households will increasingly confront the challenge of having to manage their accumulated wealth during their golden years. This has been exacerbated by the global shift away from DB towards accumulation or DC pensions. So far, relatively few households have availed themselves of payout annuities, so the process of drawing down retiree wealth appears to be growing ever riskier. Several factors are worth mentioning in this regard, including the timing of annuitisation, reverse mortgages, and inflation risk.

6.1 Timing issues

Several recent papers have examined the question of what determines the optimal pattern of wealth management in retirement. Milevsky and Young (2001) show that delaying household annuitisation can benefit the elderly by exposing them to the chance of higher returns from investing in risky assets, so they can increase their wealth further before annuitising. For instance, a 60-year-old male annuitising immediately would have a rate of consumption of 8.34 per cent of his single premium. If the same person annuitised optimally at age 73, he could consume at a rate of 8.70 per cent of his principal prior to retirement and 11.24 per cent thereafter, assuming no adverse selection.[8] And even if the 60-year-old male had a hazard rate which was 60 per cent of the baseline population (that is, is less healthy), delaying annuitisation would still result in higher consumption when compared to annuitising immediately. This research implies that if retirees' subjective mortality expectations differ from the objective mortality tables used to price the annuity product, households will perceive a gain from delaying annuitisation, even if they are healthier than the baseline population.

So-called 'self-annuitisation' paths involving alternative phased withdrawal rules are the subject of research by Dus *et al* (2005). The retiree following this tactic continues to allocate his wealth across various investments and simply withdraws funds periodically for consumption. Compared to buying a life annuity, this strategy provides greater liquidity, the chance of higher consumption while alive, and the possibility of bequeathing some assets in the event of an early death. Of course, there is no pooling of longevity risk, so the retiree could outlive his assets. Such phased withdrawal approaches have grown popular following pension reforms in Europe and the Americas; for instance, in Germany, the government is seeking to boost asset accumulation for the ageing population by giving tax-preferred investment choices to individual-retirement accounts (IRA). After retirement, 30 per cent of the accumulated assets in the IRA may be taken in a lump sum but some of the rest must be used to purchase a deferred annuity payable from age 85. Similarly in the UK, personal pensions have had to be partly annuitised at age 75. The authors

8. These estimates assume standard parameters for investment returns: non-annuitised funds are invested in a risky asset with drift 0.12 and volatility 0.20 and the rate of return on the riskless asset is 0.06. The individual has a coefficient of risk aversion of γ=2 (more risk adverse) and a subjective hazard rate in line with the mortality table used by the insurance company (average health).

compare alternative approaches using explicit measures of risk and value along with a function reflecting the trade-off between these two, and they conclude that a phased withdrawal plan which minimises the risk of consuming less than a real annuity benchmark will require the retiree to allocate the majority of his retirement assets to fixed income. Of course, the specific asset allocation must vary as a function of plan design, age, and mortality risk, as well as preferences toward bequests. In more recent work, Horneff *et al* (2006) evaluate more complex strategies combining phased withdrawal and deferred annuitisation, and find that for all but the most risk averse, some amounts of phased withdrawals are appealing.

6.2 Investment guarantees

The emphasis on DC pension plans in the US public sector has led to some states offering government guarantees to transfer the investment risk from employees. Lachance, Mitchell and Smetters (2003) study the costs of one such guarantee offered by the public sector pension system of the State of Florida. This guarantee was in the form of a buy-back option, allowing workers to convert their DC pensions to a DB pension promise, as long as it was exercised before the termination of employment. The optimal time for an employee to exercise the buy-back option is then simulated, and the cost of the guarantee for the employer is as follows:

$$\hat{E}\left\{e(R)PV\left(DB(R)-DC^{er}(R)\right)\right\}+\hat{E}\left\{e(R)PV\left(DC^{er}(\tau)-P(\tau)\right)\right\} \tag{14}$$

where $DB(t)$ is the value of the DB plan at time t, $DC^{er}(t)$ is the value of employer contributions in the DC plan at time t, $P(t)$ is the price of the buy-back option at the time of exercise, $PV(.)$ is a present value function, $e(R)$ is an indicator variable that takes the value of 1 when the option is exercised, and R is the number of years spent in the DC plan. The left-hand term in (14) is the cost the employer incurs at the termination of employment, when the employee converts from a DC plan to a DB plan, with the term $DC^{er}(R)$ representing the number of years the employee spends in the DC plan. The right hand term in (14) is the cost incurred by the employer at the time the option is exercised, denoted by τ.

The formula adopted by the State of Florida allows the DB benefits to be bought with the employee's accumulated benefit obligation. Under this formula, the cost of the guarantee could represent up to 100 per cent of the DC contributions if employees exercise the option optimally. Although such guarantees have the potential to manage the investment risk faced by employees, structuring them so that the burden is not significant remains an area for development (see Lachance and Mitchell 2003).

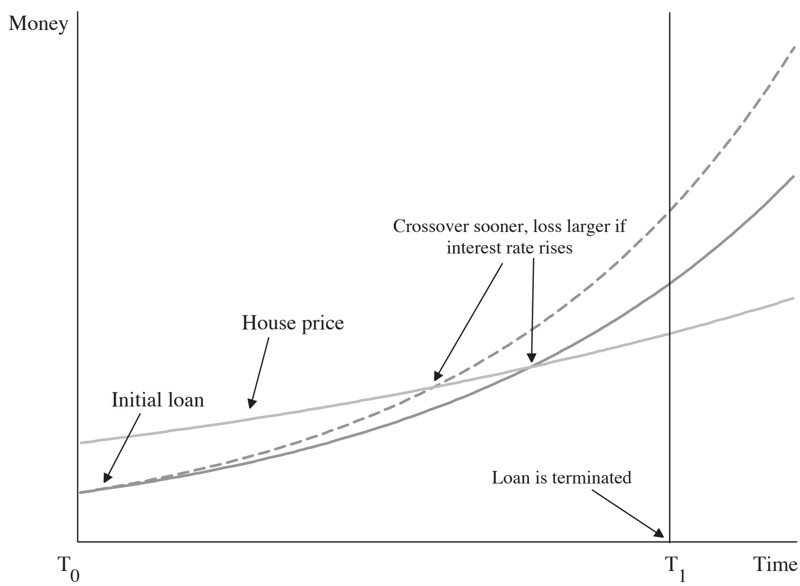
6.3 Reverse mortgages

Another possible approach would be to enhance the growth of reverse mortgages, as described by McCarthy, Mitchell and Piggott (2002) and Creighton *et al* (2005). In essence, reverse mortgages can help address the issue of households being 'asset-rich but cash-poor', as it permits retirees to borrow against their equity in their owner-occupied home without having to move out. The market potential has been estimated at 6.7 million households in the US, and 1.3 million households in Australia, and Mitchell and Piggott (2004) show that owner-occupation is highest among the age group over 60.

How these work is outlined in Figure 6. The owner's house price determines how much can be borrowed, and the loan value grows with interest over time. The figure indicates 'crossover risk', which is the risk to the lender that when the loan comes due, the property might be worth less than the loan. When the property growth rate is lower than the mortgage loan rate, at some point, the loan will 'catch up' to the property's sale price. In general, the point when the crossover occurs is a function of longevity, interest rates, general home appreciation, specific house appreciation/depreciation, and expenses.

These risks have contributed to the slow growth of reverse mortgage markets, but their recent growth has been impressive. For instance, in the US, there were 40 000 reverse mortgage originations between 2001 and 2004, an increase of 500 per cent. Part of the motivation for the growth is support by the US Government in offering Home Equity Conversion Mortgages (HECM), which provide lenders with insurance against the depreciation of property values exceeding the value of the loan in the case of relatively low-wealth buyers. In Australia, various options can also be bundled with reverse mortgages: for instance, the Australian lending company, Bluestone, allows up to 20 per cent of the property's future value to be protected, permitting bequests to be made. Further, XCapital Health combines accommodation in a retirement home and health care with the reverse mortgage product. Securitisation

Figure 6: Reverse Mortgage Risks – Loan Value May Exceed House Value



Source: Mitchell and Piggott (2004)

of reverse mortgages would also help to encourage development of the reverse mortgage arena. Australian Seniors Finance has planned the country's first reverse mortgage securitisation for 2006. By allowing companies flexibility on the balance sheet, the market for reverse mortgages has strong potential for growth.

6.4 Inflation risk

Since retirees live for many years after leaving work, they face the real possibility that their assets will fail to keep track of inflation. Accordingly, Bodie (1988) has highlighted the introduction of consumer price index (CPI)-linked bonds as a key way that governments could offer a very valuable tool to help retirees hedge against inflation risk. His analysis indicates that CPI-linked bonds improve the efficient frontier marginally at the low- risk/return end, but they contribute substantial value as long-term hedges against inflation. There does appear to be a strong need for product innovation in the financial market for inflation-protected annuities, and Bodie argues that one such innovation would be an 'inflation-proof retirement annuity', backed by CPI-linked bonds. These bonds could also be used to index benefit promises in DB plans, which would attenuate the erosion of benefits indexed to nominal salaries and improve the DB plan portability.

Despite the attributes of CPI-linked bonds, and the fact that a few governments now issue them (including France, Israel, the UK and the US), it would appear that markets for these financial products are as yet thin. Governments have been slow to offer these products and insurers have not taken advantage of them during a period of quite low inflation. Perhaps inflation projections for the future will make them more attractive going forward.

7. Recent Product Market Developments

In recent years, products to manage longevity risk have been offered at both the retail and institutional levels.

7.1 Individual or retail products

In the retail marketplace, life insurance companies have started to issue products that provide for annuity payments specifying maximum annual withdrawal levels while guaranteeing capital maintenance, and deferred annuities with guaranteed annuity rates. These generally include an initial guaranteed maximum payment equal to a percentage of an asset base (such as the funds used to purchase the annuity). The asset base is then reduced by withdrawals in excess of the guaranteed maximum; it also grows over time if the assets perform well. The maximum percentages vary by age and are reported in Table 4 for one typical product.

Payments continue throughout life even if the account balance falls to zero, thus providing protection for longevity. The charge for the longevity maximum guaranteed withdrawal for this product is 0.65 per cent per annum of the asset base for a single life and 0.8 per cent for joint lives. There are also investment charges

Table 4: Maximum Percentage Withdrawals by Age Group while Guaranteeing Account Balance

Age	Percentage
55–59	4.0
60–64	4.5
65–69	5.0
70–74	5.5
75–79	6.0
>80	6.5

Note: authors' assessments of range of market products on offer

based on daily net assets of 1.25 per cent as funds are invested into variable return investment portfolios. There is an option to annuitise the account balance into a fixed lifetime annuity. Withdrawals in excess of these maximums reduce the future guaranteed payments and are subject to withdrawal charges of up to 7 per cent. There is also a guaranteed minimum death benefit of contributions less withdrawals. The contract terminates at the annuitant's 95th birthday, at which time they must take a lump sum withdrawal or select an annuitisation option. The longevity protection in these products provides the maximum guaranteed withdrawal after the account falls to zero at around age 90, providing insurance for those surviving 25 years beyond the purchase date. An important factor causing the account balance to fall to zero after allowing for investment returns, given these maximum withdrawal percentages, is the impact of fees and charges.

In a typical deferred annuity product, the funds are invested to maturity and the product provides various annuity options, including a guaranteed minimum income benefit, a life annuity, a life annuity with period certain and with refund certain as well as variable annuity payout options. There is a charge for the guaranteed minimum income. The product often takes the form of a tax-preferred deferred annuity contract designed for the accumulation phase, but it may also include built-in annuity options on maturity. Guaranteed annuity purchase factors are included at the time an election to purchase an annuity is made. These factors are based on conservative actuarial factors and would normally be expected to be smaller than those under the standard annuity payout options. Money-back options in retail longevity products are also seen as an important component of product design.

Historically, annuity products have been thought of as expensive, though research by Brown *et al* (2001) and others shows that many annuities are actually quite fairly priced. The longevity guarantee in lifetime annuity products may also be costly depending on the investments allowed for the funds backing the annuity payments. In addition, more complex products include guarantees for death, withdrawal, and maturity benefits, all of which add additional costs. Over time, there has been increased competition in the US market, with a concomitant reduction in annuity expenses. For instance, the lowest fees reported on Morningstar/VARDS (on 31 December 2004) were 25 basis points per annum for variable annuity contracts, versus an industry average of 141 basis points. These fees would normally not include any charges for longevity and other guarantees, providing only an investment vehicle for tax-deferred retirement savings.

7.2 Institutional products

In recent years, annuity providers have strived to embed new investment choices in their products, linking returns to survival indices or cash flows from investment portfolios. In general, however, institutional products mainly provide coverage against adverse mortality events, but do not protect against cohort-wide mortality improvement. In a few circles a discussion has begun concerning the possibility of securitisation of mortality risk, thus gaining access to a larger pool of capital, and providing investors with returns from a risk that may be largely uncorrelated with other financial market returns. Issues in the design of these products are beginning to be addressed, including the development of a mortality index and the extension of securitisation techniques to include longevity risk. Thus far, the reinsurance market capacity for longevity risk is limited, so that it may make sense to turn to financial markets as an alternative source of institutional risk pooling.

Market responses to the need for these products has been mixed. For instance, Swiss Re has issued mortality-linked securities to manage adverse mortality risk, most recently with products known as Vita I and Vita II. In December 2003, a 3-year bond worth US$400 million was issued by Swiss Re and Vita Capital in the form of a floating rate bond linked to a mortality index. The repayment of principal was linked to a mortality index of experienced mortality rates in five countries (France, Italy, Switzerland, the UK, and the US). The spread was 135 basis points over LIBOR and the bond effectively covered catastrophic mortality risk such as an epidemic or perhaps a major terrorist attack or natural catastrophe. As another example, the first longevity bond was known as the EIB/BNP bond; in November 2004, BNP Paribas announced the issue of a longevity bond by the European Investment Bank (EIB) to hedge long-term systematic mortality risks. The payments on the latter bond were linked to a survivor index based on UK males aged 65. The total value of the issue was to be £540 million, and was primarily intended for purchase by UK pension funds. The issue was announced in November 2004 and withdrawn late 2005 without being issued, partly because of concerns with basis risk between the index and mortality risks in insurance and pension funds.

The contrasting market response to these two issues highlights the fact that the market for mortality-based institutional products is in the early stages of development and growing slowly. Developing the public market for mortality-based products is essential to accessing large capital markets. In doing so, these initiatives exploit the fact that financial market investors, in comparison to insurance markets, are more willing and capable of taking on these risks. Research into the pricing will help to develop a market for mortality-based products. Cox and Lin (2005) and Cairns, Blake and Dowd (2004) both deal with this issue. Many other mortality-based derivative contracts have been proposed or are under development. These include survivor bonds where coupon payments are linked to the number of survivors in a given cohort, survivor swaps where counterparties swap a fixed series of payments in return for a series of payments linked to the number of survivors in a given cohort, annuity futures where prices are linked to a specified future market annuity rate, and mortality options in the form of contracts with option characteristics whose payoff depends on an underlying mortality table. Comprehensive coverage of various examples and opportunities of the securitisation in life insurance is provided by Cowley and Cummins (2005).

An interesting development supporting the growth of these products is the recent launch of the Credit Suisse Longevity Index. It provides an objective mortality and longevity index for investors, insurance and reinsurance companies, pension plans, and other institutions exposed to longevity risk, permitting them to create new institutional financial products. Although basis risk remains an issue for insurers and pension plans, securities based on such an index to offset longevity risk have lower overall longevity risk. Institutional products to protect against longevity risk then can offer risk pricing and hedging, underpinning the increased issue of retail longevity insurance products. Products based on an index such as this could do a great deal to serve as the foundation for a more liquid market in longevity risk at the institutional level.

8. Political Risk and Demographic Ageing

Global population ageing is also putting severe pressures on traditional unfunded (PAYG) national pension systems around the world. Recent projections find that most of the OECD nations will have to cut retirement system benefits substantially and/or raise taxes dramatically, in order to keep these systems solvent. Many nations have already undergone so-called 'parametric' reforms, altering parameters such as tax rates, retirement ages, and benefit formulas to deal with cash-flow shortfalls. Going forward, legislating parametric changes is increasingly becoming politically divisive and infeasible. Accordingly, the huge underfunded liabilities of public pension and many retiree health care plans around the world presents an enormous source of political risk, attributable to and in turn affecting retirees in the baby boom generation and beyond.

In response to these challenges, some countries – most notably Chile – have moved to privatise a portion of their old-age income systems, as a means of curtailing perceived political risk. Of course this process has both positive and negative efficiency effects. Theory suggests that gains should result from lower effective tax rates on labour and positive effects on labour supply incentives. Furthermore, supplanting unfunded PAYG promises with funded capitalised accounts offers workers the chance to diversify their assets and reduce the risk of political confiscation. Nevertheless, public pensions can achieve redistributive objectives that may be difficult to obtain with private-funded vehicles. For instance, Nishiyama and Smetters (2005) simulate a multi-period OLG model in which heterogeneous agents face idiosyncratic earnings shocks and uncertain longevity. Gains or losses from privatisation are redistributed to future generations by the government. Their results suggest that privatisation produces some gains when wage shocks are insurable, but much smaller gains if wage shocks are uninsurable. Different scenarios are simulated, including allowing for international capital flows, private annuity markets, contribution matching, and progressive benefit formulas. In many cases, privatisation can result in efficiency losses. In other words, the benefits of improved labour supply incentives can be offset by the loss of risk-sharing under an unfunded social security program. It should be noted, however, that these conclusions do not generally take into account the costs of moving from an insolvent PAYG system to a solvent one.

A different tactic might be to figure out how to securitise future revenue flows promised under tax systems, which might reduce political risk. This idea is taken up by Valdés-Prieto (2005), who argues that a PAYG pension plan's assets consist mainly of the present value of all future taxes from the government to support plan participants. The 'unfunded liability' or PAYG asset is the source of political risk, as changes to legislation are often not timely nor sufficient to maintain the solvency of the pension fund. When pension system assets (if any) and PAYG flows are insufficient to cover liabilities, the difference is referred to as the implicit fiscal liability (IFL). The PAYG asset is based on the financial position of current members, while paying for the IFL relies on general taxpayers to ensure solvency. He argues that a pension plan is generally not empowered to collect transfers from the government; in this sense, these assets are not secured by property rights, but only the government's promise to donate future funds.

Valdés-Prieto then describes a complex securitisation process which would substitute the PAYG asset for a covered wage bill (CWB) perpetual bond. The first step requires identifying implicit taxes on future generations which subsidise current PAYG pension plan members. A law would then have to endow a pension institution to have property rights over the PAYG asset, and its strength would rely on the credibility of the government to remain fiscally responsible. CWB bonds can then be created based on the cash flows owed by plan members, not those owed by the state. Valdés-Prieto suggests that CWB bonds be issued such that dividend payouts are split into tranches (linked to the CPI or a wage index) to increase the attractiveness of the offer. The final step ensures the solvency of a pension plan and prevents the IFL appearing on the balance sheet. The presence of the IFL means that the pension plan is still subject to political risks. By adopting a set of rules for risk allocation, the plan must actively trade CWB bonds to ensure that they match their assets and liabilities.

Such a reform of an unfunded social security system would have some appeal, as it facilitates risk-sharing by making aggregate human capital tradable across generations which is not now feasible in existing capital markets. On the other hand, this framework would introduce significant moral hazard, reducing labour supply incentives and reducing reasons to participate in the plan. Adverse selection in household earnings reports will also be driven by the PAYG tax rate. And governments remain a source of political moral hazard, as changes to the tax rate and delaying the collection of taxes could be used to manipulate the price of CWB bonds. Nevertheless, this is a creative proposal that may be feasible at some national level, perhaps with the support of governments interested in creating national wage indices (Shiller 1998).

9. Conclusions and Discussion

This paper has reviewed the theoretical and empirical lessons regarding the potential impact of population ageing on global financial markets. Against this backdrop, we seek to draw conclusions about financial products such as longevity insurance and long-term care (LTC) insurance that might enhance old-age retirement risk management.

We acknowledge that the onset of massive demographic change may have some undesirable impacts on key forms of private and public old-age support. To respond to these shortcomings, we have outlined products that may not yet exist, or which exist but do not yet have much purchase, that can partially address these. In general, there are many products that could help allocate risk more efficiently across stakeholders. These could include reverse mortgages, annuities linked to LTC needs, survivor and mortality bonds, and mortality derivative securitisation. Yet financial and insurance markets thus far have been thin. This may be partly accounted for by myopia on the part of consumers, but is almost certainly partly due to supplier reluctance, based on uncertainties about future mortality trends, and more general information asymmetry in these insurance markets, leading to moral hazard and adverse selection against which it is difficult to price attractively. We therefore propose that the public sector in developed nations take a proactive stance to partner with private sector entities in the future, to generate better and more common information, and to help with better management of the risks associated with ageing. Important to this process will be new attention to relevant tax and regulatory reform (see also Groome, this volume).

Governments in many developed nations have taken substantial responsibility for youth and retirees in the past. Thus they provided education, invested in health care, developed the housing market, and built large social security systems. Looking forward, some of these trends will have to slow and even reverse, given rising budget deficits. Yet there are substantial opportunities for national, and indeed international, cooperation to solve market coordination problems.

It is worth considering in more detail the potential role of supra-national institutions in providing support for these markets and products, especially those concerned with longevity and LTC insurance, at both the institutional and retail levels. It would be entirely possible for the World Bank, for example, to issue survivor bonds, or to create some equivalent hedging instrument to allow annuity issuers to immunise their exposure to systematic mortality increases.

While annuity markets do exist in the UK and the US, in many smaller countries a competitive market for these products is not feasible. The possibility of a supra-national organisation overseeing a market in which annuities are issued globally on a franchise basis holds some appeal here. A suite of standard insurance products could be specified, and insurers could bid to provide them, possibly along the lines of a Demsetz auction. At the very least, such organisations could set up some consumer-friendly checklists for prospective buyers.

Such organisations are also well-placed to coordinate, with national government help, the development of accurate mortality tables for annuitants. National governments may well respond positively to an initiative whereby they require insurance companies to release their annuitant mortality experience, for example. This would help greatly in pricing longevity risk internationally. There are currently international guidelines for national account preparation; similarly, guidelines could be prepared for the computation of future mortality, social security liability, and related indices. Especially with respect to morbidity and the risk of requiring long-term care, a major international effort will likely be required to generate publicly available risk tables.

