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Global Demographic Change and Economic Performance

Applications of an Augmented *GTAP-Dynamic**

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Abstract:

The fertility declines and increased longevity associated with the final phase of the global demographic transition have led to accelerated ageing of populations in developed countries and in several advanced developing countries. This paper introduces a global demographic model from which emerge the implications of these changes for population sizes, age distributions and gender compositions. From these results are inferred corresponding changes in labour force size and in patterns of consumption and saving which are then analysed using an augmented *GTAP-Dynamic*, in which regional households are disaggregated into four age groups and two genders. Demographic change is found to act most significantly through variations across age-gender groups in both labour force participation and savings behaviour, with secondary effects arising from variations in consumption preferences across these groups. As policies to control ageing in the developed countries, increased labour force participation by the aged and replacement migration are examined and shown to have very considerable effects on global economic performance.

1. Introduction

Recent changes in global demographic behaviour, including to fertility, mortality, migration and the sex ratio at birth, have been considerable and many of these were not widely anticipated in recent decades. In most countries, consistent with the central phase of the global demographic transition, infant mortality fell through the course of the last century and adult life expectancy increased, causing a surge of population growth. The declines in birth rates anticipated as part of the final phase of this transition have been particularly sharp, first in developed countries and recently in many developing countries.[1] Before this century is half over, populations in Japan and some European countries are likely to be smaller than they were in 1990, with these declines in total populations being preceded by declines in the number and proportion of people of working age.[2]

The economic implications of these demographic trends and uncertainties are the subject of an already substantial global literature. At minimum, this literature spans demography (McDonald and Kippen 2001, Booth et al. 2002), population economics (Lee 2003; Mason 2003), public economics (OECD 1996, 1998), economic history (Bloom and Williamson 1997; Williamson 1998), growth economics (Barro and Becker 1989) and macroeconomics (Bryant and McKibbin 1998, 2001; Faruqee and Muhleisen 2002; Bryant et al. 2003). The latter macroeconomic research[3] has been path-breaking in that it has demonstrated the very substantial implications of demographic

[1] IMF (2004: Chapter 3), Lee (2003).
[2] Bryant and McKibbin (1998), United Nations (2003).
[3] Much of this research was organised under a project coordinated by the Brookings Institution in the United States and involving staff from the International Monetary Fund. Finance is from the Economic and Social Research Institute of the Japanese Cabinet Office.

change in some regions for the economic performance of others. Its focus has, however, been on the industrialised regions of the northern hemisphere. Additionally, while it uses an innovative approach to the integration of demographic information into macroeconomic models (Faruqee and Muhleisen), this approach falls short of complete demographic modelling and does not lend itself to explicit consideration of migration flows and their determinants.

This paper examines the economic implications of demographic change using a complete demographic model on 14 regions, which is constructed as integral with a dynamic model of the global economy. The latter model is a development of *GTAP-Dynamic* in which regional households are disaggregated by age group and gender.[4] Compared with other studies of global demographic change, our global scope combined with the explicit incorporation of a demographic sub-model facilitates emphasis on migration flows. And these are increasingly important. Indeed, for the industrialised economies, during this and subsequent decades total populations and labour forces will be more substantially influenced by migration than by natural population increase.[5] Additionally, for countries in which demographic changes will soon yield declining labour forces (continental Europe, Japan and even China), there will be pressure to substantially raise guest worker and net immigration rates.[6] This new wave of migration flows will have important implications for economic structure and performance in those regions and globally.

Our analysis offers a base line projection through 2030 which incorporates the final phase of the global demographic transition. Populations and labour forces are projected to decline in Europe and Japan, and to begin declining before the end of this period in China and elsewhere in East Asia. The effects of alternative demographic scenarios are then considered. First, we imagine that life expectancy beyond 60 grows faster than anticipated in all regions of the world. This follows the conjecture by Booth and others that some national projections of life expectancy may be pessimistic.[7] Second, we consider that the popular concern with the growth of aged dependency ratios induces governments to either raise retirement ages and, thereby, increase aged labour force participation rates or permit “replacement migration”. Each of these scenarios causes significant departures from the base line and each has important implications for overall economic performance.

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[4] The *GTAP-Dynamic* model is a development of its comparative static progenitor, *GTAP* (Hertel et al. 1997). Its dynamics is described by Ianchovichina and McDougall (2000). An earlier application of the standard model to the issues raised in this paper is that by Shi and Tyers (2004).