Once these activities are under way, creative new products may evolve, especially if market development is facilitated by government help. Sensible intervention in the near future, before the demographic transition progresses further, may pay off substantially in the form of better management of risks facing future retirees.

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Discussion

Graydon Paulin

The paper by Olivia Mitchell and John Piggott, and their co-authors, provides an excellent review of the range of likely effects of demographic change on financial markets. It also does much more than that, but first allow me to emphasise a point that has already surfaced in a variety of ways during our discussions. It is important to consider that many factors will, over time, influence financing patterns, and the types of investments favoured by investors and markets. Aside from demographic change, this will include the accumulation of different forms of wealth, regulatory change and liberalisation of markets, advances in technology and financial modelling, and the growth and financial development of the emerging-market economies together with greater global integration. What this means for policy-makers is that it could be difficult to disentangle the underlying sources of change for financial markets.

All of the papers in this session nevertheless provide a careful and insightful review of the available work on the impact of demographic change on capital markets and asset prices. But when you consider the broad impact on global markets, and in particular on the relative preferences for assets such as stocks, bonds and housing, I agree with Olivia and John that the aggregate impact of ageing is unlikely to be dramatic. Although different views have been expressed around this table, I do not believe that the effects will be of a magnitude that would cause considerable concern.

Having reached this conclusion, however, Olivia and John then ask exactly the right question – given the social and economic risks that ageing poses over the medium term, how can financial markets help us to address these risks? There are some very large adjustments that will take place in response to demographic change (affecting the areas of pensions and health care, for example), although they may be gradual in nature. Financial markets provide us with a substantial adjustment mechanism, one that will help us to distribute resources and allocate risk. In essence, they are an important part of the solution.

If financial markets are going to play a key role in helping us to address the issues raised by ageing populations, then policy-makers will want to make sure that markets are in a position to develop the right tools to do this. Put another way, the structure of financial markets will be important in helping us to deal with the financial implications and pressures raised by ageing. So the second part of the paper focuses on the kinds of changes in financial markets that might be useful – for example, there is a review of enhanced insurance products that would help to spread the risks associated with an older population. Indeed, there are many innovative ideas here.

Yet the development of insurance markets, and of financial products generally, along the lines that are discussed in this paper has been very slow. Despite the innovation that has occurred, it has been repeatedly emphasised that these markets remain thin. Why is this? Financial markets generally have shown an enormous ability to innovate rapidly and introduce new products, sometimes of substantial, even worrisome, complexity. So why do they appear slow to expand in this area?

There are some possible explanations for the apparently slow development of these particular markets. For example, it could involve the effects of adverse selection, or markets may be in a 'transition phase' as they take time to understand these ageing-related risks and adjust accordingly. Constraints may also arise from regulatory and tax regimes, as well as from the limitations of the relevant risk modelling such that large uncertainties remain. We may also need to broaden our definition of what constitutes an annuity, that is, it could partly be a measurement issue. But this is an area that warrants further investigation. We should be cautious when markets appear to be leaving profitable opportunities 'on the table' – perhaps they know something that we do not.

So is there a role for governments here (and perhaps international organisations, as suggested in the paper)? Eliminating outdated regulatory or taxation provisions that hinder financial development would be a good place to start. Governments may also want to consider encouraging specific markets to develop.[1] Further research on risk modelling would be very helpful – this work could come from a number of sources, including academia, and would benefit from improved access to data. Ultimately, governments may wish to absorb additional risk themselves, given their ability to spread that risk across the population. But here it is extremely important to ensure that appropriate criteria for government involvement are identified, so that harmful incentives are not created.

Another option, not mentioned in this paper, is the use of public-private partnerships (PPPs) with respect to public infrastructure projects. Governments, in Canada and elsewhere, need to upgrade ageing public infrastructure. At the same time, infrastructure investment is gaining increased acceptance among institutional investors – these projects have a relatively stable long-term cash flow and provide portfolio diversification. So PPPs in this area may provide an attractive longer-term investment for insurers and pension funds.

Finally, I would like to add an important caveat to much of what I have said above, and this involves the implications for financial stability. As financial structures change, we will want to assess elements such as the possible excessive concentration of risk. In particular, we do not want the changes that we might encourage to introduce new vulnerabilities into the financial system. The G10 report on ageing and pensions, published in September of last year, noted some of the possible financial stability concerns (G10 2005).

An enhanced degree of stress testing, providing an assessment of the impact on the financial, corporate and household sectors from changes in asset prices, would be useful in this regard. Stress testing by financial institutions (including that by central banks with respect to various economic sectors) is becoming an increasingly common practice, involving a steadily rising level of sophistication. It can quickly

1. As an example, the Bank of Canada encouraged the further development of an active Canadian money market in the 1950s and 1960s, although today the environment is rather different.

become complex, particularly when new financial instruments are involved, but, at least at a high level, financial stress analysis could be central to minimising unintended effects.

Reference

G10 (2005), 'Ageing and Pension System Reform: Implications for Financial Markets and Economic Policies', a report prepared at the request of the Deputies of the Group of Ten by an experts group chaired by Ignazio Visco, Central Manager for International Affairs at the Banca d'Italia.

Population Ageing, the Structure of Financial Markets and Policy Implications

W Todd Groome, Nicolas Blancher, Parmeshwar Ramlogan and Oksana Khadarina[1]

This paper will address four issues regarding population ageing and financial markets: (i) the nature and size of the financial challenges facing ageing societies today; (ii) the actions currently being taken or proposed to deal with these challenges; (iii) the potential role of financial markets and existing financial structures in addressing these challenges; and (iv) the role of governments, as managers of key long-term risks related to ageing. These issues are discussed in turn below. The paper draws on research and policy work conducted by staff of the International Monetary Fund, including as published in several chapters of the IMF's *Global Financial Stability Report* (GFSR), a semi-annual publication that focuses on global financial market developments, particularly the evaluation of structural influences on financial stability, and in a report prepared at the request of the Deputies of the Group of Ten.[2] Related research currently focuses on the limits of market-based risk transfer and the management of long-term systemic risks, including those associated with ageing.

1. The Financial Challenges of Population Ageing

G-20 countries are confronted with a variety of challenges associated with population ageing, reflecting in part two long-term demographic trends: increasing longevity, reflected in rising life expectancy at age 65 (Figure 1); and low and declining fertility rates (Figure 2). A direct implication of these two trends is the continued increase in the old-age dependency ratio – the ratio of pensioners to the working-age population. This ratio currently varies from approximately 10 per cent to about 30 per cent among G-20 countries, and is projected to increase rapidly based on current trends (Figure 3). As such, the demand for retirement income relative to contributions from the working population will be proportionately greater.[3]

Two broad consequences follow from these trends in population ageing. First, as individuals spend a longer time in old age and retirement, their retirement consumption needs will be greater, in large part because the period of time spent in retirement is increasing, but also because of rising health care expenditures, given

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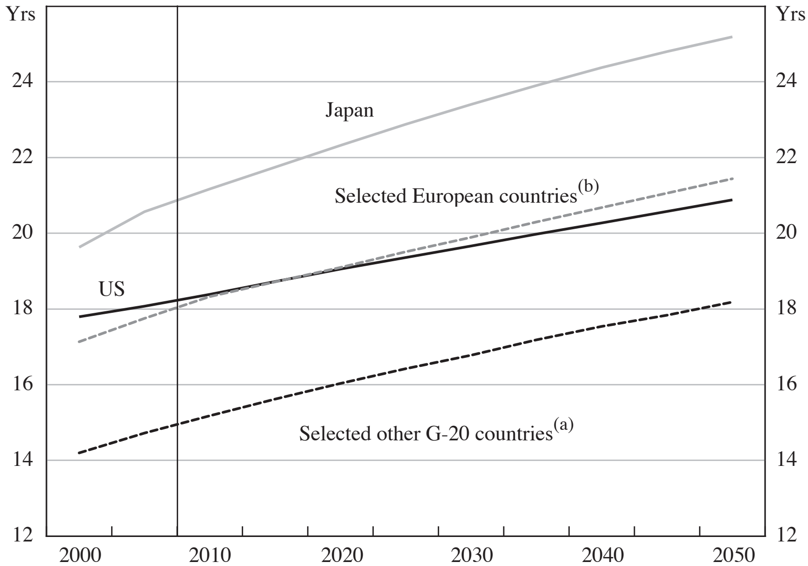
1. We gratefully acknowledge comments by Axel Bertuch-Samuels and Peter Heller. The views expressed in this paper are ours, and should not be attributed to the International Monetary Fund, its Executive Board or its management.

2. See, for example, the following publications by the International Monetary Fund: IMF (2004a, 2004b, 2005a, 2005b, 2006). See also G10 (2005).

3. For example, in China the ratio of pensioners to contributors rose from 19 per cent in 1989 to 33 per cent in 2003; while China is ageing, the change in this ratio is also materially influenced by reforms to the pension system that reduced the number of contributors. See Trinh (2006).

Figure 1: Life Expectancy at Age 65

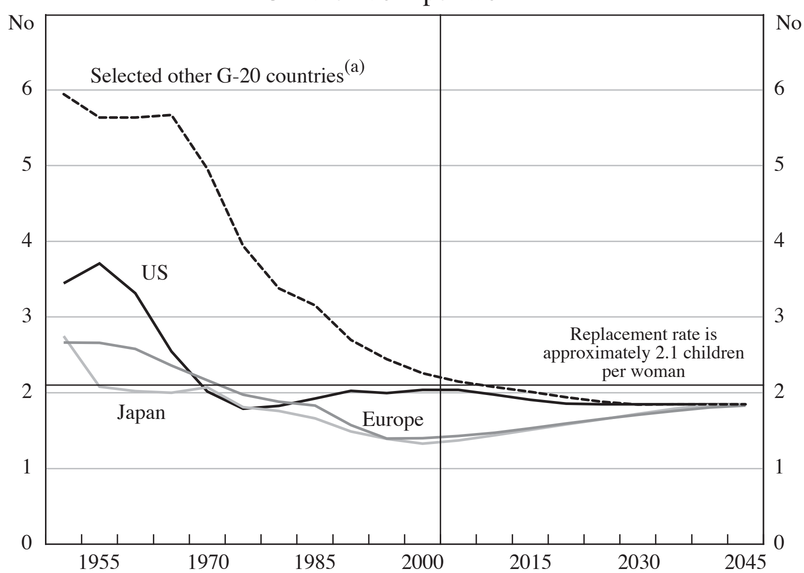


Notes: Dates refer to the beginning of the 5-year window. Data after 2005 are based on projections. For country groupings, series are weighted averages based on each country's population in 2000.
(a) Australia, Brazil, China, India, Mexico and Russia
(b) France, Germany, Italy, the Netherlands, Switzerland and the UK

Source: UN Population Division (2005)

Figure 2: Fertility Rates

Children born per woman

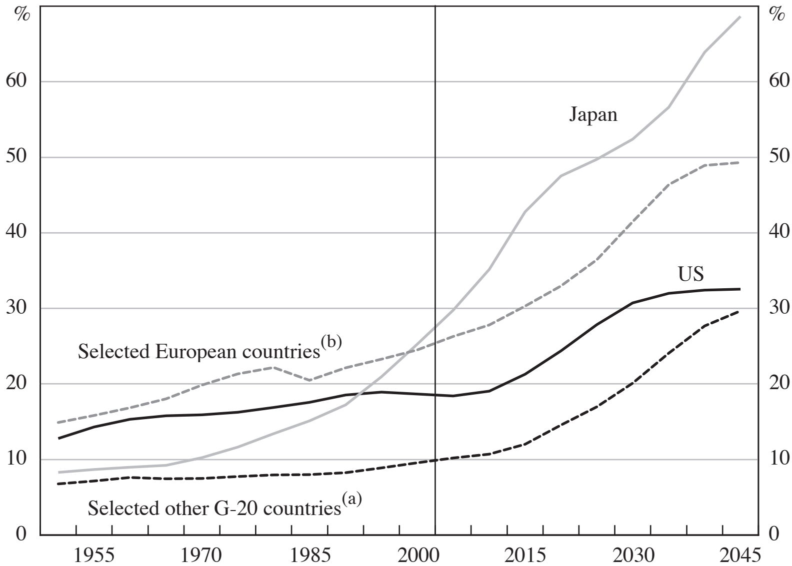


Notes: Dates refer to the beginning of the 5-year window. Data after 2005 are based on projections. For country groupings, series are weighted averages based on each country's population in 2000.
(a) Australia, Brazil, China, India, Mexico and Russia

Source: UN Population Division (2005)

Figure 3: Old-age Dependency Ratios

Population aged 65+ as a share of population aged 15–64



Notes: Data after 2005 are based on projections. For country groupings, series are weighted averages based on each country's population in 2000.
(a) Australia, Brazil, China, India, Mexico and Russia
(b) France, Germany, Italy, the Netherlands, Switzerland and the UK

Sources: IMF; UN Population Division (2005)

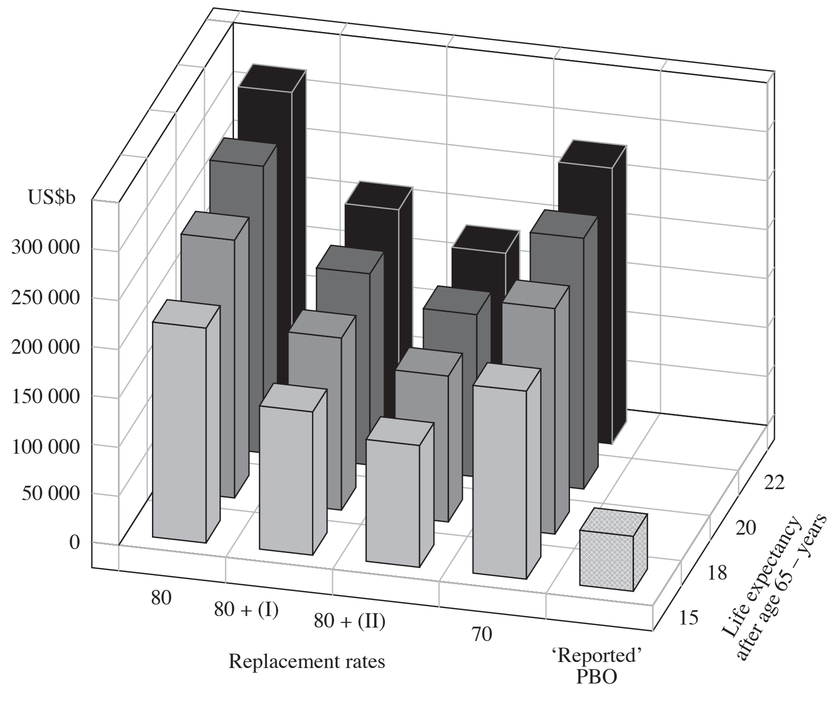
the relatively strong correlation between age and spending on health care (see Kotlikoff and Hagist 2005). Consequently, individuals' retirement (replacement) income needs relative to lifetime income will grow, unless individuals extend their working lives. Thus individuals may need to increase their savings to maintain their retirement incomes at adequate levels. Second, ageing and related pressures also highlight the importance of improving the quality of retirement savings, especially in order to better manage risks associated with longevity, investment and inflation, as well as the high and rapidly escalating health care costs in many G-20 countries. In particular, given the ongoing switch from defined benefit to defined contribution and similar pension plans, households will need to ensure that they are appropriately managing these long-term risks and financial obligations.

1.1 Increasing and improving retirement saving

A major component of retirement saving is pension saving. As populations age, the relative size of pension fund liabilities grows, with the total 'theoretical' level potentially dwarfing levels recognised thus far (Figure 4). Moreover, the growth in liabilities may be greater than expected, as increases in longevity have consistently exceeded actuarial forecasts. Therefore, the challenge of managing and maintaining adequate savings levels by the public, private (i.e., corporate) and household sectors has become more urgent.

The impact of population ageing on defined benefit pension plans has been compounded since 2000 by lower equity market returns and (importantly) low interest rates, which have significantly affected pension funds' asset and liability valuations. Equities remain a large component of the asset portfolios of pension funds

Figure 4: Total Potential Pension Liability of G10 Countries
Estimates based on current wage levels

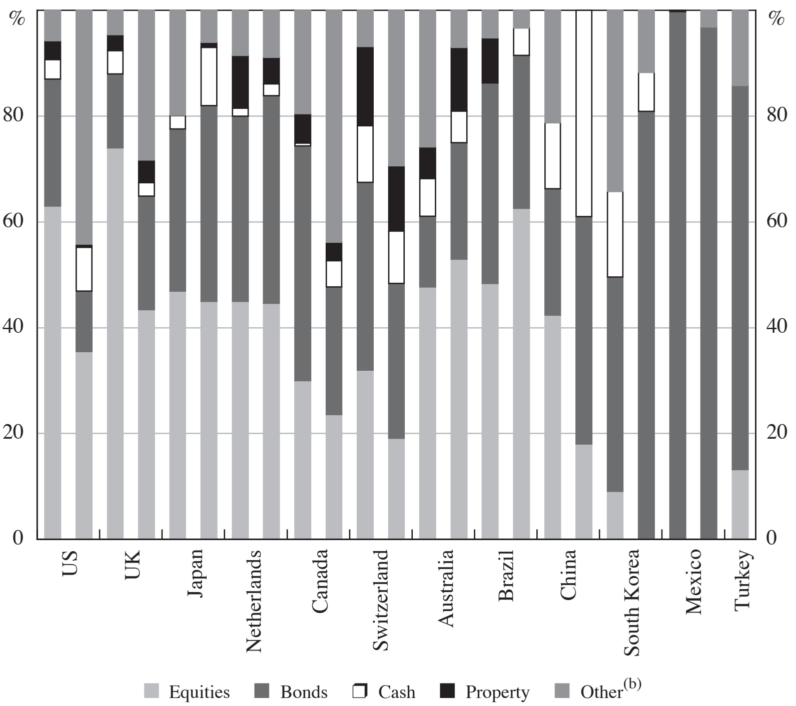


Notes: Replacement rates: 80 + (I) is defined as 80 + 1/3 of population working full-time; 80 + (II) is defined as 80 + 1/3 of population working full-time and 1/5 of population working part-time. 'Reported' PBO (projected benefit obligation) is based on estimates of total public pension liabilities (see Holzmann, Palacios and Zviniene 2004) and private pension benefit obligations (OECD 'Global Pension Statistics').

Sources: Holzmann *et al* (2004); IMF; OECD; World Bank

Figure 5: Asset Allocation of Pension Funds – 1999 and 2004[(a)]

Share of pension fund assets



Notes: (a) Brazil – data for 2004 refers to 2003; China – data for 1999 refers to 2002; Turkey – data only for 2004

(b) Other includes loans, mutual fund and hedge fund investments, unallocated insurance contracts, and other investments

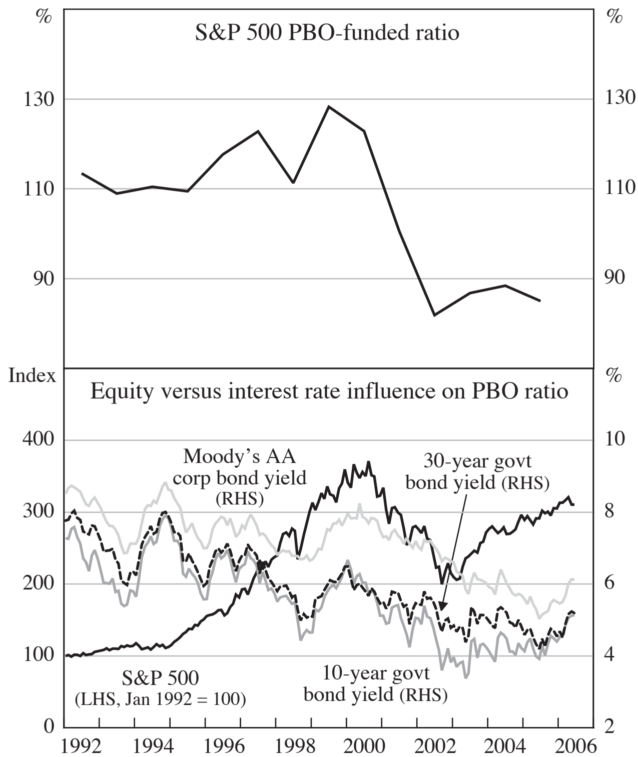
Sources: OECD 'Global Pension Statistics' and *Institutional Investors Statistical Yearbook*; UBS Pension Fund Indicators

in many countries (Figure 5), but the effect of lower interest rates on funding ratios may have been at least as large as that related to lower market returns (Figure 6). Reflecting the above factors, many defined benefit pension plans have become significantly under-funded since 2000 (Figure 7), although funding ratios appear to have recovered somewhat in the past two years. This is true in both industrial and non-industrial countries.

The growing pressure on both public and private defined benefit pension plans in these countries may lead to lower replacement rates, and has accelerated the trend toward defined contribution and hybrid plans in the United States, Europe and Japan.[4] Contribution rates in defined contribution plans tend to be lower; and where participation in such plans is voluntary, the experience of many countries

4. Hybrid plans have some features of defined benefit plans, but often with a greater sharing of risks between sponsors and beneficiaries.

Figure 6: US – Ratio of Assets to Projected Benefit Obligation (PBO)

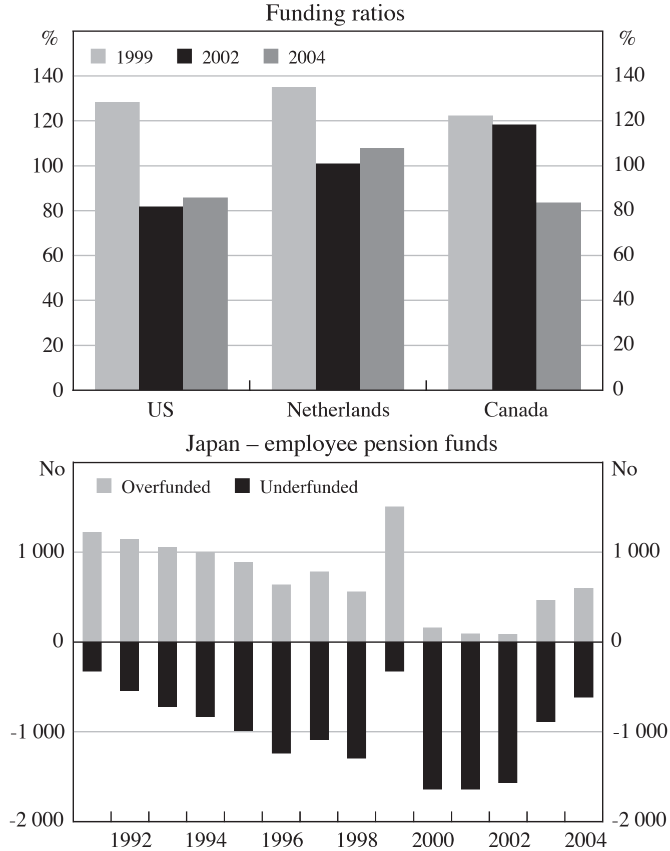


Sources: Bloomberg LP; Standard & Poor's

is that participation rates tend to be low. Both of these factors adversely affect retirement saving.

There remains concern in some countries that households may not be adjusting their saving levels to achieve expected replacement rates. In the United Kingdom, the 2006 *Pensions Commission Report* warned that many households are significantly undersaving (Pensions Commission 2006). In the US, a newly-developed national retirement risk index shows that almost 45 per cent of working-age households are at risk of having inadequate retirement income (see Munnell, Webb and Delorme 2006). Of particular concern may be the impact on middle-income and middle-age cohorts. Unlike low-income and high-income individuals, who benefit from safety nets and private savings, respectively, this group tends to rely disproportionately on traditional private and public benefit schemes, which are already in decline

Figure 7: The Deterioration of Defined Benefit Funding Ratios

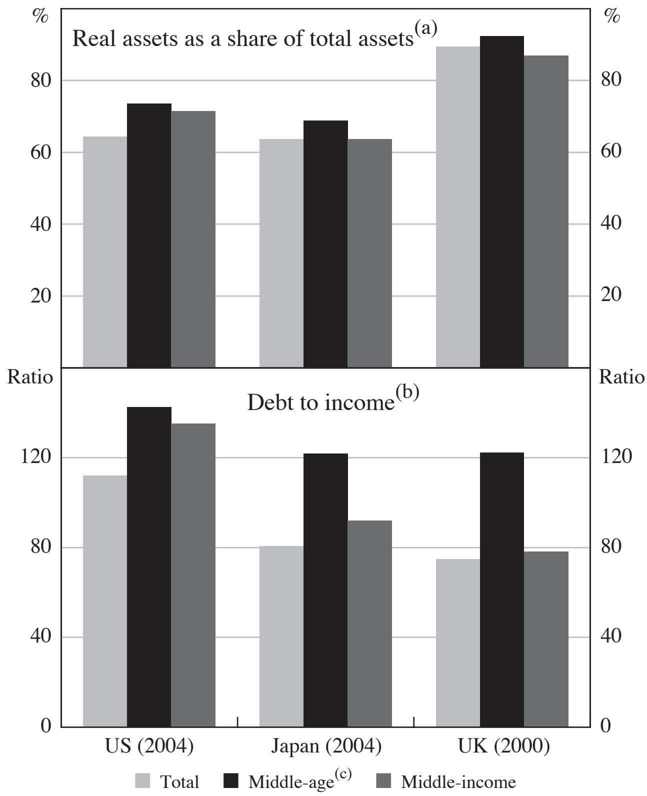


Sources: Bank of Canada; Pensions and Insurance Supervisory Authority for the Netherlands; PIMCO; Van Ewijk and van de Ven (2003)

(Figure 8). In countries where public programs (such as health care and education) are more extensive, the adequacy of household saving has not been a major source of concern to date. However, ageing-related fiscal pressures in these countries have also increased the focus on the need to encourage greater private savings, and the development or deepening of Pillar 2 and Pillar 3 pension systems is increasingly important.[5]

5. Pillar pension schemes here are defined according to the source of savings (government, employment, or individual): Pillar 1 – state-provided pensions, often a combination of a universal entitlement and an earnings-related component; Pillar 2 – occupational pension funds, organised at the workplace; and Pillar 3 – private savings plans and products for individuals.

Figure 8: Household Assets and Indebtedness



Notes: (a) For the UK, data are calculated as housing wealth as a share of total assets.
(b) For the US and Japan, data are calculated as total debt as a ratio to before-tax annual income; UK data are calculated as total debt as a ratio to disposable annual income.
(c) Age 35–44 for the US; age 40–49 for Japan and the UK

Sources: Board of Governors of the Federal Reserve System *Survey of Consumer Finances* (US data); Office for National Statistics *Family Expenditure Survey* (UK data); Statistics Bureau *National Survey of Family Income and Expenditure* (Japan data)

1.2 Managing long-term financial risks

There is likely to be growing attention on the capacity of governments, pension funds and households to not only save more for retirement and ageing needs, but also manage key ageing-related risks. In essence, this involves a reconsideration of existing risk-sharing arrangements. Such risks include: (i) market risks (i.e., interest rate, equity and credit risks, as well as derivatives embedded in structured products); (ii) inflation risk (as governments and corporates adjust or eliminate benefit indexation); (iii) investment planning and reinvestment risk (i.e., operational risk); and (iv) longevity risk (as public and private annuity income streams are reduced or eliminated).

The ongoing shift from defined benefit to defined contribution pension plans is a major channel for the transfer of risks to households. This trend is more prevalent in some countries, notably the UK and the US, but also increasingly in other G-20 countries. In the UK, for example, active membership of open defined benefit schemes is estimated to have fallen by 60 per cent since 1995, and only 15 per cent of new private sector employees are members of salary-related schemes. Among other G-20 countries, India, China and South Korea have recently introduced defined contribution pension systems, while in 1997 Mexico replaced its national pay-as-you-go (PAYG) pension plan for private sector workers with a fully-funded system. The increase in household exposure to a variety of new risks is greater in such countries, since self-managed plans require more individual decision-making, and do not normally provide (or require) annuity or similar payout features. As such, a sufficiently broad range of saving, investment and payout products are likely to be needed to expand households' saving and investment opportunities, and to enable households to appropriately diversify and manage their risks.

Population ageing also exposes households, private insurers and governments to substantial health care risks, given the correlation between age and spending on health care. Health care costs have risen well in excess of household incomes and general inflation in many G-20 countries. For example, total health care spending in OECD countries rose from 8.6 per cent of GDP in 1990 to 10.9 per cent of GDP in 2003, and public sector spending on health care has increased at an even faster pace in some countries. Advances in medical technology account for about 90 per cent of the increase in health care spending over the past three decades, while population ageing explains the rest (see Kotlikoff and Hagist 2005). Rising health care costs may prove a significant burden for households. Given budgetary pressures in many countries, similar to pensions, public sector subsidies for health care and long-term care may decline in the future, or new 'sharing' arrangements for such costs and risks may be proposed.

A challenge for authorities will be to influence how households manage their long-term financial obligations and risks, which are becoming larger and more complex. Developing and executing long-term saving and investment plans are skills that many individuals may find very difficult without expert advice and assistance. As a first step, households' awareness of the challenges that face them needs to be increased. This requires more communication by authorities, and greater financial education of most individuals.

From the government's perspective, the increasing financial pressures on pension plans and health care provision pose substantial long-term risks. Ageing-related costs represent latent but unavoidable liabilities of the state, associated with its role as employer and provider of public social services to the population, which often may not fully be accounted for. Furthermore, the responsibilities of the state may go beyond its explicit commitments, and encompass a role as the 'insurer of last resort'. This is a source of additional and possibly significant implicit contingent liabilities.

Over the coming decades, the projection of current trends is likely to result in a dramatic increase, relative to GDP, in the share of public expenditure related to population ageing (i.e., pension, health care and long-term care), fuelled primarily by the rise of health care and long-term care expenditures. Absent further reforms, spending reductions elsewhere or changes in the distribution of risks, the implications of ageing and related government liabilities have the potential to provide 'intense pressure' on public finances. As highlighted by several researchers, the resulting fiscal implications could significantly undermine the credit standing and sovereign ratings of many countries (Table 1). Moreover, as one considers this analysis closely, there is considerable uncertainty regarding the estimates and extent of these ageing-related liabilities. Longevity and health care costs are influenced by a large number of variables that are difficult to model and predict. Nevertheless, scenario analysis undertaken by different researchers to control for some of the key variables indicate that the projection of rapid growth of pension, health care and long-term care spending, including as a significant and rising percentage of GDP, is a robust one.

Table 1: Hypothetical Projected Long-term Sovereign Ratings
Baseline scenario

	2005	2020	2030	2040
Australia	AAA	AA	BBB	Non-IG
Canada	AAA	AAA	AAA	AA
France	AAA	A	Non-IG	Non-IG
Germany	AAA	AAA	A	Non-IG
Italy	AA	A	Non-IG	Non-IG
Japan	AA	Non-IG	Non-IG	Non-IG
South Korea	A	A	Non-IG	Non-IG
Spain	AAA	AAA	BBB	Non-IG
Sweden	AAA	AAA	A	Non-IG
UK	AAA	AAA	A	Non-IG
US	AAA	BBB	Non-IG	Non-IG

Note: Non-IG = non-investment grade
Source: Standard & Poor's (2006)

2. Current Efforts to Address the Challenges

In seeking to address the above challenges, countries are generally following three broad avenues. First, some countries have taken, or are considering, steps to strengthen the financial position of pension plans, including Pillar 1 pension plans, and public health care systems. In particular, and most effectively, they have sought to influence the risk management behaviour of pension fund managers in some countries through changes in financial regulation and supervision, accounting standards and taxation. Second, some governments have started to give greater priority to increasing the ability of households to manage financial risk through financial education. Finally, to complement actions in the above areas, several governments have sought to encourage the development of new financial markets and instruments to provide pension funds, insurance companies, households, and possibly the public sector, with better tools to manage these important long-term risks. This section looks at the actions being taken in the first two areas. The development of financial markets is examined in Section 3.

2.1 Reform of public pension and health care systems

In recent years, many governments have implemented reforms to make public pension and health care systems more sustainable. In the case of pensions, such reforms have primarily focused on changing key state pension parameters, including contribution rates and periods, benefit indexation, statutory retirement age and incentives for early retirement. Recent reform proposals by the UK Government are a good illustration of such reforms, and contribute significantly to the ongoing debate in Europe and elsewhere about the need to reform state pension systems to cope with the rising cost of rapidly ageing populations, and to tackle the problem of undersaving for retirement, while seeking to clarify the respective roles of the State, the employer and the individual in this respect.

Governments have also moved to reduce or better control the high and rising cost of health care. In Europe, some governments have cut back on publicly provided benefits, and private health insurance is increasingly being used to supplement state-funded health care systems. Steps have also been taken to introduce greater competition in the health care industry. For example, in 2006 the Netherlands introduced compulsory health insurance, which is now being supplied by private insurers who compete for customers through the flat-rate premiums they charge.[6] In the US, where employment-based private health insurance is predominant among the non-elderly, the introduction of managed care in the 1980s (under which insurers establish contractual arrangements with health care providers and exercise greater surveillance over costs and practices) has helped to control costs. The Japanese Government is currently debating reforms to contain health care costs and achieve a more sustainable public health care system, including disease prevention measures, shortening hospital stays, and increased co-payments.

An increasing number of countries account more explicitly for ageing-related liabilities, including health care liabilities, in their long-term fiscal framework. Some countries, such as China, France, Ireland, Japan and the Netherlands have also set up reserve funds aimed at better securing the financing of public pension liabilities, including through investments in financial instruments. However, in many countries, further efforts will be necessary to put state pension and welfare systems on a sustainable path. Unless social security and welfare benefits are brought under

6. Half of the premiums are flat-rate, and paid directly by individuals to insurance companies. The other half are income-linked, and paid by employers into a Health Insurance Fund that reimburses insurance companies after risk equalisation. Insurance companies are required by law to accept anyone who applies for insurance, and must charge all enrollees the same premium regardless of age or health status.

control, many G-20 governments will face stark options in the medium term, such as significant cuts in other government programs or large tax increases, or both.

2.2 Regulatory and supervisory frameworks

In many countries, pension regulations have rarely encouraged a focus on financial risk management, emphasising instead pensioner and employee rights. Regulators have traditionally influenced solvency or prudential considerations through minimum funding requirements, restrictions or limits on certain types of investments, or 'prudent person' rules (which generally establish a principle of diligence that a prudent person acting in a like capacity would use). However, these initiatives do not deal explicitly with the risk inherent in a pension fund's balance sheet, and pension fund investment and risk management practices have often focused more on asset returns than addressing the actual liability structure of the pension balance sheet.

Recent regulatory (and accounting) changes have put more focus on risk management. The Dutch authorities have led the way in encouraging a more rigorous asset-liability management focus by pension funds, with the introduction of a new risk-based approach to supervision, expected to be fully implemented in early 2007. The new framework seeks to ensure that pension funds remain fully funded at almost all times. Important elements of this new framework are the reliance on fair-value measures and advanced risk modelling techniques (including, where appropriate, pension funds' own risk models), and the use of market interest rates as a discount factor for pension liabilities (across the market yield curve and liability profile of the pension fund). In particular, a 'solvency test' introduces an innovative risk-based capital framework requiring pension funds to maintain at least a 105 per cent funding ratio under most circumstances, while a 'continuity' analysis requires them to project their financial position over 15 years, reflecting various long-term scenarios (i.e., a sensitivity analysis).

Similar moves toward more risk-based regulatory frameworks are also evident in the UK and the US, where market-based discount factors have been introduced, and where the use of risk-based premiums for payments to pension guarantee funds (e.g., the US Pension Benefit Guaranty Corporation or the UK Pensions Protection Fund) are being considered, including having such premiums reflect a pension fund's risk profile or asset-liability mix. The choice of the discount rate for minimum funding requirements increasingly influences pension fund asset allocation and investment strategies. As such, pension fund managers wishing to limit the volatility of their funding ratios (and the sponsor company's obligations) may hold a larger allocation of assets with a higher correlation to the discount rate used to measure liabilities. Historically, in many countries the regulatory discount rate was fixed, or only adjusted periodically. More recently, there has been a shift toward greater use of market-based discount rates. In the UK, for example, discount rates based on AA-rated corporate bond yields were introduced in 2001, and produced a greater demand for corporate bonds in recent years.

2.3 Accounting standards

Following recent and ongoing changes in international accounting standards, as part of the International Financial Reporting Standards and market-based, fair-value accounting principles, listed firms must incorporate pension liabilities in their financial statements, so as to provide greater disclosure of a pension fund's financial condition and obligations. The use of fair-value accounting principles addresses the arbitrariness of certain traditional pension fund accounting practices, which tended to smooth pension returns over several periods in the financial accounts of sponsor companies. It has been recognised that such smoothing mechanisms introduce arbitrary and inconsistent accounting and reporting standards, contributing to poor risk management practices and limiting the usefulness of financial reports. In particular, the use of subjective assumptions and projections (e.g., regarding asset returns), which frequently vary between companies, may hamper comparative analysis, and the financial risks borne by the sponsor companies may be understated.

However, by generating greater volatility in sponsor companies' balance sheets, fair-value accounting may also have unintended consequences, especially with regard to a pension fund's investment behaviour. Recent experience in the UK, but also in other countries such as Japan and the US, indicates that fair-value principles may accelerate moves from defined benefit to defined contribution and hybrid plans, as companies seek to 'de-risk' their pension obligations and transfer investment and market risks to employees/beneficiaries. Importantly, from a financial stability perspective, greater sensitivity to accounting volatility may also encourage sponsor companies and fund managers to focus on short-term investment strategies, or seek to reduce accounting volatility by reallocating their portfolios from equities to bonds (or related derivative strategies). As such, accounting changes may raise the risk that pension funds act in a more procyclical fashion while the longer-dated nature of their liabilities has historically allowed them to act as long-term, stable sources of capital, demonstrating essentially acyclical investment behaviour, which benefited financial stability.

2.4 Tax policy

In many cases, tax rules on pension contributions have been used to effectively set upper and lower bounds for funding decisions. This is the case in the US, where contributions that would increase the funding level beyond a 100 per cent funding ratio are not tax deductible, and may even attract an additional 10 per cent tax. Taxation and other rules can create disincentives or prohibitions to annual contributions, or the withdrawal of surplus assets, thereby further discouraging precautionary overfunding. In addition, the loss of tax deductibility for interest payments on long-term bonds (e.g., those with a maturity greater than 30 years) has worked to limit the supply of such securities, which would benefit pension fund risk management efforts.

Tax rules also influence how individuals save. Tax incentives are generally designed to give preferential treatment to retirement savings. Indeed, the fiscal cost of tax incentives for retirement savings may be viewed as preventative of potentially much larger costs that may otherwise be incurred later to support people with inadequate retirement savings. It remains unclear, however, whether tax incentives help raise overall retirement savings, or merely shift existing savings. Empirical evidence is mixed, but an OECD survey found that about 60 to 75 per cent of savings in tax-favoured vehicles represents a reallocation from other savings (OECD 2004). However, even such a reallocation of savings may be beneficial from a retirement planning perspective, if it represents a shift from short-term to longer-term and more stable and committed savings.

2.5 Financial education of households

Improved household financial literacy should be seen as an integral part of efforts to improve financial and macroprudential stability. Indeed, if households are unable to manage the above growing challenges, governments may come under pressure to support the household sector directly or to re-regulate certain products or services. Furthermore, raising household financial literacy should enhance the efficiency of financial intermediation, and encourage the development of products that are better-tailored to the saving needs of individuals.

The design of financial education programs is attracting increasing international attention. The OECD has recently completed a cross-country Financial Education Project aimed at identifying international good practices for financial education programs, in particular with respect to their focus, their delivery channels, and their relative effectiveness. Overall, more efforts are needed by governments to help improve household financial behaviour, including by strengthening basic financial education programs in schools, by designing fiscal and regulatory frameworks that motivate households to save more and to better invest their savings, and by encouraging financial advisers to provide long-term planning advice. To complement this, the private sector is well-positioned to deliver targeted financial education and advice to households. Indeed, in many countries, employer-sponsored seminars have had a positive impact on employee participation rates in occupational pension plans, and financial institutions increasingly realise that it is in their own interest to provide households with better educational tools and sound advice on financial decisions.

3. The Potential Role of Financial Markets

A variety of financial instruments are required to meet the challenges of raising long-term saving and investment, and managing long-term risks and obligations. However, many of these instruments, and their related markets, remain underdeveloped or non-existent. Markets that facilitate the transfer of ‘alternative’ risks (or their components) via the capital markets lag financial developments that enable the transfer of interest rate, foreign exchange and credit risk, and relatively little market-based alternative risk transfer is taking place today. Moreover, within alternative risk transfer markets, innovations to transfer or hedge exposures to longevity- and health care-related risks have proved especially difficult.[7]

This section looks at governments' efforts to deepen existing markets and to create new markets that may better meet the needs of households and institutional investors. The government's role may vary from country to country, as the level of financial sector development, and therefore the capacity of financial markets to respond to the challenges of population ageing, varies greatly across G-20 countries. In countries where capital markets are under-developed, it is often difficult to find long-term instruments to satisfy the saving/investment and risk management needs of households and institutional investors. Even among G10 countries, the relative availability of products varies significantly.

3.1 Development of existing markets

Pension fund managers routinely stress that new instruments and a greater supply of certain existing securities are needed to help them better manage duration, longevity and inflation risks. The availability of such instruments would complement the introduction of more market-oriented or risk-based regulatory frameworks that, as noted, encourage a greater focus on asset-liability management. These instruments include long-dated (30 years and longer) and inflation-linked bonds. By facilitating hedges against duration, longevity and inflation risk, such instruments may also encourage insurance (and reinsurance) companies to increase the supply of annuity products for individuals.

In many countries, authorities have sought to further develop longer-dated bond markets, which remain small relative to the potential demand of pension funds and insurance companies (Figure 9). While the market for long-dated bonds is deepest in the US, even there the size of the market for maturities beyond 10 years is relatively modest. In 2005, a few European countries started issuing very long-dated bonds. Corporate issuers desiring longer-term funding also exist in most mature markets (e.g., capital-intensive industries, utilities, and financial institutions). However, corporate issuance of long-dated bonds is limited and may be hampered by a variety of factors, including the lack of publicly traded benchmarks, tax disincentives in some countries for very long-dated issuance (e.g., beyond 30 years), as well as more cyclical factors, such as the strong liquidity of many corporate balance sheets worldwide and the low cost of shorter-term credit in recent years.

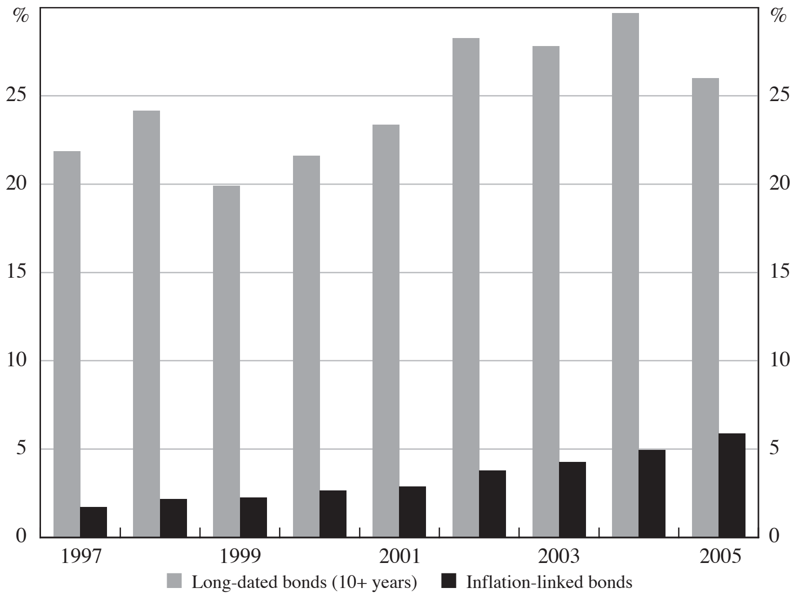
As with long-dated bonds, the market for inflation-linked bonds (ILBs) remains small relative to potential demand (Figure 9). Several countries, including Argentina, Brazil and Mexico, issued ILBs in the period 1945–1980. However, the modern ILB market began in 1981 with more substantial issues by the UK Government. Today, several G-20 countries in addition to the UK have issued ILBs: the Australian Government began in 1985;[8] the Canadian Government since the early 1990s; the US Treasury since the late 1990s; and the Japanese Government since 2004;

7. In the UK, new private equity-style funds have been recently established to acquire the assets and liabilities of closed UK defined benefit pension plans, including longevity risk.

8. However, in 2003, the Australian Government suspended new offerings of ILBs, citing a reduced need due to budget surpluses.

Figure 9: Size of the Global Long-term and Inflation-linked Bond Markets

Per cent of global pension fund assets



Sources: Barclays PLC; IMF; International Financial Services, London (IFSL); Merrill Lynch & Co, Inc; OECD; Watson Wyatt Worldwide

and other countries, such as Germany, have recently announced their intention to issue. In the US, the largest ILB market, the nominal amount outstanding exceeded US\$360 billion as of May 2006, against about US\$220 billion in the UK and US\$141 billion in France. Nevertheless, if the potential demand for long-dated bonds and ILBs from pension funds and insurers materialised (e.g., due to regulatory and accounting pressures), such demand would overwhelm existing supply, and may materially contribute to flatter market yield curves.

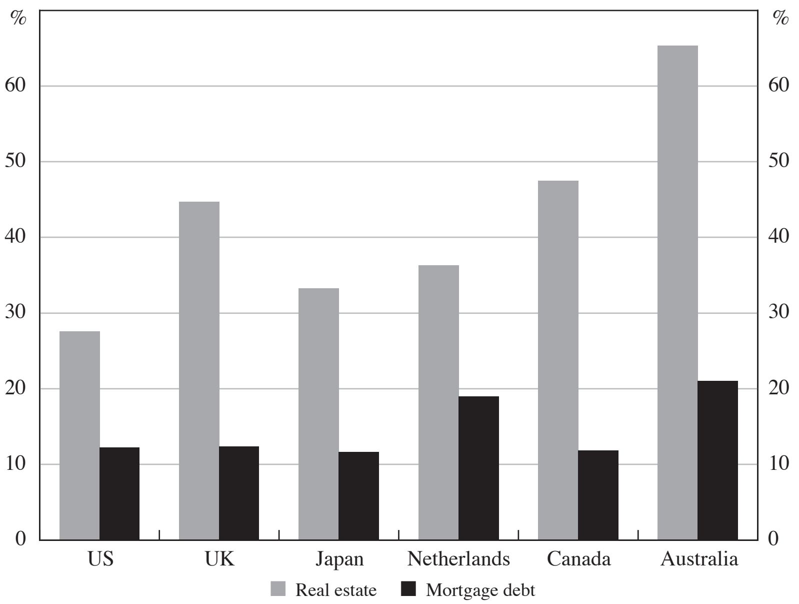
The availability of a variety of retail products, ranging from saving and investment to payout instruments, and broader liability management products, is increasingly important for individuals and households, and in recent years there has been growth and diversification in the range of investment products available to individuals for retirement. Regarding the investment phase, 'life-cycle' products have been developed to address certain 'operational risks', such as the perceived need to reallocate or rebalance portfolios in line with individuals' theoretical reduced risk tolerance as they age. In some countries, structured products also offer a variety of risk/return profiles, including capital or performance guarantees. Going forward, retail investment products that provide access to additional asset classes (e.g., hedge funds, commodities, or real estate) may also be sought as, similar to pension funds and other investors, households may seek investments that provide diversification and correlation benefits.

A crucial element of household retirement planning is the ability to convert long-term savings into a dependable income stream during retirement (i.e., annuitisation). Increasingly, academics and policy-makers are concluding that an individual's greatest retirement risk may be that of outliving his or her retirement assets (i.e., longevity risk). However, annuity markets are generally underdeveloped (or at least underutilised), particularly for individuals, and in several countries the number of institutions providing annuity products has declined in recent years.

Housing assets generally make up a large share of household net worth (Figure 10). The availability of home equity release products, such as reverse mortgages, may help households to realise this form of long-term saving and obtain an annuity-like income stream. More generally, since housing is for households both a major savings vehicle and a currently consumed asset, financial instruments that support these two functions may have an important role to play. In particular, instruments that provide hedges against house price movements may facilitate residential real estate

Figure 10: Housing Assets

Share of total household assets, 2004



Notes: Total assets are the sum of financial and non-financial assets. For the US and Canada, data refer to 2005.

Sources: Australian Bureau of Statistics; Bank of Japan; Board of Governors of the Federal Reserve System; De Nederlandsche Bank; Economic and Social Research Institute, Cabinet Office, Government of Japan; European Mortgage Federation; OECD *Economic Outlook*; Office for National Statistics; Statistics Netherlands investment for existing homeowners (and institutions) and prospective purchasers, thereby potentially enhancing market liquidity. In May 2006, indices of house prices in 10 US cities started trading on the Chicago Mercantile Exchange.[9] Some countries (including France, Germany, Hong Kong SAR, Japan, and the UK) also have developed, or are looking to develop, broader real estate products, including more conventional real estate investment trusts for a variety of property types.

3.2 Efforts to develop new markets

New products and markets, including risk transfer markets, may need to be developed to expand the range of long-term saving/investment and risk management instruments available to institutions and households. These include, among others, markets to manage longevity, health care costs, and house price risks, all of which are important in the context of ageing populations.

3.2.1 Longevity risk

Annuities provide a longevity risk hedge for consumers, and longevity bonds could do the same for insurance companies and pension providers. However, the development of the annuities market has been hindered in part by the limited availability of suitable long-term hedges, including against inflation risk, as well as by lacklustre consumer demand, reflecting the insufficient focus on long-term risk management and perceived cost considerations. A particular problem is the uncertainty related to longevity estimates (e.g., medical developments), which introduces risks that may not be diversifiable. The European Investment Bank (EIB) tried to meet the demand for longevity hedging instruments in 2004/05 with an offering of longevity bonds, which was eventually withdrawn. The failure of the issue was attributed to several design flaws, including a somewhat narrowly defined underlying index (based on 65-year old English and Welsh males), and (more importantly) its 25-year maturity, which left extreme longevity (i.e., life beyond 90 years) uncovered.[10]

3.2.2 Health care coverage and costs

Reinsurance is used to a very limited extent to manage health care coverage and costs, and there is no capital market activity for health care-related risks. A major factor is the large number of variables that affect health care costs and spending, which are inherently difficult to model and predict. This difficulty is compounded in some countries by the fragmented and local nature of the health care delivery system, which makes it more difficult to produce comparable health care data on a

9. Homeowners are exposed to the risk of prolonged and/or significant decline in house prices, whereas would-be homeowners are exposed to the opposite risk of sharp/prolonged increase in house prices. House price indices, by supporting the needs of savers and homeowners, should improve the liquidity of housing markets.

10. For a detailed analysis of the EIB issue, see Blake, Cairns and Dowd (2006).

broad geographical basis. Private insurers and the government – a major player in the health care market – manage these risks largely by shifting them to households and/or plan sponsors, primarily through repricing mechanisms (usually annual) or, in the case of the government, increases in taxation and/or reductions in benefits. The ability to reprice such coverage and risks is frequently cited as the primary risk management tool for health care provision, and the reason reinsurance is rarely utilised.

3.2.3 House price risk

Housing wealth is a growing and increasingly important source of retirement income in Europe, the US and a number of other developed economies. Declines in house prices could therefore have a significant impact on individuals' retirement consumption, making the ability to hedge price movements increasingly relevant. As noted above, house price indices started trading very recently in the US, but the market to hedge house price risk remains nascent or non-existent elsewhere.

3.2.4 Market structure and innovation

In some G-20 countries, capital markets are less developed, and the range of saving and investment instruments available to households and institutional investors may be limited. For example, pension funds in some countries (e,g., China, Mexico and Turkey) are invested largely in domestic government bonds and short-term investments (see Figure 5). The further development of capital markets in these countries – including credit markets – would introduce opportunities for greater portfolio diversification while improving the risk-return profile of households and institutional investors. Moreover, further capital market development and diversification opportunities are also important for the development of broader risk management instruments and risk transfer markets.

In many G-20 countries, market development may be hampered by a variety of structural and institutional impediments, including limitations on international investment flows. In the case of risk transfer markets, traditional techniques for the 'true sale' of assets, such as loans, encounter numerous legal and institutional frictions in many countries which may prevent banks from transferring risks through direct or cash securitisations. Such frictions typically include transfer taxes, inadequate or inconsistent loan documentation, requirements relating to borrowers' consent, uncertainties regarding the bankruptcy status of special purpose vehicles and often other legal uncertainties. Additional frictions in some emerging-market and developing economies, such as those in Asia and the Middle East, include conflicting or incomplete local regulations and standards (e.g., creditors' rights and bankruptcy proceedings). As a result, in a number of countries synthetic credit risk transfer structures have developed, and have been instrumental in overcoming many of these frictions. Indeed, much of the credit risk transfer activity in Europe has been achieved synthetically, in part because of market structure factors, such as less complete bond markets, but also in response to some of the frictions noted above.

Regulation, technology (including risk modelling) and data quality and availability are very important influences on market development and innovation. In industrial economies, market participants and academics believe that the technology and financial skills necessary to realise deeper and more complete markets, including new risk transfer markets, are currently available. However, they also frequently state that policy-makers and regulators must attempt to provide more consistent and stable supervisory and prudential frameworks, in order to encourage or allow market participants to pursue the longer-term investments needed to achieve some of the risk management objectives discussed in this paper. For example, the Basel regulations since the late 1980s have encouraged banks to sell credit risk and create more liquid balance sheets, and technology has evolved allowing banks to evaluate and differentiate credit-related risks more precisely, which has enabled them to tailor securitisations to meet ever more specific investor demands. Similar regulatory vision or influences may be required to encourage the development of risk transfer markets in the insurance and pension sectors, since many of the products to manage ageing-related risks have an insurance or pension component. The forthcoming Solvency II principles in Europe may be important in this regard, and may be used to promote new risk management practices and tools in the insurance industry, including greater risk transfer activity.

Through the various policy levers at their disposal – regulation, accounting standards, taxation, and compulsion – governments exercise important influences on the flow of risks, asset allocation decisions and the behaviour of market participants. This ability to influence market developments differs from country to country, based on the degree of development of financial markets and institutions. As such, governments may increasingly wish to understand how they may influence and benefit from market practices, including in their role as a risk manager. These issues are explored in Section 4.

4. The Government as Risk Manager

As outlined above, the economic and financial challenges associated with population ageing have continued to grow. Ongoing reforms of pension and other benefit systems have increased public awareness of these issues in some countries, and reforms are increasingly being debated among policy-makers. In the UK, in particular, the debate has progressed significantly in the last 12 months, based on the work of the Pensions Commission.

Increasing public awareness and debate is important, but only a first step. Government should increasingly approach these issues as a risk manager, particularly due to the long-term and systemic nature of many of the risks associated with ageing. In doing so, authorities should also consider various market solutions and inputs as they evaluate the costs and benefits of different policy options. In this regard, governments may consider three broad, possibly complementary, approaches: (i) the use of various policy levers noted above to encourage the private sector to address incomplete markets for the management of ageing-related risks; (ii) to act as the 'insurer of last resort', and directly assume (perhaps temporarily) some of these risks; and/or (iii) to determine that households are best positioned to bear and manage these risks, support efforts to improve financial literacy, and encourage the availability of long-term planning advice and products.

4.1 Encourage the private sector to address incomplete markets

Through the use of the various policy levers described below, governments influence the flow of risks in the financial system, and can encourage the development of new products and risk transfer markets, as occurred with respect to the credit derivative markets during the 1990s. Many observers (particularly insurers) previously believed that credit risk was inherently 'untransferable' or 'untradable', which has proven not to be the case. Similarly, insurers today believe that certain ageing-related risks reflect 'one-sided' markets,[11] where they must price exposures to reflect the cost of capital and reserves required to hold such risk, and the most effective risk management technique is portfolio diversification. As with banking and the Basel guidelines, governments may seek to influence traditional insurance risk management practices and encourage market innovations, particularly with respect to ageing-related risks.

4.1.1 Regulatory frameworks

As noted above, some countries, most notably the Netherlands, have recently made significant strides to strengthen the regulation of pensions, particularly through more risk-based supervision to encourage fund managers to focus more on risk management and asset-liability management. Regarding the management of longevity risk, last year's attempt by the EIB to issue a longevity bond highlighted that post-90-year longevity is particularly difficult to hedge, and represents a significant capital exposure for providers (estimated to be 20–25 per cent of allocated capital). Therefore, efforts to improve supervisory frameworks, including increased risk-based principles and internal modelling, should improve the risk management focus of pension fund and insurance managers. Moreover, such an approach is also likely to encourage the development of new products, which may also alter the allocation of risk between insurers and beneficiaries (e.g., annuity products may be repriced and renewed every 10 years or so to mitigate the uncertainties of modelling longevity beyond 15 or 20 years). As a result, more basic products may emerge, which may also encourage greater demand and use.

11. In the insurance industry, reference is made occasionally to 'one-sided' markets, which are those risks considered most appropriate for classic insurance coverage, in that there are no natural hedges or netting opportunities, and insurers 'risk manage' the positions solely or primarily through portfolio diversification (e.g., earthquake risks). Two-sided markets exhibit liquid and traded offsetting positions, such as foreign exchange, and are considered capable of capital markets risk reduction.

4.1.2 Accounting standards

The shift to fair-value accounting principles in many jurisdictions was intended in part to bring more market values and discipline to pension reporting. In general, this seems to be a sensible policy. However, it is not clear that the volatility associated with fair-value accounting measures accurately reflects a pension fund's true risk profile, or properly focuses risk management on these long-term pension obligations. Indeed, an important question is whether full implementation of fair-value accounting may lead pension funds to overly focus on accounting volatility and become more active traders, thereby reducing the traditional long-term investment focus of pension funds (and insurers), which has typically enhanced financial stability. Similarly, policy-makers may also consider whether broader disclosure of the asset and liability structure of pension funds (including the maturity profile of pension obligations, and market and interest rate sensitivities) may provide investors and beneficiaries with more useful information.

4.1.3 Tax policy

In theory, tax policies often seek some form of tax neutrality, in that such policies are not necessarily meant to dictate decision-making. However, as noted earlier, with regard to pensions, taxation is often the determining factor in setting annual contributions. As such, tax regimes for pension funds should be designed to encourage prudent, possibly continuous funding policies, and ideally seek to build reasonable funding cushions (e.g., two or three years of normal contributions). With regard to the household sector, the clarity and stability of tax regimes is deemed essential to encourage the development of adequate long-term savings and investment products. More broadly, tax incentives may also be used to trigger the development of new markets, such as 'macro swaps', through which (for instance) the pension fund and health care industries may swap their complementary cash flows and exposure to longevity.[12] Governments may encourage these transactions, for example, by introducing appropriate tax incentives for the health care industry, perhaps conditioned on certain research or product development efforts targeting the needs of the ageing/retiring population.

4.1.4 Data availability

The availability, reliability and timeliness of data required to decompose, price and trade individual risks, are broadly cited as crucial (and often missing) for the development of markets to better manage certain ageing-related risks. Governments may have a comparative advantage and interest in improving the availability of data, which may be seen as a relatively low-cost method to support market-based solutions. For example, market participants cite the absence of comparable health care data,

12. Longevity increases lead to both greater liabilities for pension funds and higher revenues for health care companies (from increased health care spending by the elderly). The availability of an index reflecting the cumulative survival rate in a given population would provide the basis for both parties to trade such symmetric exposures, and hedge against unexpected changes in longevity.

the unreliability and out-of-date nature of mortality information, and the lack of reliable local data on house price movements as reasons these areas have been slow to develop or altogether absent from financial market analysis. The development of liquid housing price index markets would provide savers with opportunities to hedge against price increases (for those saving to buy real estate), and homeowners to hedge potential price declines (e.g., as they approach retirement). Such hedging instruments may facilitate the growth of reverse mortgages or similar equity release products, allowing households to more easily realise an annuity-like income stream, and thus better hedge longevity risk.

4.1.5 Compulsion

The need to pool diversified risks is an important feature of insurance, including annuities and health care coverage. For example, to reduce adverse selection and bias, governments may impose a degree of compulsory annuitisation, possibly as a proportion of tax-privileged pension savings. In the UK, the authorities require that at least 75 per cent of defined contribution or personal pensions be annuitised by age 75. Importantly, mandatory annuitisation may encourage the emergence of more 'vanilla' annuity products, and potentially improve households' understanding and acceptance of such products.[13] In the health care sector, compulsory coverage may also be a way for the government to overcome market limitations. For example, many OECD countries have mandatory universal public or private health care.

4.2 Government as insurer of last resort

In some cases, governments may need to act as the 'insurer of last resort' to address incomplete markets or to provide solutions where markets may be unable. This role is already recognised in areas where risks (or related costs) are deemed too great or undiversifiable for the market to effectively insure. For example, the government's role in providing bank deposit insurance has been seen in some countries as a cost-efficient way to promote the stability of the banking system, and pension guarantee funds, backed ultimately by the government, are present in several countries.[14] Continuing with the consideration of longevity risk, which most insurers describe as unhedgeable, governments may consider assuming a limited (but important) portion of longevity exposure, such as extreme longevity risk, possibly defined as persons over age 90. In this way, by assuming the costly tail risk, governments may increase the capacity of pension and insurance industries to supply annuity protection to employees and households, and facilitate the broader development of longevity risk markets.

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13. A similar result, driven by annuity providers, may be realised if risk-based regulations are adopted, which require capital to be more precisely allocated relative to specific product or balance sheet risks (e.g., better reflecting the 20–25 per cent tail risk associated with extreme longevity).

14. Similarly, there may be strong economic reasons for governments to ensure that flooding or terrorism insurance remains available, either by providing or requiring minimum coverage, or by 'capping' such exposures and insuring the extreme risks themselves, thereby seeking to attract private capital and additional insurance coverage.

When considering the government as an insurer of last resort for ageing-related risks, an important consideration is the extent of state pension provision under Pillar 1. For example, if the state provides a substantial public pension benefit, such existing exposure may limit the scope for the state to take on greater risk. Conversely, where state plans represent more of a safety net (and not a retirement-style pension), or as the level of state pension is reduced in some countries, governments may 'free up capacity' to absorb certain ageing-related risks, ideally in a manner which may also attract private capital and capacity.

In all cases, government interventions should be part of a comprehensive strategy, taking into account expected costs and benefits (i.e., the impact on the public sector balance sheet), the time horizon, and the existence of potential financial market solutions. In this regard, government interventions may be tailored to very specific risks or of limited duration, and removed as private financial services develop. For example, in the area of housing policy, the Mexican authorities introduced the Sociedad Hipotecaria Federal (SHF) in 2001, which offers public guarantees and seeks to improve liquidity in the country's secondary mortgage market. However, the mandate of the SHF is explicitly limited, with the Federal Government's guarantee to be eliminated in 2014.

4.3 The household sector

Households, as the 'shareholders' of the system, have always been the ultimate bearers of financial and other risks. However, they are increasingly facing additional and new risks more directly as a result of public and private benefits being reduced or restructured. Policy considerations regarding the desirable risk profile of the household sector involve important cultural, social and political issues, which may be addressed differently across countries or regions. Nevertheless, a greater transfer of risks to households raises the question of how well-equipped households are to bear such risks.

In considering the allocation or sharing of risks, policy-makers need to measure the impact of ongoing and proposed changes in pension and welfare systems on the household sector. In particular, they may use or develop statistical tools to capture the distribution of risks across population subgroups, especially age and income cohorts. Efforts to improve the collection, timeliness and comparability of data for the household sector should be encouraged, since in a number of countries it remains difficult to obtain consistent data for household balance sheet items. Policy-makers may also look to develop broader, more forward-looking measures of household wealth. For example, they may try to define an appropriate financial margin measure to evaluate households' financial cushions relative to anticipated future obligations. In Sweden, the Sveriges Riksbank has sought to develop such an approach, assessing the financial margin (i.e., post-tax income, after interest expenditure and regular living costs) of Swedish households, and their ability to service their obligations when faced with potential benefit adjustments or economic shocks (e.g., a rise in interest costs and/or a decline in income) (Sveriges Riksbank 2004).

Pursuant to ongoing policy considerations, various modalities to encourage savings or to achieve a desired risk sharing are possible. With regard to savings, the workplace (i.e., Pillar 2 pension schemes) may be the most efficient location to organise and accumulate retirement savings. Through occupational pension schemes, employers can most effectively organise the funding of employees' retirement savings. Moreover, employees seem more prepared to contribute wages at source to long-term work-related pension schemes, whereas efforts to attract funds in various Pillar 3 schemes in many countries have been less successful. In addition, by bundling employee savings, employers are well-positioned to negotiate lower investment costs and obtain professional advice to the benefit of employees. More generally, traditional defined benefit schemes and principles should not be uniformly discarded, and 'hybrid' occupational pension plans may provide a useful risk-sharing approach, for example, by providing a minimum guaranteed level of benefit and corporate pension contribution, while sharing some of the investment and longevity risks with employees.[15]

As noted above, in most countries policy-makers need to communicate more effectively the pension and health care agenda to the public, including to develop a broader understanding of, and support for, reform efforts. Governments should strive to provide households with improved financial literacy, as households generally need greater understanding of the risks related to these long-term financial challenges and alternative strategies to manage these. Moreover, governments and private industry have comparative advantages in this regard, and the incentives for financial advisors to provide long-term, impartial advice to households may need to be re-examined, including relatively simple and stable tax and regulatory regimes that encourage advisers to develop more long-term planning products.

5. Concluding Remarks

We have sought in this paper to highlight how policy-makers may influence, and potentially benefit, from financial market developments and possible market-based solutions to some of the challenges related to population ageing, and to encourage early action by authorities. Indeed, further delay in addressing these challenges may only serve to increase their ultimate economic cost and financial impact. As such, this paper has discussed how some of the policy levers available to governments may be utilised to progress or complement reform efforts, as well as the need for governments to approach these long-term challenges as a risk manager, considering both explicit and contingent obligations related to ageing.

The implications of population ageing for financial markets, as well as for macroeconomic and financial stability, are getting greater attention. For governments, threats to fiscal sustainability have been brought to the fore in recent years, and pension and health care reforms are increasingly high on the policy agenda in many countries. Similarly, since 2000, the weak financial position of many pension funds has highlighted the need to secure financial resources and to develop better risk management practices in order to meet retirement needs, and has triggered

15. In addition, a number of countries are considering opt-in *vs* opt-out schemes to encourage household enrolment in pension plans, as part of broader efforts to address the adverse consequences of individuals' inertia in managing their long-term financial affairs.

reform efforts in the regulatory, accounting and tax domains. More broadly, several governments and international institutions have taken action to raise the public awareness of the various challenges related to ageing, and have begun to address some of the main issues.

Financial markets may play an important role in the management of ageing-related risks. Governments should seek to influence market developments in this area, and reform efforts may need to reconsider the appropriate sharing of risk between the public, private and household sectors. In some cases, governments may simply provide a framework or otherwise influence market participants to address incomplete markets, such as longevity or housing. As evidenced in the banking sector, clear and consistent regulatory frameworks can influence and encourage innovations in the area of risk management. In other cases, governments may need to intervene directly, perhaps temporarily, to provide some minimum and/or extreme insurance coverage, ideally to facilitate the development of private capacity, such as in the area of health care. Lastly, some risks may be best managed by the household sector, although shifting more risks to households will likely require additional measures to ensure they have some minimum ability to manage such risks. The selection of any combination of these alternatives will be influenced by the sophistication and depth of domestic or regional financial markets and institutions, as well as cultural and social considerations.

Importantly, governments should act as a long-term risk manager, pursuing proactive and comprehensive risk management strategies. In doing so, they would likely benefit from greater market inputs and risk management instruments, including the ability to better measure and monitor explicit and contingent obligations (e.g., volatility measures). To date, few governments have approached ageing-related challenges in this manner. However, given the focus that rating agencies are increasingly applying to long-term sovereign fiscal issues and related risks, and the potential for rating downgrades if such risks are left unaddressed, greater action may soon be required. Indeed, while the typically shorter-term focus of politicians and much of society may often inhibit more immediate efforts to address these longer-term challenges, greater scrutiny from public auditors and legislators, financial media and international financial institutions and investors, and possibly even domestic households, is likely to increase the policy emphasis on ageing-related challenges.

Finally, the issues related to ageing are relevant to all countries, and are not going to fade away. On the contrary, these tend to be cumulating risks, and with time may well exacerbate a number of related social, economic and financial challenges. Moreover, governments, as well as domestic businesses and financial markets, compete globally for investment capital, and the potential economic impacts of ageing may adversely influence their competitive positions, as well as macroeconomic and financial stability. These and other factors should compel policy-makers to build greater public support for more immediate policy initiatives designed to mitigate such adverse impacts. Given the multi-generational nature of the challenges and most of the likely reforms, it is important to start such efforts now.

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Discussion

Carmelo Salleo

The paper by Todd Groome, and his co-authors, is a well-written survey of the main issues concerning ageing and financial markets. I would like to add a few that aren't mentioned. Then, based on the example of Italy, I will offer some views on how to deal with the problems posed by population ageing.

First, some issues that could have been mentioned in the paper are as follows.

The authors identify the increase in longevity and the decline in fertility rates as the main factors that characterise the impact of ageing on finance. The consequence is, other things equal, an increase in the dependency ratio. Another factor that should be considered is the long-term growth prospects of economies.

The authors make some use of projections, but they could be more precise on the following points. What do we know about future developments in longevity? Until now its increases have been consistently underestimated, but why should we keep making the same mistake? How likely is it that we will live much longer than we already do? There is a high degree of uncertainty on this issue. As for fertility rates, they seem to be sensitive to policy measures and not exogenous. Furthermore, the impact of immigration should be taken into account, even if only to say that it will be small. Finally, expectations regarding long-term growth should be made more explicit. All these points deserve papers of their own, but they should be acknowledged and maybe used to give a sense of the uncertainty that surrounds these issues and of how sensitive projections are to changes in the assumptions.

The authors could also have mentioned some of the reforms undertaken in the past few years in many countries, or described in some detail ones that they particularly liked, to give an idea of the extent of action that is needed. The problem with the policy measures needed is that they imply sizeable redistribution of disposable income and are therefore unpopular, the more so the older the current population; this political economy dimension is lacking in the paper.

A final point on what could have been said. Much attention is given to the second pillar of retirement income systems, particularly on whether pension funds are underfunded, whether they have the right incentives to manage their assets and liabilities properly, and whether the supervisory framework is sound. What is missing is a sense of the optimal asset-liability structure, and on what it depends. This of course has implications for the regulatory framework and the incentives that should be given to fund managers.

Now to some thoughts on the challenge posed by ageing.

It's probably fair to say that changes in the dependency ratio have two dimensions: one is its expected increase, the other is its variance. The increase in the mean is mainly the preserve of policy options, while the variance could, in principle, be dealt with by financial markets.

The increase in life expectancy is already being dealt with (if not adequately) by most countries, through the adoption of conceptually straightforward policy measures. Let's take the example of Italy. In the early nineties it faced a 'perfect pension storm': it had one of the most generous pension systems in terms of retirement age and benefits, funded on a pay-as-you-go basis, combined with one of the highest life expectancies in the world, one of the lowest fertility rates and one of the lowest rates of economic growth. The system was basically heading towards bankruptcy but, through an increase in retirement ages and contributions, the development of the second and third pillars and changes in the funding method (to notional defined contribution), the system is forecast to return to equilibrium (in net present value for newly retired individuals) by 2040.

In general, since there seems to be little room for increases in contributions, the favoured policy measures are: changes in the minimum retirement age and making households save more by pushing second- and third-pillar schemes; little is being done on the fertility side of the issue, probably because the effects would be uncertain and much delayed. So, after the reforms, households will face more of the traditional risks, including: inflation risk, investment risk and liquidity risk. These risks are well understood and can be hedged by appropriate financial instruments, such as inflation-indexed bonds and very long-term bonds.

But longevity risk is much harder to hedge, as there is no natural counterparty (the industries that would benefit from increases in longevity, such as pharmaceuticals and health care, are far too small to satisfy the forecast demand – witness the figures mentioned for longevity risk in the United Kingdom), so the issue here is really about risk sharing.

The authors recognise that annuities, which are the natural product for households to insure against longevity risk, are not as widespread as one would expect; there are many good reasons for this. First of all, households already have an annuity – their social security pension. Second, they might want to leave a bequest, or keep their financial wealth in a way that allows them to insure against liquidity shocks (such as unexpected health problems that require costly cures), or they might simply be myopic and underestimate the magnitude of the problem.

If one looks at Italian data, for households headed by a person aged between 65 and 80, three things are striking: (i) the share of disposable income derived from a pension is more than two-thirds for 75 per cent of them – in effect they are already annuitised to a large extent; (ii) even for the 25 per cent in the highest disposable income quartile, annuitisation of half of their financial wealth (a rule-of-thumb indication of how much they could annuitise) would only provide an income stream equivalent to around 20 per cent of their disposable income; and (iii) on the other hand, most 65–80 year old households have substantial wealth invested in real estate – more than 75 per cent own some property (55 per cent in the lowest quartile of the disposable income distribution), which, if converted to an annuity would yield at least 25 per cent of disposable income, even for the households in the lowest quartile. (It could be much more if one assumes that this real estate consists mainly of a home and that it is possible to extract its full equity value.)

Therefore, if we want households to contribute more towards sustaining themselves after retirement, we must think of ways to extract wealth from where it is: in real estate. Reverse mortgages are still rare, so a sound policy would be to remove whatever regulatory and tax impediments there are to buying and selling these products; in general on this issue I would defer to the paper by Olivia Mitchell and John Piggott. Making reverse mortgages possible, affordable and desirable would go a long way towards enabling households to insure against longevity risk.

Finally, as for pension funds, which also have to deal with longevity risk with little chance of hedging it, an interesting proposal was made by Boeri *et al* (2006).[1] They basically suggest that the younger the participant in the fund, the more junior his/her claim – that is, the less certain the amount he/she will receive after retiring. This would share longevity risk across generations and as people approach retirement it would stabilise their expectations about their pension.

Reference

Boeri T, L Bovenberg, B Coeuré and A Roberts (2006), *Pension Funds: Dealing with the New Giants*, Geneva Reports on the World Economy, 8, Center for Economic Policy Research, The Brookings Institution, Washington DC.

1. Longevity bonds seem out of the question for the moment, leaving the government as the insurer of last resort – but governments already have huge exposure, coming from social security systems.

General Discussion

Discussion focused on the role of financial markets and governments in managing ageing-related risks, particularly longevity risk. While financial products like annuities and reverse mortgages assist households in managing longevity risk, participants observed that these markets are thin in most countries. Various explanations for this were debated, including whether myopia limits consumer demand, as well as whether supply is constrained by uncertainties about future mortality trends, and information asymmetries leading to moral hazard and adverse selection.

On the demand side, there was some debate about the extent of myopia and non-rational behaviour in household decision-making. Some participants agreed that weak demand for products like annuities may reflect myopia, and observed that households may not adequately prepare for retirement or may not be aware of the risks associated with their retirement incomes. Some participants suggested that this might usefully be addressed by financial literacy campaigns, already underway in some G-20 countries. Others noted that such campaigns would only really be effective if also combined with the simplification of existing retirement income systems, which had become so complex that even those with some level of expertise in the area had trouble fully understanding them. Along these same lines, another participant thought that any simplification should include eliminating differences in taxation across asset classes. Some participants argued that apparently short-sighted household behaviour may be rational on further examination; weak demand for annuities may reflect the fact that – in their current form – these products are generally not inflation-indexed, do not cover long-term care costs, and leave a purchaser exposed to the risk of default by the issuer. Also, the concentration of household wealth in housing may reflect a move to protect wealth in jurisdictions where owner-occupied property is exempt from eligibility tests for government assistance.

On the supply side, there was some debate as to whether annuity markets are thin because of adverse selection, requiring government intervention to support their development, or whether they are merely immature and would develop without intervention. In particular, several participants took issue with the assertion in Todd Groome's paper that there are no natural counterparts for longevity risk, which might support the development of such a market, citing examples such as investment in providers of long-term care services, consumer goods favoured by the elderly or even investment in human capital (given that in the presence of increasing longevity, the present value of human capital increases, as potential working lives are longer). However, a participant noted that this ignores the argument that the supply of natural hedges is also endogenous. Also, Todd Groome suggested that only explicit swaps will be recognised by regulators or rating agencies. More generally, to the extent that the development of annuity markets is impeded by adverse selection, participants suggested that policy responses could include improving information or compelling annuitisation. One participant suggested that governments should provide inflation-indexed annuities, where the price is linked to the survival of the cohort. However, other participants argued that, while government-mandated annuitisation would be useful, the private sector may be better placed to issue these annuities and invest the proceeds. Similarly, numerous participants agreed that the development of reverse mortgage markets could be supported by improved house price information. One participant noted that in the United States the government serves as a re-insurer for reverse mortgages, through Fannie Mae and Freddie Mac.

Participants also discussed government exposure to longevity and other risks through the provision of age pensions and health care. One participant argued that public pension systems provide a safety net – which is necessary where the markets used to insure against age-related risks are missing – and provide a mechanism for age-related risks to be shared across generations. However, some participants suggested that the public sector and corporations providing defined benefit pension schemes had taken on excessive longevity risks, and that it is not clear if this was a useful thing to do. In particular, state pensions and defined benefit plans with retirement ages largely determined early on in a worker's life entail a large amount of longevity risk for the sponsor. This could be reduced by linking retirement ages to life expectancy. Another participant argued that it is important to distinguish between the type of longevity risk borne by governments and that borne by private insurance firms, as the state can renege on promises without becoming bankrupt. For example, the unfunded liabilities held by the state can change as the parameters of public pension schemes are modified. Against this background, one participant called for greater use of intergenerational accounting by governments, to increase awareness of long-term fiscal risks associated with public pension plans.

There was some discussion of methodological issues arising from Philip Davis' paper. One participant argued that when estimating the contemporaneous link between financial market structure and characteristics like GDP per capita, to the extent that financial market structure is pre-determined, it is necessary to control for lagged dependant variables. And, to the extent that development and increasing life expectancy are linked, it may be difficult to interpret demographic coefficients. Some participants also noted that the three age categories used by Philip Davis may be too broad. For example, a significant shift in saving behaviour may be observed within the 40–65 age bracket because in many countries children typically leave home when their parents are aged around 50.

Finally, Philip Davis' paper suggested that ageing is associated with a shift from investment in equities to investment in bonds. Some participants noted that, as well as reflecting changes in household demand for risk, this pattern is reinforced by regulations and accounting treatments affecting pension funds.

Wrap-up Discussion

1. Gary Burtless

Thank you for the invitation to participate in this conference and to hear the very interesting papers and discussion.

The critical question raised by the conference is: 'What should governments do now about population ageing?' There is a real prospect that population ageing will bring undesired or potentially catastrophic financial market consequences sometime in the future. That is a possibility raised in several of the papers and it is one that newspaper readers are reminded of a few times every year – at least in North America and Europe.

Among the unpleasant possibilities we are warned against are the following:

- an unsustainable fiscal burden to support aged populations, which after all derive much of their consumption from state-financed pensions and health programs;
- a labour shortage, as the proportion of working-age people in the national population declines;
- paradoxically, we are also warned about the prospect of a capital shortage, as big retired populations draw down their assets for retirement consumption; and
- finally and most ominously, readers of the business pages are sometimes alerted to the possibility of a future 'asset-price meltdown' when big retired generations try to sell off their assets to shrunken working-age populations.

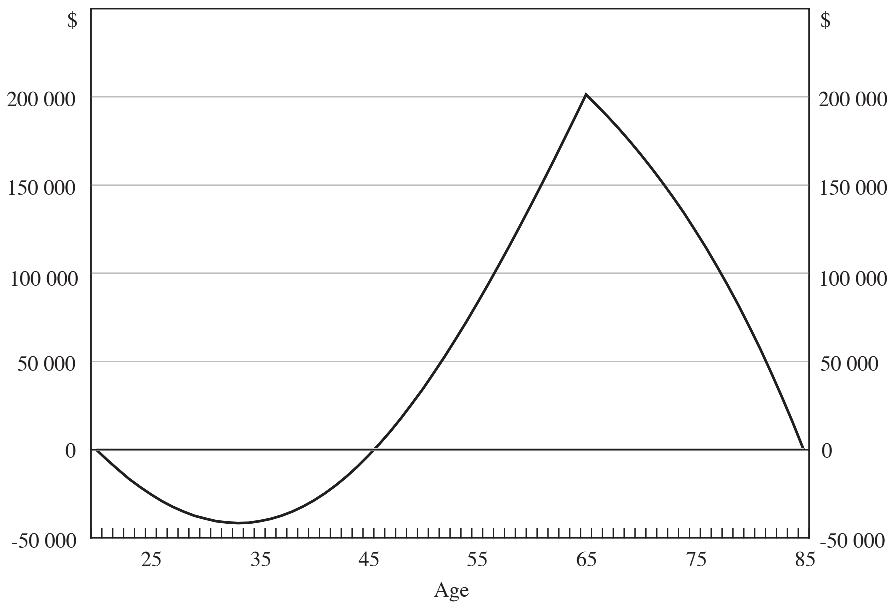
It is not likely that population ageing will produce *all* of these outcomes, at least in the same country and the same decade. (I'm not sure what it would mean to have *both* a labour *and* a capital shortage.) But the crucial question for policy-making is: 'Which of these is likely and what can we do *today* to make them less likely or at least less disruptive?'

The basic problem economists face in answering this question is uncertainty about the correct model linking population age structure to saving, investment and financial markets. For example, will rapid population ageing trigger a catastrophic fall in asset prices in some future decade when huge numbers of retirees try to unload their retirement savings? If so, will retirees face major deprivation because of their inability to convert financial market claims into retirement consumption?

Yesterday I said I was sceptical about this prospect. Still, we should acknowledge that an asset-price meltdown is within the realm of possibility. It is at least conceivable that asset prices could fall sharply under some plausible model of retirement saving, portfolio preferences by age and asset-price determination when there is herd behaviour and panics. There are two crucial questions: (i) are these models true, and (ii) what should we do about this looming disaster *today*? The correct answer to question number one is 'we don't know'. This makes it a bit difficult to answer question number two.

Let's take a simpler question: 'Will the aggregate private saving rate decline at some point as the population gets older?' As shown in Henning Bohn's paper and noted in the general discussion, the prediction of a saving rate decline is usually based on a straightforward application of the life-cycle consumption model. According to this theory, far-sighted workers/consumers borrow or save very little in early adulthood, gradually accumulate increased wealth up to the point at which they retire, and then gradually liquidate their wealth in order to consume when their labour income stops at retirement (Figure 1).

Figure 1: Life-cycle Consumption Theory
Hypothetical age profile of wealth accumulation

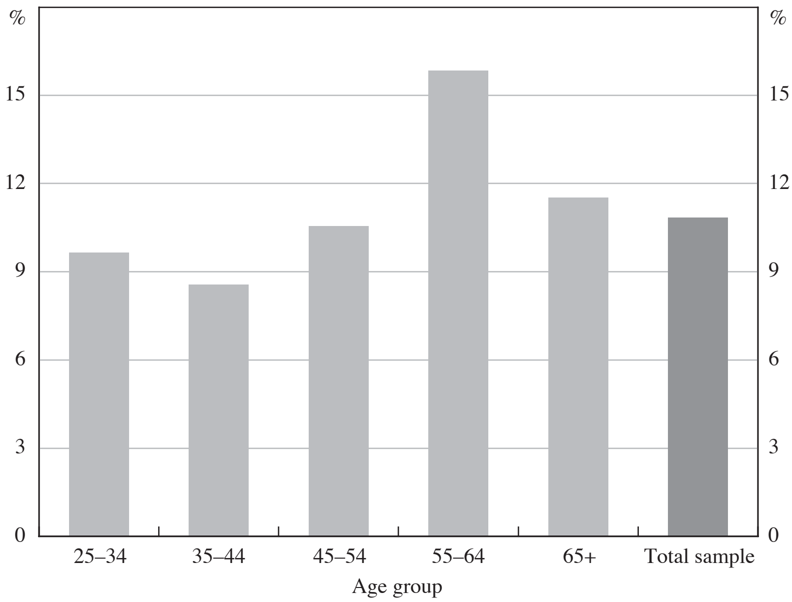


As several of us noted earlier, the theory seems to roughly predict the pattern of saving rates out of incomes over the lifetime. Figure 2 shows tabulations of the saving rate, by different age groups, uncovered in the main US consumption survey. You'll notice that saving rates in late middle-age are higher than they are at younger or older ages. And as Larry Kotlikoff pointed out, better definitions of current income and saving would show an even stronger life-cycle pattern, because most of the health consumption of the aged is not counted either in income or consumption, and part of what is counted as 'income' to the elderly – namely, their defined benefit pensions – actually represents liquidation of prior wealth accumulation. So, if we make plausible adjustments, the age pattern of saving is quite a bit stronger than that which is shown here.

Aggregate private saving should vary as the age profile of the population changes. But a variety of studies show that trends in OECD private saving rates have not followed this prediction. Based on the age pattern of life-cycle consumption, economists would predict that the aggregate private saving rate should increase

Figure 2: Age Pattern of US Saving Rates – Consumption Survey Results

Per cent of after-tax income



Note: Saving measured as after-tax income less consumption expenditures

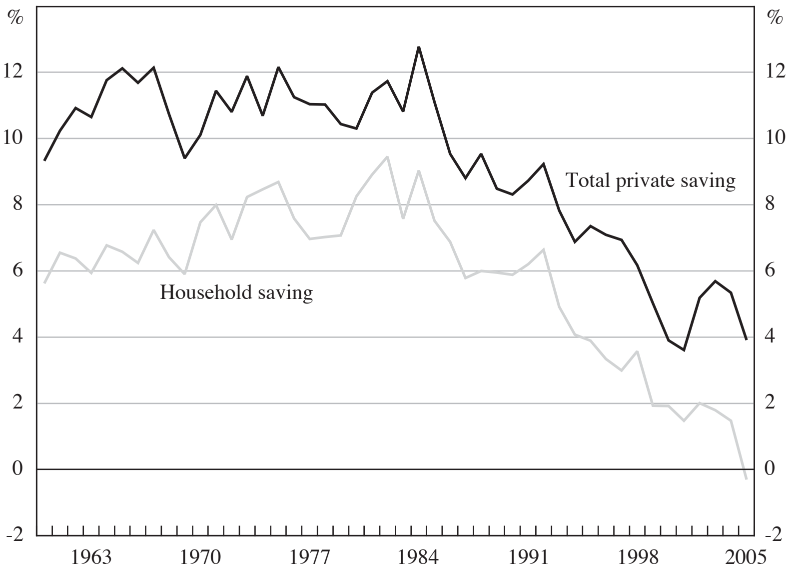
Source: Bosworth, Burtless and Sabelhaus (1991)

along with the percentage of aggregate income that is received by the population aged between 40 and 60. Notoriously, the US private saving rate has fallen by two-thirds or three-quarters over the past two decades, even as the share of the population aged between 40 and 60 has reached an all-time peak (Figure 3).

The same is true in other rich countries. My colleague Barry Bosworth (1996) examined the prediction that a middle-aged population should save more than a younger one by comparing the private saving rate between the late 1960s and late 1980s. In 12 out of the 13 OECD countries he looked at, private saving should have increased; the predicted rise in private saving should have averaged almost 4½ per cent of GDP. The private saving rate actually *fell* in 11 of the 13 countries and the average *decline* in private saving was 2 per cent of GDP. Incidentally, Barry measured the saving rate as the percentage of current production that is withheld from consumption, which is the relevant way to measure saving in standard growth models.

I don't claim this pattern of aggregate private saving disproves the life-cycle model. It simply shows that other changes in the environment swamped whatever effects were caused by the demographic cycle. Swings in the saving rate *within* each age group in the population have been much bigger in OECD countries than the impact on aggregate saving of changes in the age distribution of the population.

Figure 3: US Total Private and Household Saving Rates
Per cent of income



Note: Saving rates measured as income withheld from current consumption, divided by private income

Sources: BEA; author's calculations

What does this mean? It means that many modelling exercises based on straightforward application of the life-cycle model over long periods of time may *correctly* predict the supply and demand for savings – within a single country or in a cross-country framework – but the predictions are *mainly* useful for thinking about pure effects of life-cycle saving accumulation and decumulation *when no other factors are at work*. But that is very unlikely to be the case over the next three, four or five decades. Other determinants of private saving and willingness to invest are likely to change too.

I want to strongly associate myself with some comments made in earlier discussions that when we think about the long-term predictions of these models, we should also think about their capacity to explain the past variations in saving, investment, or cross-national capital flows. If the stylised model predicts large capital flows from more-developed to less-developed economies and it should happen that recent capital flows have been in precisely the opposite direction, users should be a bit slow to adopt policies suggested by predictions of the model.

It will not do to say 'Oh, the recent past has been affected by special circumstances – asset-market collapse in east Asia or Latin America or a spike in energy prices. Those factors are going to disappear so the predictions of the model are reliable'. The reason it won't do is that the future is as likely as the past to be pockmarked by 'special circumstances'.

The private saving rates of OECD countries should have increased as larger fractions of their populations approached their peak earning years. And that would have happened, too, except that private saving was also affected by these special circumstances. You can pick from a long menu of special circumstances – some plausible and many less plausible – because researchers in and out of economics have given us a long list of explanations to consider. Our uncertainty about the correct model is what makes it hard to know how to apply the life-cycle model – which I find persuasive but incomplete – to the business of making policy *today*.

The life-cycle model is one reason among many that I think rich countries like the United States save too little *today*. This is partly based on a prediction – namely, that the future, older population of the US would benefit if the country had a deeper capital stock and more overseas investments when the number of dependent old is much bigger than it is today. But it is also based on looking at Figure 3, which shows that current private saving is much lower than it was in the not-too-distant past. In my judgment, total national saving (including government saving) should probably be *higher* than it was in the past. Even though I am not completely confident in the model that says optimal US saving should be higher, I am more confident in that than I am that demographic ageing will automatically produce first a rise and then a decline in private saving. And I am certainly more confident of that than I am of claims that demographic ageing is going to generate an asset-price meltdown.

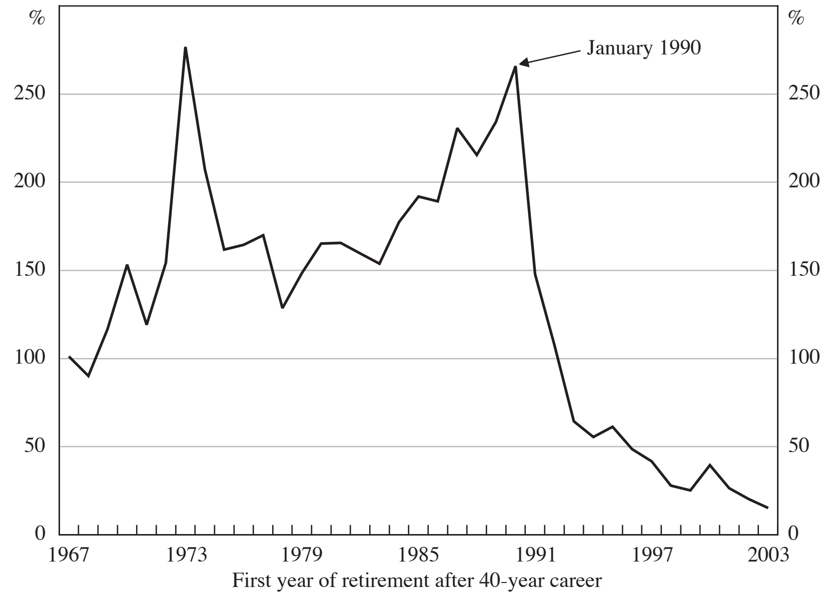
Let me turn last to the 'asset-price meltdown' scenario. Paul Samuelson quipped some time in the 1970s that 'the stock market has predicted nine of the last five recessions' in the US. Since then it has gone on to predict seven of the last three recessions. The 'demography predicts asset-price meltdown' theory has the opposite problem. Many countries in many historical eras have had asset-price meltdowns, but it's very hard to think of a single one that can be convincingly explained by demographic change, which, after all, usually occurs on a rather slow schedule.

I think the lesson for policy-making *today* is not to disregard the possibility of asset-price meltdowns. Instead it is to look soberly at the historical record and design your country's retirement system around the reality that meltdowns are going to occur from time to time – *even if only a handful of them will be caused by demographic change*.

Let me illustrate with evidence from recent years. Figure 4 shows the pension replacement rate that a newly retired Japanese worker could have expected after contributing 7 per cent of his pay to a defined contribution pension plan over a 40-year career and placing all of his retirement savings in a composite fund that invests solely in the Japanese stock market. I calculate the replacement rate by converting the worker's final savings into an annuity, whose price is determined by the Japanese long bond rate.

Workers retiring from 1967 through 1990 would have done pretty well. Their pensions would have replaced all their final salaries – or more. Workers retiring after 1990 would have fared much worse because of the prolonged stock market decline that followed the 1990 peak. By January 2003 the pension replacement rate had fallen to about 20 per cent of final salary. This worker also would have suffered

Figure 4: Japanese Replacement Rates Under 100 Per Cent Stock Investment Strategy



Note: Per cent of final salary replaced if all of a Japanese worker's contributions were invested in Japanese stocks

Source: Burtless (2003)

because the decline in Japanese long bond rates should have increased the price of annuities or led to the bankruptcy of Japanese insurance companies.

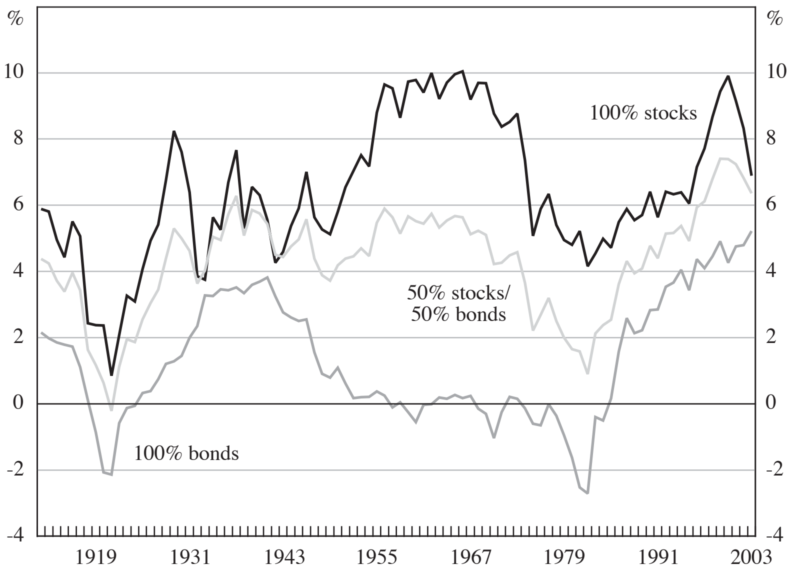
Most of you know the US stock market performed better than the Japanese stock market over the past 15 or 16 years. Even so, stock market gyrations lead to big ups and downs in what US workers can expect to earn on their retirement savings. Figure 5 shows the real returns Americans would have earned after investing their retirement savings in three different portfolios over a 40-year career. I remember someone yesterday saying the long return on US stocks has been stable at around 6½ or 7 per cent per annum for the past 200 years. This chart only uses stock return data back through 1872, but the 135-year average return is almost precisely in the middle of that range.

The problem is, workers won't necessarily earn that average return if they invest steadily in stocks over their careers. That's because their career-average returns are affected by the 40-year period in which they happen to work and especially by returns in the last few years of their careers. The worker retiring in January 2000 would have earned 10 per cent on his career investments and the worker retiring in January 2003 would 'only' have earned 7 per cent. The difference might seem small, but it translates into a startling difference in retirement income.

Figure 6 focuses on just the years from 1991 to 2003. Someone retiring in January 2000 would have received a pension that replaced 156 per cent of final

Figure 5: US Internal Real Rate of Return on Retirement Savings Over a 40-year Career

Career ends on 1 January of indicated year



Note: Internal annual rate of return if an individual invested in a representative sample of US securities in the specified proportions

Source: Burtless (2003)

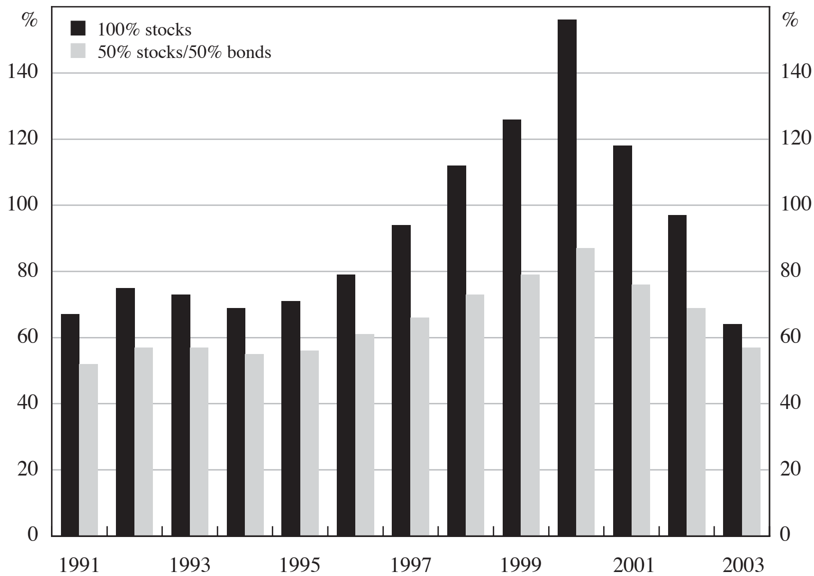
salary; someone retiring in January 2003 would have received just 64 per cent. Putting 50 per cent of your retirement savings into stocks and 50 per cent into bonds reduces that particular fluctuation, but even that moderate portfolio would have produced pension replacement rates ranging between 52 and 87 per cent over a 13-year period.

My point is that you don't need demography-induced asset-price meltdowns to think that there's a realistic possibility that asset-price meltdowns will occur. Policy-makers *today* should take that possibility into account when reforming their retirement systems.

Also, no one should misinterpret this evidence to be an argument *against* defined contribution or individual investment-account pension plans. It isn't. Instead, it is an argument for providing workers with a portfolio of old-age income sources, some dependent on investment performance in a funded system and some dependent on an income source that is outside of financial markets – for example, a basic pay-as-you-go pension system that relies on a modest wage or consumption tax.

In addition, I would argue that the evidence of occasional asset-price meltdowns offers a strong argument for creating new kinds of financial market instruments that can shelter workers against the effects of wild up-and-down swings in asset prices and annuity prices late in their careers. Olivia Mitchell and John Piggott described some interesting kinds of new instruments in their paper. The evidence I just presented

Figure 6: US Pension Replacement Rate After a 40-year Career
Career ends on 1 January of indicated year



Note: Per cent of final salary replaced if a US worker's contributions were invested in the specified proportions

Source: Burtless (2003)

offers an argument, for example, for indexed bonds and new financial products that guarantee workers at least a zero per cent real rate of return on their contributions, with some possibility of obtaining better returns on the part of their savings that is not needed to obtain the minimum zero per cent real return.

So, number one, the life-cycle model offers a good guide to *one* important determinant of saving: the age structure of the population. Unfortunately, it is not a *complete* explanation of saving, so policy-makers have to be very cautious in adopting policies that rely *solely* on that theory to forecast future aggregate saving.

And, number two, future asset-price meltdowns may or may not occur as a result of population ageing. But future asset-price meltdowns are likely to occur for other reasons. Policy-makers should design national pension systems and pension reforms with that thought in mind.

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2. James Glassman

I will recall the areas from the discussion that I feel are most relevant for policy-makers, reflecting my own roots at the Federal Reserve.

Yesterday, we discussed the nature of the demographic challenge – the rise in the world's population from 6 billion at present to an expected peak of 9 billion by the year 2050 and the significant ageing that David Bloom described so well. In the industrial world, this was partly a result of World War II's disruptions, and in the developing world, a result of falling infant mortality in the latter half of the 20th century (the demographic transition). Linking the debate about the demographic challenge to another important policy debate, I would say that the predicted consequences of this demographic transition make concerns about global 'imbalances' seem misplaced.

International trade 'imbalances' are merely symptoms of forces that are profoundly stabilising. These forces have nothing to do with the United States, unless you consider the US economy to be overheated and over-employed, and have everything to do with a global economy that is growing or developing at different speeds.[1] The truth is that we are watching one of the great human endeavours that is lifting a large part of the world's population out of poverty and that provides the answer, the antidote, to many of the problems we have discussed at this workshop. There is nothing like economic development and rising living standards to cure poverty and to enable a society to meet the needs of its ageing population.

Demographic developments always appear daunting when viewed in isolation – that is, when holding everything else the same. Malthus was sidetracked by a misunderstanding about the economic mechanisms that transform all scarcities into demand-supply balance. But everything else isn't the same. Several forces are unfolding that will prove to be powerful antidotes for the demographic burdens that will emerge in coming decades.

1. Life expectancies are rising, tempering pressures associated with the natural ageing of our populations. Some who think about relative age (for example, Sanderson and Scherbov 2005) – that is, the actual average age of the population relative to its life expectancy – assert that the US is getting younger in relative terms and that the same will be true for Japan and Germany in about a decade. Rising life expectancies imply that those in the workforce are becoming productive for longer spans of time, compared with earlier generations. As Charan Singh

1. For example, had US households saved more in this recovery and, equivalently, had consumer spending been more restrained, the US policy response to numerous economic threats would have been even more aggressive than it was. This is because the Federal Reserve's congressional mandate is to foster maximum sustainable output. Given this, the Federal Reserve's policy response likely would have restored aggregate demand in line with what actually occurred, supporting a recovery in US imports. Those who worry about global imbalances offer no solutions of practical value, because there are no credible solutions, other than the of-course-sensible platitudes about structural reforms to promote growth. Structural reforms will enhance economic performance but would do little to address current growth disparities.

noted in his discussion, rising life expectancies call for a new conversation about retirement.

The challenge for many of our social insurance systems is that they have coded in rigid retirement ages that are unrelated to life expectancy. In these cases, each future generation of retirees can expect to draw more benefits, compared with the previous generation. This represents the fundamental source of the projected financial shortfall in the US Social Security system as well as in social insurance programs in other countries.

If the public debate has failed to address this reality, private individuals have not. Workers over 55 years of age in the US are staying on the job longer, and by enough to offset the growing numbers approaching retirement, whose participation rate typically drops off sharply as they approach retirement.[2] The same is true for Japan, according to Hiroshi Watanabe. Because the principal source of stress on social insurance systems will be the result of a favourable factor – people are living longer – solutions can't be all that unpalatable politically.

2. A second industrial revolution is taking shape, this one centred in east Asia, with India and China choosing to lean toward market-based economies, anchoring their currencies to the dollar (particularly in the case of China) and joining the international trading community. Some have noted, with good reason, that this effort echoes the spirit of the Bretton Woods System of fixed exchange rates that helped Japan and Germany regain vigour after World War II. This time, however, it is east Asia, and particularly China, that voluntarily chooses to anchor currencies to the dollar. This effort will accomplish for one-half of the world's population what the first industrial revolution did for the 15 per cent of the world who lived in the West. Of course, this is contributing to the US international trade deficit. And so what?

   With reference to Larry Kotlikoff's simulations of the future transition path in 'Will China Eat Our Lunch or Take Us to Dinner?', I don't know who is eating who for dinner. The US Congress apparently thinks it is China that is eating the US. I suspect China thinks it is the other way around, with foreign companies profiting from businesses in China. I am certain, however, that this important trade partnership is putting a nice feast on China's table. And I suspect that most people affected are getting a pretty good meal out of it, US consumers and businesses alike.

   As an aside, there is a reason why China is investing the dollars it earns in trade with the US in Treasuries. It is in China's own interest to do so, for if China were unwilling to hold the dollars it earns in trade, and were to diversify its dollar holdings into non-dollar-denominated assets, market pressures on the yuan would build. This would undermine China's current competitive advantage and

2. A Federal Reserve Board staff study for the Brookings Institution, to be published in a forthcoming issue of the *Brookings Papers on Economic Activity*, warns of a coming slowdown in labour force growth. The warning is a point taken, although it may be a little premature.

discourage foreign companies from investing in manufacturing operations in China, which are so essential to China's long-run economic ambitions.

If east Asia's development proceeds as intended, at current growth rates China and India's per-capita incomes will rise to the level enjoyed by those in the West by mid century. Can there be an easier way to support China's ageing population? We ought to embrace what east Asia is undertaking rather than resist it, and rather than complaining so much about countries' currency pegs. And, as one participant noted in discussion, we should encourage China to reform its financial system as rapidly as possible.

3. Productivity growth, which for more than a decade has been far stronger in the US than most expected, is a third key force, as several participants have noted. Productivity growth is an important antidote for growing demographic burdens. This has been vividly revealed in the official long-term fiscal projections for the US. The economic assumptions underpinning official projections of a substantial deterioration in the fiscal budget position in coming decades are based on productivity and potential growth assumptions that, although they might seem reasonable to cautious economists, are strikingly pessimistic, both in comparison with the experiences of the past decade as well as the historical performance of the US economy. For example, these forecasts assume that US real GDP growth will slow to about 1¾ per cent annually, essentially half the pace experienced over the past 150 years. It takes no expertise to realise that if an economy's growth rate slows to half of its pace in the industrial age, a period that shaped current government commitments to its citizens, then it will have trouble financing those obligations. The outlook for productivity growth is absolutely critical to the anticipated burden of ageing populations and the current productivity 'surprise' is quite promising in this regard.

These three forces have important policy implications. First, with respect to the fiscal burden of ageing:

- We need to open up the conversation about retirement age and social insurance systems, recognising that retirement should be related to longevity, since presumably the factors boosting longevity are also extending the amount of time that we can work productively. Better yet, social insurance systems ought to be structured to provide incentives for those who are able to work as long as they choose. Many present systems include disincentives to working beyond retirement age.
- We need to put more energy into promoting structural reforms that enhance growth, because it is growth that provides the means to finance our obligations to the aged.
- We need to turn our attention away from worries about global imbalances, which are organic and reflect favourable developments, and embrace the efforts by China, India and others.
- We need to encourage reform of financial systems, because, as Glenn Stevens implied in his opening remarks, market mechanisms are the best and most efficient

means to help households manage risks related to their saving and retirement needs.

Second, with respect to asset values and demographics, as an economist, the discussion we had during the session on the evidence regarding links between demographic change, savings and asset prices was intriguing. But my peers on Wall Street who analyse equities for a living would be horrified to hear that our discussion about demographics and equity valuation made no reference to earnings and the fundamentals that drive earnings and market valuations.

As a market economist, I have been asked by numerous business groups to discuss demographic trends – demographics are a key driver for some businesses, including the beer and cosmetic industries, for example. But equity analysts, those dealing with reality, rarely consider demographic developments. I too am a bit sceptical of stories, like demographics, that focus on only one dimension, such as the role of investors in the stock market valuation equation.

Many of us who are sceptical about the role of demographics are influenced by the events of the past decade. We just witnessed one of the most significant moments in the history of the stock market, with price-earnings ratios doubling in the late 1990s, from around 15 to 30, all over speculation about the dimensions of the new economy. Earnings turned out to be far better than anyone expected – they doubled over the span of five years, despite the turbulence of the times – and valuations are back to where they were, justifying the 'bubble' prices of the late 1990s. Demographic factors changed little in that time and no one talked about demographics as a driver of the stock market. I suspect that the demographic variables in the equity equations discussed by Robin Brooks in his paper are standing in for more complex linkages between demographic developments and corporate profits.

This issue is relevant to two further important policy discussions:

a. Reservations about the measurement of economic concepts notwithstanding, it is widely believed within the Federal Reserve System and the community of macroeconomic economists that the US household saving rate, narrowly measured – that is, excluding capital gains – fell from around 10 per cent in the early 1980s into negative territory most recently. This is verified in the two official measures of saving: the national income accounts measure, which is the difference between income and consumer spending; and the Federal Reserve's flow-of-funds measure, which reflects the net new additions to household savings-type accounts, including retirement vehicles. Alternatively, the ratio of consumption to GDP has increased.

   It is also firmly believed that this decline in US household saving was mostly a rational response by households to the rise in net worth to historically high levels in relation to income. Real estate net worth (net of mortgage debt) is an important component of household balance sheets, but real estate net worth represents only about one-quarter of total household net worth. Equities represent the most significant contributor to the rise in household net worth.

Consistent with a number of participants' comments, it appears to be true that ownership of financial wealth is skewed to wealthier households. Nonetheless, it is this part of the population that contributes to most of the saving in the US. Moreover, those earning more modest incomes who struggle and are unable to save much probably always contributed little to overall national saving. Of course, that doesn't diminish the need for policy-makers to provide more incentives to boost saving.

There is little reason to doubt that ownership of wealth is skewed to wealthier individuals, but I suspect that surveys attempting to assess the ownership of wealth don't fully capture the information respondents have about inheritances, perhaps because respondents don't think about this, aren't willing to share information about expected inheritances or are unaware of assets that may be passed down to them. What is certain is that the vast accumulation of wealth that has built up through the generations during the industrial age will not travel to paradise.

b. It is rather ironic that many encourage central banks to explicitly target asset prices, when there is such little consensus among economists about the factors that determine equity values and what constitutes 'fair value'. There is even less consensus among equity analysts and investors of course, which is why we leave these things – equity valuations – to financial markets to determine. 'Render unto Caesar what belongs to Caesar' comes to mind.

Third, with respect to the conduct of monetary policy, there are a number of relevant issues. On the one hand, demographic shifts pose little challenge to the conduct of monetary policy. For one thing, supply creates demand, and if demographic forces slowed the supply of labour and potential output growth, the slowdown in supply would result in slower growth of income and ultimately curb aggregate demand growth.

Also, central banks are well-equipped to manage uncertainties regarding the growth of the labour force and potential output because they are accustomed to monitoring pressures on resources. For example, if demographic factors slowed labour force growth, the evidence would be clear in the evolution of the unemployment rate.

The more challenging issue for central banks is to determine the equilibrium level of interest rates. The discussion in the session on what theory can tell us about optimal responses to demographic trends was a reminder that demographic developments can have important effects on equilibrium real interest rates. There is little agreement among economists about what the magnitude of that impact is, or even what the direction of the impact is. Nevertheless, central banks need to anticipate expected economic outcomes when they set policy rates, given the lags between policy actions and their impact on the economy. As a result, they need to be able to assess the stance of their interest rate actions. Economies that have well-developed capital markets provide important market guides about equilibrium. This is why we in the financial markets, if not those at the central banks, devote so much attention to the yield curve – the level of policy rates versus long-term market rates. Without a well-developed capital market, central banks would be flying blind.

In conclusion, the demographic trends in store will be challenging. Yet, the forces that are unfolding, including rising longevity, rapid development for newly industrialising economies, and rapid labour productivity growth – even if they are contributing to large and growing international trade 'imbalances' – represent antidotes for the social burdens associated with growing and ageing global populations.

Reference

Sanderson WC and S Scherbov (2005), 'Average Remaining Lifetimes Can Increase as Human Populations Age', *Nature*, 435(7043), pp 811–813.

3. Adair Turner

I would like first of all to thank the Reserve Bank for organising this workshop. I spent about three years working on pensions, demography and capital markets, and I thought that I had got to the end of being interested in this subject. But I think that this workshop has provided a very effective exploration of some very important issues.

I would like to begin with some comments about some of the macroeconomic issues that we discussed yesterday and then turn to some of the issues relating to financial risk that we discussed today. Yesterday, David Bloom gave us a broad outline of likely future demographic trends, while some of the other speakers provided additional detail. In particular, Axel Börsch-Supan highlighted the differences in demographic structures among developed countries. I would like to draw about three or four points out of that overall demographic picture.

First, I do think that it is very important, amid all the talk of the problems of ageing, slowdowns in the rate of population growth and even population decline, to note that the biggest demographic problems in the world today are still those created by population expansion. They are associated with environmental pressures, which will increase further as the world's population expands from 6 to 9 billion, and exist most crucially in those African countries where fertility rates are still five births per woman or even higher. I do think that the problems that those societies have in dealing with rapid population growth are really much more severe than the problems facing developed rich countries in dealing with slow or negative population growth. Not least because rich countries, simply because they are rich, have the resources and the capabilities to deal with such problems.

Second, I think it is very important when we focus on rich developed countries, and indeed some developing countries, to realise that we are talking about two completely different demographic factors, increasing longevity and falling fertility. Both of them together produce an increase in the elderly dependency ratio, measured for any fixed retirement age, but it is important to distinguish between them. And once you have done this, I would like to reiterate my argument that longevity in itself is not really a problem or is a problem at least to which there are very straightforward solutions.

If the only effect at work was increasing longevity and there had been no fertility fall then it is easy to show that, as long as the retirement age rises proportionately with life expectancy, you would get no increase in the ratio of the retired population to the active population. And therefore as long as the pay-as-you-go pension system has within it a rule that the retirement age should rise proportionately with life expectancy, no other adjustment is needed. You can, provided you have that one policy, maintain a stable replacement rate of earnings with a stable contribution rate during working life. Now you might want to change either of these for other reasons but you would not be doing it because you are under demographic pressure.

I believe that the core of all PAYG pension system reform should be this proportional principle. I think it is also useful to note, however, that the analogous finding exists for capital-market-based systems. These are, of course, also exposed to demographic risks through the rate of return and asset-price effects, which we discussed extensively. But it is straightforward to illustrate again that if the only effect was longevity, and if people on average took their longer life and split it in the same proportions as before, into a period of working and saving and a period of retiring and decumulation, then ageing would produce no significant change in the capital-labour ratio since extra capital (arising from a longer period of accumulation) is largely offset by extra labour.

So the problems are not fundamentally created by ageing. The key problems for both PAYG and funded systems arise from the fertility decline. The fertility decline means that, even if we adopt the principle of proportional rises in retirement ages, we will still have an increase in the dependency ratio. In a PAYG system, even if you have the principle of a proportional rise in the retirement age, you will still have to make some other adjustment, whether it be an increase in the contribution rate or a reduction in the replacement rate.

There are two important features of this fertility decline effect which I'd like to highlight. First, I think it is important in the long term, looking out over the whole century, to realise that the effect of declining fertility on the dependency ratio is a one-off effect. Now, it is a one-off effect spread over 50 years or so, which is a funny sort of one-off effect, but it is still a one-off effect. But once you are through it you don't have a permanently increasing dependency ratio whereas the longevity effect, as best we know, continues forever and therefore the adjustments to it through increasing retirement age will probably also have to be permanently sustained.

Second, and more importantly, there are major differences across countries in the extent to which fertility rates have declined and these differences have a big influence on how challenging PAYG system reform is. France, at 1.9 births per woman is, I think, in a completely different position to Germany or Italy at 1.4 or 1.3. Those differences in fertility rates, as Axel's charts yesterday showed, produce really dramatic differences in what is happening to the ratio of active workers to retirees. And these differences have major implications for the severity of problems in PAYG systems.

Our analysis for the UK Pensions Commission leads me to believe that, provided that your fertility rate or your fertility plus immigration rate – the effective fertility rate – is up at about the 1.8 or 1.9 level (in the high 1s rather than the low 1s), which is where Australia, France, the UK and the US are, then the challenges to PAYG systems, while significant, are manageable. The required changes are not transformational and certainly do not require wholesale rejection of existing PAYG systems.

To illustrate, in the UK we have a dependency ratio, expressed as if the retirement age stays at 65, which will rise from 28 per cent to 48 per cent. That means that, if we accepted that we had to maintain a stable replacement rate as a proportion of average earnings, we would have to increase the share of GDP devoted to pension expenditures from about 6 per cent to 9 per cent. Or, alternatively, we would have to cut the generosity of the replacement rate promised by about 33 per cent. But of that increase from 6 per cent to 9 per cent of GDP, about half would be due to the longevity effect and about half due to the fertility effect. So as long as we put in place the measures the Pensions Commission has proposed and the UK Government has accepted, namely, a proportional rise in the retirement age, then the UK can maintain a stable earnings replacement rate within its PAYG system while having an increase in the share of GDP devoted to pensions from 6 per cent to 7.5 per cent. And no further increases will be needed when you get to 2050 because, as I mentioned earlier, the fertility effect is a one-off effect.

Now, some people would argue against an increase from 6 per cent to 7.5 per cent of GDP – they would say that they would rather have a reduction in benefits. If you switch the choice around the other way and say we are going to keep expenditure as a percentage of GDP at 6 per cent, then we are going to have to cut benefits by about 20 per cent. While this is significant, it is not transformational. So I do not believe that PAYG systems are all that radically challenged provided that your fertility rates are in the high 1's. I think there are adjustments that you have to make but I think they are adjustments that society can debate and then get on with.

I think the problem is significantly different for countries with fertility rates in the low 1's – 1.2, 1.3, 1.4. In these countries, even if you have the proportional principle on retirement age, you still have to make very significant additional adjustments either in the form of a higher contribution rate or a lower replacement rate. And these adjustments really do strike me as quite daunting politically. So, my basic message, and I think it is a good message for world environmental sustainability, is that there is nothing wrong with stable populations based on fertility rates of around 2 or even slightly below. We can live with those. But once fertility rates are down as low as 1.4, there are really major problems for pension systems.

So given that these really low-fertility-rate countries have a severe problem, what are the solutions? Well, one possibility that we discussed yesterday was immigration and the consensus I think was that the levels of immigration required to make a big difference to those systems were so large as to be essentially impractical. While I agree with that point, I think it is important not to overstate it. And the way that you can overstate it is to use models which assume that the retirement age will stay fixed and then work out how much immigration you need to stabilise the dependency ratio. Of course, the assumption of the fixed retirement age is absurd. But even when you replace it with a more sensible assumption, the figures are so big as to be effectively impractical. We are not going to solve these problems entirely by immigration.

If not immigration, how about moving from PAYG systems to funded pension systems? The issue that we spent a long time struggling with over the last day and a half was the fact that shifting from PAYG to funded systems does not free us entirely from demographic risks. The change in the ratios of the retired population to the active population or other changes in age structure may produce changes in the capital-labour ratio, and thus in underlying rates of return. Or it may cause changes in the balance of purchases and sales of existing capital assets, and thus in the price of those capital assets.

Clearly, moving from PAYG to funded systems doesn't magically make the demographic risks disappear. We have had several papers trying to work out how big the price and quantity effects of ageing on financial markets are and how certain we are about them. I think that what is obvious is that we face major methodological problems in deriving firm conclusions. There are major debates over whether savings behaviour actually does follow the life-cycle model. We've struggled with how to fit bequests into these models, but I'm not sure if any of the models yet capture them effectively. And I think there remains one very major conceptual issue that we haven't discussed, although James actually just mentioned it, and I think we really need to incorporate it to have a better understanding of savings behaviour. Namely, how to deal with those categories of wealth accumulation which don't arrive from annual saving, that is, the fact that your wealth might increase even though you didn't save in a particular year because the equity market goes up or because house prices go up. We know that the US has had a very low private saving rate for the past 20 years, but US personal sector wealth has soared in that period and the behaviour of individuals is determined by the wealth that they have. I think that the conundrums about how we correctly measure saving are ones that we haven't really fully got to grips with in the models with which we try to determine the effects of demography on financial markets.

But with all that methodological uncertainty, I think we probably know two things. First, we probably know that ageing will tend eventually to produce a somewhat higher capital-labour ratio and a slightly lower rate of return, the effect of which, while not trivial, is also not huge. Second, I think, on balance, the argument about asset prices suggests that, although there will be asset-price effects, the more extreme asset-price meltdown scenarios will not result (at least in response to demographic change).

Today, we have had a very useful discussion of risk. I think that there are two aspects of risk that we ought to focus on. One is longevity risk, where I reiterate the point I made earlier that I think the key issue is that longevity risk for young individuals is very large and it's unlikely that anybody other than individuals should absorb most of it. The second is investment return risk, where I think Gary's conclusion was absolutely right. Whether or not there are demographic effects on asset prices, we do know that asset prices are highly volatile and therefore funded systems create significant risks for individuals. In what follows, I can do no better than repeat what has already been suggested. I think we need mixed systems of pension provision that have a base load of defined benefits, which may well best be provided by PAYG systems and which, through appropriate adjustments, have been made robust in the face of future changes in longevity. On top of that we need to build a funded element into systems, but we need to think carefully about the balance of assets in which those funds are invested in order to mitigate, while not fully removing, the investment return risk.

4. General Discussion

A common theme of the discussion in the wrap-up session was the potential for financial markets to help governments and households to manage the risks associated with demographic change. Following Gary Burtless' remarks, there was some debate about whether high-frequency volatility in asset prices creates excessive uncertainty over the value of retirement income in private, prefunded pension systems. A number of participants argued that individuals could minimise this market risk by annuitising their accumulated retirement savings gradually in the years leading up to retirement, although those who retire during times of particularly low asset prices may still be disadvantaged. Another participant pointed to the potential for households to minimise risks by investing in countries with different demographic trends and suggested that the G-20 might be a useful forum for encouraging such cross-border diversification. However, it was also noted that population ageing will ultimately affect the entire world, meaning that some risks cannot be diversified away by foreign investment.

With regards to pension system design, the discussion focused on how policy-makers could minimise the marketing and administrative expenses of pension funds in order to reduce fees for members. A number of participants felt that governments could play a useful role in the collection and distribution of pension fund contributions. In doing so, governments could take advantage of economies of scale to minimise administrative charges and force pension funds to focus on funds management, where the scope for effective, price-based competition is far greater. There was also general agreement on the need to simplify retirement income systems. Some went so far as to suggest that this could be done by restricting individuals' choices over fund managers for investment portfolios and providing individuals with prudent default contribution rates while working, and drawdown strategies at retirement.

The likelihood that demographic change will generate substantial increases in the cost of health care was also debated. Several participants cited the rapid growth of health expenditure relative to output in many countries and noted that, if present trends continue, health expenditure will far exceed rising pension expenditure as a source of pressure on fiscal balance sheets. Other participants argued that future increases in health expenditure may not be so dramatic if increasing longevity is associated with an increase in the number of years of life spent in good health. In a similar vein, it was also noted that cross-country studies show little relationship between health expenditure and health outcomes. Another participant argued that the growth of the health care sector is a positive development, noting that it is an innovative and productive industry. To the extent that increasing health expenditure is a cause for concern, the problem lies in the reliance on public funding, rather than the growth of the industry itself.

Finally, several participants stressed that urgency is required in developing policy responses to demographic change. One participant noted that, even under optimistic assumptions about future increases in public health expenditures and pension benefits, the fiscal balance sheets of many G-20 countries will come under increasing pressure in the coming years. Given the extent of the problem, no single reform will allow a country to resolve the challenges associated with demographic change, highlighting the need for policy-makers to develop a mix of policy responses. Even so, many of the solutions proposed to correct these fiscal imbalances involve large, immediate policy shifts, rather than gradual reforms. More broadly, a number of participants argued that the painful adjustments that responses to demographic change are likely to require increase the importance of immediate action. There was a consensus that population ageing is manageable, but that the greatest risk is that countries will wait too long to respond and be forced to choose between painful adjustments to the circumstances of the elderly or large increases in the obligations of younger generations.

Closing Remarks

Glenn Stevens

Thanks very much Malcolm. Well I think we've had a fascinating, very productive, very intense discussion in the past day and a half and as usual the intensity and the speed heats up towards the end as people want to get in points about which they feel passionate. It is very hard to do justice to a discussion of this quality in five or ten minutes and what I'm not going to try to do is to give you another summary of what we have learnt. I started yesterday with four questions and I thought about going back to the four questions and seeing if I could give the answers, but I think what might be more useful now is to try to distil what sorts of policy issues we might consider putting in front of G-20 Deputies and G-20 Ministers and Governors when they meet later in the year. So I'm going to try to confine my remarks to that sort of framework.

A couple of preliminary comments:

Firstly, Malthus has got a run here a few times in discussion and I think it is worth recording that to the extent that ageing is about living longer, that is a good thing. So we shouldn't refer to that, actually, as the ageing 'problem'. It will be a good thing to have more time to live, to work, to drink wine, to go to G-20 meetings – or perhaps to live long enough not to have to go to G-20 meetings anymore, take your pick. So to that extent at least longevity is a good thing.

A second preliminary comment: what struck me about some of the discussion today was the extent of model uncertainty and the implication that has for care in policy responses. Of course, a fundamental principle in making monetary policy, which is what I do, is that if the model is uncertain, you are more careful in your responses lest you have unintended effects. It doesn't mean no response at all, but it does mean taking a bit of care and being on the alert for unintended consequences.

A third preliminary comment: a lot of discussion has mentioned things like health care. As big an issue as that is, I think for G-20 Finance Ministers and Central Bank Governors in particular that is something we can't do much about. Nor, I'm afraid, can we save the institution of marriage in this framework!

Those things said, let me make a couple of observations from a policy point of view then:

I think one thing that has come through strongly is that the usual messages about retirement incomes policy issues, the associated questions of fiscal sustainability and so on, are reinforced by everything that we have heard. So were policy-makers to be thinking that there might be a magic bullet here if only we could have some fancy financial engineering – no there isn't. Many of the normal messages that we are accustomed to hearing in the context of population ageing are reinforced by the discussions we've had. In particular, a message that I think has come through very clearly is that if you've got fixed points in your retirement income system – like a fixed age for eligibility of public pensions or something like that – you are going to, sooner or later, have a problem and those fixed points actually would need to be moveable points in the future. So many of the normal messages about these things have come through again.

A second point: I thought the distinction between longevity effects and fertility effects was particularly important because they have different implications. I never got the chance, but I wanted to ask which of these changes people thought would present the bigger challenge. On the one hand, longevity could, in principle, keep increasing indefinitely so it would require continual adjustment. On the other hand, fertility is ultimately about the survival of the human species, so presumably that becomes pretty important if fertility continues to decline!

A theme we have heard repeatedly is the extent to which risks, particularly these longevity risks, have been transferred to households and away from institutions like large corporations or governments, which formerly bore them. There is actually a very big policy issue here, about the extent to which we want to leave households with all these risks, and the extent to which governments and society generally should bear some residual risk. That theme has come through on a number of occasions in our discussion and that's a question to which we might suggest our Ministers and Governors give some thought. I'm not sure where they'd come down, but to the extent that households continue to face these risks there are policy responsibilities, firstly in terms of educating them as to the risks they have. And then the second issue is: are there market mechanisms in place and operating well to allow households to manage those risks, assuming that they can be educated to understand that they have them?

I thought it was interesting that there probably was not all that much support in our discussion for the idea that asset markets will melt down. There do seem to be plausible, measurable effects of demographic variables on asset prices and returns but they are not large and, as I said yesterday, I think that leaves open the question of what's causing all the other variation in asset-market prices and returns. That is important because of the risks remaining with households should they happen to retire at the wrong time. I take the point that was made today that you don't have to annuitise all your wealth in the one year. That's right, but nonetheless people who retired in about 1990 or 1995 did handsomely compared with those who retired in 1970, and I think that it just wasn't possible for people to manage their way out of that problem.

I think a theme which will be important to stress to Ministers and Governors is the need to keep markets open and well-functioning in general. I think where we came to on international capital flows is that they will help, but are unlikely to be big enough to be a magic bullet. So if you are thinking that ageing will be handled by immigration, by financial engineering, by just a bit more saving or by international capital flows, I think the answer is that none of these things in themselves are enough, though we do need all of these things working in our favour to handle this issue. Or if you *did* think that international capital flows were going to be a big part of the solution, what I took from Larry Kotlikoff's paper is that the size of capital flows that you would see are nothing like we have ever seen before. The baseline scenario in that paper had current account deficits for the United States of 16 per cent of GDP and some of the other scenarios 20 or 30 per cent or even more. So if international capital flows are a big part of the answer, they are much bigger flows than we have ever been accustomed to thinking about and we would need to completely rethink the way we analyse those flows.

Keeping markets open and well-functioning also involves making sure they efficiently allocate and manage the savings that people accumulate. Here there are a number of issues related to regulatory oversight, supervisory oversight and the need to be alert to unintended consequences from these. I regard what has been happening in the United Kingdom indexed-bond market as basically an unintended consequence of a well-meaning reform which will, if it persists, raise the cost of providing those pension benefits over the long run. That is, presumably, not what the regulators intended.

Transparency of costs and fees is an issue which is growing and which will grow further. When nominal yields on retirement assets were in the teens, no one worried about giving away 100 or 200 basis points a year to have these funds managed; they never asked any questions. Now that the returns are 5, 6 or 7 per cent, this is a much bigger question, and I think there is potentially a role for policy-makers in enforcing transparency there.

On the issues of missing markets, missing instruments and what we do there, there does seem to be a set of concerns around whether there is enough capacity to annuitise. Here I am a little uncertain whether the real problem is the capacity to annuitise or the incentive to do so, or some mix of those depending on what the public-sector schemes are offering. But to the extent there is an issue of capacity, I suppose policy-makers have three types of responses they could think of.

One is the provision of information, and today we talked about the need for better information on mortality or on house prices, or whatever it may be, depending on what instrument we are talking about. So there may be a case for public policy to try to force the pace, perhaps by collecting the information itself. I can say that in this country the issue of house price information is one that the central bank has put a lot of resources into – not because of ageing issues but because we wanted to know what was going on in that market and the statistics were so poor. But in general there is perhaps a role for public policy there.

There's probably also a role in ensuring that there are no unintended impediments, be they of a regulatory or a tax nature for the development of appropriate instruments. That is something policy should always be doing anyway but it is no less urgent in light of these ageing issues. Policy would be saying: 'here, we're setting some preconditions for markets, now markets off you go and sort all this out'.

The bigger, more forceful response, and probably more controversial one, would be for governments themselves to get into the issuing of some of these instruments, if we thought the private markets were not going to do so. As Todd Groome said, there is ample precedent for governments being involved in tail insurance in other areas, so this is not a crazy idea, but I think governments who were inclined to issue longevity bonds, or whatever it may be, are then actually themselves taking on a set of risks and they've got to think about how to manage those risks. It may well be that we conclude in the end that these are risks that only can be managed by the government, but we should go into that with our eyes open.

I could say more but I think that is enough. There's been a rich vein of issues mined here in the last day and a half. Again thanks to all the people who've contributed to that.

What we'll do now is to try and write up a summary of these issues and the discussion that will be available to participants and to the G-20 process and from there we will seek to fashion a useful discussion for our Ministers and Governors later in the year.

Let me now hand over to Martin who has one or two observations and then a farewell word for you. Thank you.

Martin Parkinson

Thanks Glenn. If what I say sounds eerily similar to some of the things Glenn has mentioned just now, put it down to the close working relationship of the RBA and the Treasury.

A good conference is one where you leave with one new idea or fact, so I think this must have been a great conference because not only am I leaving with a new word, pro-natalist, which I heard for the first time yesterday, but with a mix of ideas that we will want to grapple with in the period ahead. I think the presentations and discussions have been excellent. I would like to just make a few comments on the issue of risk and touch on some policy issues.

The thrust of much of the reform that has been undertaken in Australia and other countries in recent years has been to transfer risks from governments or corporations to households. You see that in labour market reform, you see it in tariff reform and in changes in the funding and provision of health care, the move from defined benefit to defined contribution pension schemes, and so on. When I think about the transfer of risk in relation to ageing though, I am not quite sure whether we know enough to decide the optimal path to follow. It might be that the incompleteness of markets that we talked a bit about yesterday is simply a transitory phase during which both the demand and supply side are adjusting; people have to become better educated about their own situation and markets have to develop, and that doesn't happen instantaneously. But there may also be key issues that policy-makers need to address on both the supply and demand sides. If households really are myopic, is there a role for policy-makers to create a mandatory saving component? If markets are leaving profitable opportunities on the table by being unable or unwilling to create new products, is there a role for government to either provide those instruments – those risk sharing and management tools – or to somehow facilitate their development by the private sector?

Despite the past day and a half of discussions, I don't have a sense that we have reached a conclusion around these issues in terms of what should be done. In contrast, I take away a very unambiguous message that we need to engage in a dialogue with our citizens to ensure that they are under no illusions about the magnitude and the types of risks that they confront. We need to educate them so they can take better decisions, and in Australia we have been very successful at one level in getting people to understand the demographic challenge in aggregate. But as I said yesterday, we have been unsuccessful to date in getting them to think through how best to provide for their retirement, and this is notwithstanding the attention and publicity given to the *Intergenerational Report* (which we produce every five years). Also, I think that we haven't explained enough to them about why we are forcing them into mandatory saving with our superannuation guarantee charge.

The inability of both public and private sectors to convince people of the importance of appropriate levels of funding for their own retirement is demonstrated by the fact that we have found the need to launch a major financial literacy program, again notwithstanding all the media attention in recent years on appropriate saving behaviour, retirement planning and money management. This program is intended to get people from a very young age to understand the need to provide for themselves, and to understand better exactly how much they might need to save, and when.

Glenn talked about a range of things that the policy-makers in the G-20 could usefully focus on. It strikes me as obvious that we need to improve the data and to begin to ask ourselves how we might facilitate some of the practical solutions that people put on the table, such as the creation of longevity indices. Bringing together the policy-makers within the G-20 can help, especially if we give people the task of coming up with small but concrete steps to follow. In this way, I think that we can actually address some of these issues.

It should be clear though that further education of the public will inevitably promote further debate about the extent and nature of risks society wants individuals to manage. As economists, we may not like the outcome of those debates. But it is a debate that we should be encouraging society to have.

Glenn also touched on the issue of market openness being important if we want society to deal with the implications of ageing in a macroeconomic sense. One striking observation is that when thinking about the solutions to the ageing challenge we keep coming back to the sorts of domestic reforms that we have highlighted previously in the *G-20 Accord for Sustained Growth*: the importance of having flexible markets, clear signals, not having inhibitions over the way in which resources and assets can move, and so on.[1] It is important that we continue to reiterate these things because, like Glenn, I take away from our discussions that most of the solutions are going to have to be undertaken at a national level. We are looking at supra-national solutions and, yes, international capital flows and migration and the like will have to be part of the portfolio of responses, but ultimately, much of the response will take place at home.

1. See <http://www.g20.org/Public/Publications/Pdf/2004_g20_accord_for_sustained_growth.pdf> for details.

Biographies of Contributors

David E Bloom

David E Bloom is the Clarence James Gamble Professor of Economics and Demography at the Harvard School of Public Health. He is also a Research Associate with the National Bureau of Economic Research and a member of the American Arbitration Association's Labor Arbitration Panel. Professor Bloom has made an extensive contribution in the fields of economics and demography, having published over 80 books and journal articles. These cover a range of topics including: the effects of population change on economic development; the effects of rapid population growth; the emerging world labour market; the linkages between health status and economic growth; the sociology and economics of marriage and fertility; and the spread and economic impacts of HIV and AIDS. He has also consulted for numerous international bodies including multilateral development banks and UN agencies and has been a contributing editor of *American Demographics*, an associate editor of the *Review of Economics and Statistics* and on the Board of Reviewing Editors of *Science* magazine since 1991. Professor Bloom has been honoured with an Alfred P. Sloan Research Fellowship and the Galbraith Award for quality teaching in economics, and was a Fulbright Scholar in India. He holds a PhD in Economics and Demography and an MA in Economics from Princeton.

Henning Bohn

Henning Bohn is Professor of Economics at the University of California, Santa Barbara. Professor Bohn has published numerous articles about monetary and fiscal policy and has served as a consultant for the Federal Reserve and several other central banks. His research interests include the distribution and sharing of risk from an intergenerational perspective (and the effects of government policies on these risks), the viability of pension and health systems given population ageing, and optimal approaches to public asset and liability management. Professor Bohn holds a PhD from Stanford University. Prior to joining the University of California in 1992, he was an Assistant Professor of Finance at the Wharton School of the University of Pennsylvania.

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Axel Börsch-Supan is Director of both the newly founded Mannheim Research Institute for the Economics of Aging and the Institute for Economics and Statistics. He is also a Research Associate of the National Bureau of Economic Research, Research Fellow of the Centre for Economic Policy Research, member of the Berlin-Brandenburgische Academie of Science and the German Academy of Sciences Leopoldina. He advises the World Bank and the OECD on pension reform and ageing matters, is a member of the German president's Commission on Demographic Change and chairs the Council of Advisors to the Economics Ministry. Professor

Börsch-Supan has been at the University of Mannheim since 1989 and, prior to this, was an Assistant Professor of Economics at the University of Dortmund and an Assistant Professor of Public Policy at Harvard University. His research interests include savings behaviour, retirement models, housing markets, firm growth, structural and frictional unemployment, and nonlinear and panel data econometrics. Professor Börsch-Supan is a member of a number of professional associations including the American Economic Association and the European Society for Population Economics. He holds a PhD in Economics from Massachusetts Institute of Technology and a Diploma in Mathematics from the University of Bonn.

Robin Brooks

Robin Brooks is a Senior Economist in the Asia and Pacific Department of the International Monetary Fund, where he is a desk officer on the Philippines and contributes to regional surveillance in Asia. Prior to his current assignment he worked in the Research Department, developing tools to monitor corporate sector vulnerabilities, and as a fiscal economist in the Fiscal Affairs Department. He joined the IMF in October 1998 after spending a year as a Research Fellow in the Economic Studies Program at the Brookings Institution, where he studied the effects of population ageing on financial markets. He holds a PhD from Yale and a BSc from the London School of Economics.

Ralph C Bryant

Ralph C Bryant is currently the Edward M. Bernstein Scholar at the Brookings Institution and has been Senior Fellow in the Economic Studies program of the Brookings Institution since 1976. His primary fields of expertise are international economics, monetary economics and macroeconomic policy. Before joining Brookings, Dr Bryant was Director of the Division of International Finance at the Federal Reserve Board, the international economist for the Federal Reserve's Open Market Committee, and held various consulting, teaching and research positions. He has written numerous journal articles and books and is co-organiser of the Brookings project 'The Global Dimensions of Demographic Change'. Dr Bryant has been selected as a Member (1990) and Officer (1996) of the Order of the British Empire, and in 1983 was the first recipient of the Distinguished Fellowship in International Banking and Finance at the Institute of Southeast Asian Studies in Singapore. During 1996, he was the Professorial Fellow in Monetary Economics in New Zealand, based at the Reserve Bank of New Zealand and the Victoria University of Wellington. In 1989 and 1990 he was a Visiting Scholar at the Institute for Monetary and Economic Studies at the Bank of Japan. Dr Bryant holds a PhD in Economics from Yale and a BPhil degree in Economics from Oxford University, which he completed as a Rhodes Scholar.

Gary Burtless

Gary Burtless holds the John C. and Nancy D. Whitehead Chair in Economic Studies at the Brookings Institution. Before joining Brookings in 1981, he served as an economist in the policy and evaluation offices of the Secretary of Labor and the Secretary of Health, Education, and Welfare. In 1993, he was Visiting Professor of Public Affairs at the University of Maryland, College Park. Dr Burtless' research focuses on issues associated with public finance, ageing, saving, labour markets, income distribution, social insurance and the behavioural effects of government tax and transfer policy. He has written numerous scholarly and popular articles and is co-author of, or editor and contributor to, a number of books including *Aging Societies: The Global Dimension* (1998), *Can America Afford to Grow Old? Paying for Social Security* (1989) and *Retirement and Economic Behavior* (1984). Dr Burtless holds a PhD from Massachusetts Institute of Technology and a degree from Yale.

E Philip Davis

E Philip Davis is Professor of Economics and Finance at Brunel University and a Visiting Fellow at the National Institute of Economic and Social Research. He is also a member of the European Shadow Financial Regulation Committee, a Research Fellow of the Pensions Institute at London's Cass Business School, an Associate Fellow of the Royal Institute of International Affairs, and a Research Associate of the Financial Markets Group at the London School of Economics. Before his appointment at Brunel in October 2000, Professor Davis worked at the Bank of England for 20 years where he was most recently Senior International Finance Advisor, Europe. He has also been Deputy Head of Division at the European Monetary Institute, Frankfurt. Professor Davis has written extensively in various fields of finance including pensions, institutional investment, banking, financial regulation and financial stability and has also prepared and published work on pension funds for numerous international bodies and national authorities. Professor Davis holds an MPhil in Economics from Nuffield College, Oxford.

Alain Duchâteau

Alain Duchâteau is the Director for International and European Relations at the Bank of France. He is also a member of the International Relations Committee of the European System of Central Banks (ESCB) and a member of the Committee for Global Financial Stability of the BIS. Previously, he spent nine years in banking supervision, notably as Director of the General Surveillance of the Banking System at the French Banking Commission, working on the design of future prudential regulation and conducting economic studies on the French banking sector. He was also a member of the Banking Supervision Committee of the ESCB and of various technical groups of the Basel Committee. Mr Duchâteau started his career in foreign exchange markets and in the management of the central bank foreign exchange reserves. He holds an MA in Economics from Chicago University and degrees in Business Administration from HEC Paris and Political Sciences from Sciences-Po Paris.

Richard T Freeman

Richard T Freeman has been a staff member at the Federal Reserve Board since 1977. Currently he is the Associate Director of the International Finance Division, with responsibility for overseeing work related to foreign exchange markets, international banking, and global financial markets. Earlier Federal Reserve assignments include: Chief of the International Finance Division's section concentrating on macroeconomic developments in foreign industrial countries; Senior Economist in the International Finance Division's Financial Markets Section; and specialist on Japan. Dr Freeman has also served as Senior Staff Economist at the President's Council of Economic Advisors and Brookings Policy Fellow at the World Bank and was previously a member of the Cornell University faculty. He holds a PhD from Stanford University and a BA from Amherst College.

James Glassman

James Glassman is Managing Director and Senior Economist with JPMorgan Chase & Company. He works closely with the firm's global treasury and capital markets groups, and is an advisor for the firm's key corporate relationships. Dr Glassman publishes independent research on the forces shaping global financial markets and is a co-author of *Global Issues*, a publication that explores a wide range of global economic and market issues. His views are widely cited in the financial media, where he is a frequent commentator on economic policy issues. Before joining JPMorgan, Dr Glassman served in a number of areas in the Research and Statistics and Monetary Affairs Divisions at the Federal Reserve Board. His responsibilities included coverage of inflation, labour market developments, money and capital markets trends, and work on the Federal Reserve's monetary policy operating procedures. He joined Morgan Guaranty in 1988 and Chemical Bank in 1993, which, through mergers with Chase Manhattan, JPMorgan, and most recently Bank One, is now JPMorgan Chase & Company. Dr Glassman holds a PhD in Economics from Northwestern University and a Bachelor's degree in Economics from the University of Illinois.

W Todd Groome

W Todd Groome is the Division Chief of the Financial Markets Stability Division in the International Capital Markets Department of the IMF. This Division is responsible for multilateral surveillance activities and review of capital markets issues in the mature markets, focusing on structural issues which may influence medium-term financial stability considerations. Mr Groome has 18 years of investment banking and legal experience related to financial institutions in the US, Europe, and the Asia-Pacific region, including significant experience in debt and equity capital markets, balance sheet and capital management issues, and merger planning and execution for banks and insurance companies. Before returning to Washington DC in 2002, Mr Groome was Managing Director and Head of the Financial Institutions Groups of Deutsche Bank and Credit Suisse First Boston in London. Other previous roles include: managing the European High Yield origination business at Deutsche Bank;

work in M&A, advisory, and debt and equity financing for banks and insurance companies with Merrill Lynch & Co. in London and New York; and work as an attorney in the Financial Institutions Group of Hogan & Hartson in Washington DC. Mr Groome holds an MBA from the London Business School, a law degree from the University of Virginia School of Law, and a Bachelor of Arts in Economics from Randolph-Macon College.

Christopher Kent

Christopher Kent is the Head of Economic Research Department at the Reserve Bank of Australia, a position he has held since November 2004. Prior to rejoining the Bank as Deputy Head of Economic Analysis in September 2003, Dr Kent spent almost three years working in the European Department of the International Monetary Fund. His earlier career was spent at the Bank, where he worked in Economic Group and Financial Stability Department. His research interests include the links between asset prices and monetary policy, inflation targeting for small open economies, and the relationship between the current account and the terms of trade. Dr Kent is also a member of the Advisory Board of the Melbourne Institute of Applied Economic and Social Research at the University of Melbourne. He holds a PhD from the Massachusetts Institute of Technology.

Laurence J Kotlikoff

Laurence J Kotlikoff is currently Professor of Economics at Boston University. He is also a Research Associate of the National Bureau of Economic Research, Fellow of the American Academy of Arts and Sciences, Fellow of the Econometric Society, and President of Economic Security Planning Inc., a company specialising in financial planning software. As well as various academic appointments, Professor Kotlikoff has consulted for the IMF, World Bank, OECD, and various central banks, finance ministries and major private US corporations. He also served as a Senior Economist with the President's Council of Economic Advisers and has provided expert testimony on numerous occasions to committees of Congress. Professor Kotlikoff is co-author of 11 books and hundreds of professional journal articles, and has written extensively in more popular media, including on issues of generational accounting, social security, health reform, pensions, saving, insurance, and personal finance. He holds a PhD from Harvard and a BA from University of Pennsylvania, both in Economics.

Mariano Kulish

Mariano Kulish joined the Economic Research Department of the Reserve Bank of Australia in October 2005 as a Senior Research Economist. His research interests include macroeconomics, monetary economics and applied econometrics. Previously, he worked in an economic consulting firm in Argentina. Dr Kulish holds a PhD in Economics from Boston College and studied undergraduate economics at the University of Buenos Aires.

Olivia S Mitchell

Dr Olivia S Mitchell is the International Foundation of Employee Benefit Plans Professor of Insurance and Risk Management, and the Executive Director of the Pension Research Council, at the Wharton School of the University of Pennsylvania. At the University, Dr Mitchell is also the Director of the Boettner Center for Pensions and Retirement Research, a Senior Fellow of the Wharton Financial Institutions Center and the Leonard Davis Institute, and a Research Associate as well as Board member of the Penn Aging Research Center. Concurrently, Dr Mitchell is a Research Associate at the National Bureau of Economic Research and a Co-Investigator for the Health and Retirement Study at the University of Michigan. Her main areas of research and teaching are private and public insurance, risk management, public finance and labour markets, and compensation and pensions, with a US and an international focus. Her co-authored study on Social Security reform won the Paul A. Samuelson Award for 'Outstanding Scholarly Writing on Lifelong Financial Security' from TIAA-CREF. In 2003, Dr Mitchell received the Premio Internazionale Dell'Istituto Nazionale Delle Assicurazioni (INA) from the Accademia Nazionale dei Lincei, Rome, Italy *ex aqueo*. Dr Mitchell received the MA and PhD degrees in Economics from the University of Wisconsin-Madison, and the BA in Economics from Harvard University.

Anna Park

Anna Park is currently a Senior Economist in the Overseas Economies section of the Reserve Bank of Australia's Economic Group. Ms Park has also worked in the Reserve Bank's Regional and Industry Analysis section and in its Research Department. Her recent research has focused on the impact of demographic change on financial markets and on firm-pricing behaviour. She holds a Bachelor of Economics with Honours and a Masters in Applied Law from the University of Queensland.

Martin Parkinson

Martin Parkinson is currently Executive Director (Macroeconomic Group) in the Australian Treasury with responsibility for domestic and international macroeconomic issues. He is also Australia's G-20, IMFC and Development Committee Deputy and is Co-chair of the G-20 Deputies process in 2006. He has previously worked at the International Monetary Fund where he headed a unit dealing with issues related to the reform of the international financial architecture. Prior to joining the IMF, Martin headed Treasury's economic conditions branch, with responsibility for analysing economic developments and preparing the official forecasts for the domestic economy and external accounts. In the early 1990s he served as Senior Adviser to Treasurer Dawkins; he also worked for Treasurers Kerin and Willis. During his Treasury career Martin has also worked on taxation reform, structural policy, and labour market and industrial relations policy issues. He is a member of the advisory board of the Centre for Applied Macroeconomic Analysis at the Australian National University and has previously served as a member of the Australian Statistics Advisory Council and of the advisory boards of the School of Economics at the University of Adelaide and the Centre for Business Cycle Analysis at the Melbourne Institute. In the mid 1990s he also served as a committee member of the Review of the Australian National Accounts Program. He holds a PhD from Princeton University and a MEc from the Australian National University.

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Graydon Paulin is Deputy Chief of the Bank of Canada's International Department. The Department undertakes analysis of current and prospective developments in foreign countries, provides policy advice on global economic and financial issues, and undertakes related research. Previously, Mr Paulin was research adviser in the Monetary and Financial Analysis Department, where he oversaw the first several issues of the Bank's *Financial System Review*. Recent publications include articles on the evolution of central bank inflation-targeting frameworks and on the implications of the Basel II international accord on bank capital.

Avinash D Persaud

Avinash D Persaud is Chairman of Intelligence Capital Limited, a financial advisory boutique specialising in the management of financial assets, risks and liquidity. Persaud is a Fellow of Gresham College and was formerly the Gresham Professor of Commerce. He is a director of the Global Association of Risk Professionals, Co-Chair of the OECD Emerging Markets Network, Visiting Scholar at the European Central Bank and a Member of Council of the Royal Economics Society. He is also a Governor and Member of Council of both the London School of Economics and Political Science and the Overseas Development Institute. Persaud has won both major essay awards in international finance: the Jacques de Larosière in Global Finance from the Institute of International Finance (First, 2000) and the Amex Bank Award (Bronze, 1994). Previously, Mr Persaud was Investment Director at Global Asset Management (2003–2005), Managing Director, State Street Corporation (1999–2003), Visiting Scholar, International Monetary Fund (2000–2001), Global Head of Currency and Commodity Research at JPMorgan (1993–1999) and director of fixed-income research at UBS (1989–1993).

John Piggott

John Piggott is Professor of Economics and Director of the Centre for Pensions and Superannuation at the University of New South Wales. He is also Associate Dean (Research), Faculty of Economics at UNSW and has previously served as Director of UNSW Professorial Superannuation Ltd and as Head of the UNSW School of Economics. Other previous appointments include research and teaching positions at the University of Western Ontario, Canada, and the Australian National University. Professor Piggott has published over 70 journal articles and chapters in books and is on the editorial board of the *Journal of Pension Economics and Finance*. He is a member of the Research Committee of the International Network of Pension Regulators and Supervisors. Professor Piggott's current research interests include retirement benefits and annuitisation, life-cycle asset allocation and insurance, self-annuitisation within a group, and the role of housing in retirement portfolios. He has served on several committees related to superannuation and pension reform in Australia and his international consulting experiences include working with the governments of Japan, Mauritius and Russia. He was elected Fellow of the Academy of the Social Sciences in Australia in 1992. Professor Piggott holds a PhD and MSc from the University of London.

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Daniel Rees is an economist in the Economic Research Department of the Reserve Bank of Australia. His current research is focused on issues related to the impact of demographic change on asset prices and the monetary policy transmission mechanism. Mr Rees holds a Bachelor of Commerce with Honours and a Bachelor of Arts from the University of Sydney.

Carmelo Salleo

Carmelo Salleo is a senior economist at the Bank of Italy and Head of the Financial Structures Unit, which monitors the financial conditions of the corporate sector as well as savings and portfolio choices by Italian households. His prior assignment was with the Research Unit of the Banking Supervision Department and involved monitoring the banking industry and economic analysis of regulation. His current research interests include the role of financial constraints for households and for firms and issues of financial stability. He joined the Bank of Italy in 1995, holds a PhD from Harvard and a BA from LUISS in Rome.

Helmut Schwarzer

Helmut Schwarzer has been the Brazilian Social Security Secretary since January 2003. Between 1998 and 2002 he was a staff researcher at the Brasilia-based IPEA (the Applied Economic Research Institute of the Brazilian Federal Government) and held the position of Editor of IPEA's *Social Policy Bulletin* between 2000 and 2002. During this period he also held academic positions teaching undergraduate and graduate courses at the Catholic University Brasilia and the Fundacao Getulio Vargas. Dr Schwarzer holds a PhD in Economics from the Freie Universität Berlin and a MSc in Development Economics from the Universidade Federal do Paraná (Curitiba, Brazil).

Charan Singh

Charan Singh is Director, Banking Development in the Department of Economic Analysis and Policy at the Reserve Bank of India (RBI), where he has worked since

1984. During his career at the RBI, he has served as Director (Research) of the Department of Internal Debt Management, and as Editor of the RBI monthly *Bulletin* and the annual *Report on Currency and Finance*. Prior to joining the RBI, he worked in commercial banking and briefly as a university lecturer in economics. Dr Singh earned his doctorate in economics from the University of New South Wales and has recently spent a year each at the Department of Economics, Harvard University and at Stanford Center for International Development, Stanford University.

Glenn Stevens

Glenn Stevens was appointed Governor of the Reserve Bank of Australia with effect from 18 September 2006. He has spent most of his professional career in the Reserve Bank, joining the Research Department in 1980. He was Deputy Governor from December 2001 to September 2006 and held various senior positions in the 1990s. From 1996 to 2001 he was Assistant Governor (Economic), responsible for overseeing the economic analysis and research of the Bank's staff and formulating policy advice for the Governor and Board of the Bank. In 1990, he was Visiting Scholar at the Federal Reserve Bank of San Francisco. He has also been a member of Advisory Boards for the Hong Kong Institute for Monetary Research and the Melbourne Institute of Applied Economic and Social Research at the University of Melbourne.

Adair Turner

Adair Lord Turner of Ecchinswell has combined careers in business, public policy and academia. He is director of Standard Chartered, United Business Media plc, Siemens Holdings plc, and Paternoster Holdings Ltd, and a Visiting Professor at the London School of Economics and at City University. He is a member of the Board of Trustees of WWF-UK and Save the Children UK. He became a cross-bench member of the House of Lords in 2005. He was Chairman of the Pensions Commission from 2003 to 2006, and of the Low Pay Commission from 2002 to 2006. Formerly, he was Director General of the CBI. He is the author of *Just Capital – The Liberal Economy*, published by Macmillan in 2001.

Hiroshi Watanabe

Hiroshi Watanabe is Vice Minister of Finance for International Affairs at the Japanese Ministry of Finance. He is also a Japanese G-20 Deputy and attends meetings of groups such as the G7, World Bank, IMF and APEC. He is responsible for governing all international affairs of the Japanese Ministry of Finance including foreign exchange stabilisation, foreign development assistance and efforts to improve the international monetary system. Since joining the Ministry of Finance in 1972, Mr Watanabe has specialised mainly in taxation and international affairs. Previously he has also served as executive secretary to the Minister of Finance, Kiichi Miyazawa. Mr Watanabe holds an LLB from the University of Tokyo and an MA in Economics from Brown University.

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Wen Jiandong is Deputy Director and Senior Economist of the Foreign Exchange Market and Exchange Rate Division and the Policy Research Division at the State Administration of Foreign Exchange (SAFE). Before joining the SAFE, Dr Wen served as Negotiator for China's accession into the World Trade Organisation. His particular areas of interest include exchange rates and capital account liberalisation. Dr Wen holds a PhD in Economics from the Chinese Academy of Social Sciences and an MBA from the University of Cambridge, Queens' College.

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