[5] For a summary of the impact of migration for all advanced economies, see IMF 2004: Figure 3.2. For Australia, net immigration contributes substantially to overall population growth and is likely to do so to an increasing extent (Khoo and McDonald 2002, 2003).

[6] See United Nations (2000) for a treatment of replacement migration in Europe. Further discussion of the European case is offered by Tani (2003) and Hatton and Tani (2003).

[7] See Booth (2004), Booth and Tickle (2003) and Booth et al. (2002). A key point to emerge from these papers is that principal causes of death change through time as life styles change and medical science addresses new frontiers. When the potential for successive medical breakthroughs is ignored, projections of death rates are pessimistic.

The key mechanisms by which demographic change affects overall economic performance operate on both the demand and supply sides. Population growth raises aggregate demand, with relative price effects depending on income elasticities of demand and supply growth in each sector. In models of the Solow-Swan type, where endogenous growth takes the form of physical capital accumulation only, population growth raises GDP but reduces per capita income. This tends to cause a demand shift away from income-elastic products, advantaging agriculture. When population growth is associated with ageing, however, the composition of consumption also changes, with net effects on product and service demand that vary by age-gender group. On the supply side, changes in the size and composition of the population correspondingly change the size and composition of the labour force, though as we show, these changes are most often far from proportionate. Where this leads to an expansion of the labour force, the relative endowment of labour rises and labour intensive industries are advantaged, particularly manufacturing. Finally, changes to the age distribution alter the average saving rate. This changes the magnitude and global distribution of investment and hence the rates of economic growth in each region.

In Section 2, the demographic model is introduced and its population and labour force projections are briefly discussed. Section 3 describes the extension of the *GTAP-Dynamic* model to incorporate populations disaggregated by age and gender. Section 4 then describes four scenarios for global demographic change through 2030: the base line, accelerated life expectancy, high aged participation and high migration scenarios. The simulation results from each scenario are then compared and implications discussed for the performance of the global economy. Section 5 then offers brief concluding remarks.

2. The Demographic Sub-Model

To capture the economic implications of demographic change it is cumbersome and unnecessary to carry the 20 five-year age groups used by the United Nations in its population projections. We have settled on a model that tracks populations in four age groups and two genders: a total of 8 population groups in each of 14 regions.[8] The four age groups are the dependent young, adults of fertile and working age, older working adults and the mostly-retired over-60s. The resulting structure is displayed in Figure 1. Each age-gender group is a homogeneous sub-population with group-specific birth and death rates and rates of both immigration and emigration. If the group spans *T* years, the survival rate to the next age group is the fraction *1/T* of its population, after group-specific deaths have been removed and its population has been adjusted for net migration. The final age group (60+) has duration equal to measured life

[8] The demographic sub-model has been used in stand alone mode for the analysis of trends in dependency ratios. For a more complete documentation of the sub-model, see Chan and Tyers (2004).

expectancy at 60, which varies across genders and regions. The key parameters, then, are birth rates, sex ratios at birth, age and gender specific death, immigration and emigration rates and life expectancies at 60.

Immigration and emigration are also age and gender specific. The model represents a full matrix of global migration flows for each age and gender group. Each of these flows is currently set at a constant proportion of the population of its destination group. The only exception to this is in experiments where migration flows are adjusted to meet a policy objective such as the retention of a desired aged dependency ratio. Migration flows are therefore driven by population growth in the destination region. One rationale for this strong assumption is that countries are better able to cope with migrants' adjustment costs when flows are kept to particular fractions of indigenous populations.[9]

Sources and structure:

The demographic sub-model and the economic model both cover 14 regions.[10] This regional structure is designed so as to single out countries that are populous or groups of countries of particular demographic and economic interest. Key parameters in the model are the migration rates, M^{R}_{agrd} , birth rates, B^{t}_{r}, sex ratios at birth, S^{t}_{r}, death rates, $D^{t}_{a,m,r}$, and the life expectancy at 60, $L^{t}_{60+,g,r}$. The migration *rates* are based on recent migration records[11] and are held constant through time.[12]

Asymptotic trends in key parameters:

The birth rates, life expectancy at 60 and the age specific mortality rates all trend through time asymptotically. For each age group, *a*, gender group, *g*, and region, *r*, a target rate is identified. The parameters then approach these target rates with initial growth rates determined by historical observation. In year *t* the birth rate of region *r* is:

(1) $$B^{t}_{r} = B^{0}_{r} + \left(B^{0}_{Tgt} - B^{0}_{r}\right)\left(1 - e^{\beta t}\right) ,$$

where the rate of approach, β, is calibrated from the historical growth rate:

[9] On the other hand, there is plenty of evidence that migration flows have been inversely proportional to indigenous population growth, driven for example by the need to maintain labour forces in the face of declining rates of natural increase. Our modelling of migration behaviour is readily altered to allow for a variety of economic and policy related incentives.
[10] See Chan et al. (2005: Table 1) and Shi and Tyers (2005) for the regional aggregation in detail.
[11] Records of gross migration flows are weak at best in most countries. Destinations are therefore restricted in this model to Australia, Western Europe and North America, where at least some relevant records are kept. Although the model represents a complete flow matrix, only these three regions receive non-zero inflows.
[12] The migration rates and the corresponding birth rates are listed in detail in Chan et al. (2005: Tables 2-5).

(2) $$B\ddot{x}_r^0 = \frac{B_r^1 - B_r^0}{P_r^0} = \frac{\left(B_{Tgt}^0 - B_r^0\right)\left(1-e^{\beta}\right)}{B_r^0}$$, so that

(3) $$\beta = \ln\left[1 - \frac{B_r^0 \hat{P}_r^0}{B_{Tgt}^0 - B_r^0}\right] .$$

The birth and death rates and the live expectancies at 60, thus calculated, are presented in detail by Chan et al. (2005).

Labour force projections:

To evaluate the number of "full-time equivalent" workers we first construct labour force participation rates, $P_{a,g,r}$ by gender and age group for each region from ILO statistics on the "economically active population". We then investigate the proportion of workers that are part time and the hours they work relative to each regional standard for full time work. The result is the number of full time equivalents per worker, $F_{a,g,r}$. The labour force in region r is then:

(4) $$\overline{L}_r^t = \sum_{a=1539}^{60+} \sum_{g=m}^{f} L_{a,g,r}^t \text{ where } L_{a,g,r}^t = \mu_{a,r}^t P_{a,g,r}^t \, F_{a,g,r} \, N_{a,g,r}^t \; .$$

Here $\mu_{a,r}^t$ is a shift parameter reflecting the influence of policy on participation rates. The time superscript on $P_{a,g,r}^t$ refers to the extrapolation of observed trends in these parameters.[13]

Asymptotic trends in labour force participation:

For each age group, *a*, gender group, *g*, and region, *r*, a target country is identified whose participation rate is approached asymptotically. The rate of this approach is determined by the initial rate of change. Thus, the participation rate takes the form:

(5) $$P_{a,g,r}^t = P_{a,g,r}^0 + \left(P_{Tgt}^0 - P_{a,g,r}^0\right)\left(1-e^{\beta t}\right) \; ,$$

where the rate of approach, β, is calibrated from the initial participation growth rate:

(6) $$\hat{P}_{a,g,r}^0 = \frac{P_{a,g,r}^1 - P_{a,g,r}^0}{P_{a,g,r}^0} = \frac{\left(P_{Tgt}^0 - P_{a,g,r}^0\right)\left(1-e^{\beta}\right)}{P_{a,g,r}^0}$$, so that

(7) $$\beta = \ln\left[1 - \frac{P_{a,g,r}^0 \hat{P}_{a,g,r}^0}{P_{Tgt}^0 - P_{a,g,r}^0}\right] .$$

Target rates are chosen from countries considered "advanced" in terms of trends in participation rates. Where female participation rates are rising, therefore, Norway provides a commonly chosen target because its female labour force participation rates are higher than for other countries.[14]

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[13] Although part time hours may well also be trending through time, we hold *F* constant in the current version of the model.
[14] The resulting participation rates are listed by Chan et al. (2005: Table 10).

Accounting for part time work:

For each age group, *i*, gender group, *g*, and region, *r*, full-time equivalency depends on the fraction of participants working full time, $f_{a,g,r}$, and, for those working part time, the ratio of average part time hours to full time hours for that gender group and region, $r_{g,r}$. For each group, the ratio of full time equivalent workers to total labour force participants is then

(8) $$F_{a,g,r} = f_{a,g,r} + \left(1 - f_{a,g,r}\right) r_{g,r} .$$

Preliminary estimates of $f_{a,g,r}$ and $r_{g,r}$ are approximated from OECD (1999: Table 1.A.4) and OECD (2002: Statistical Annex, Table F).[15]

The aged dependency ratio:

We define and calculate four dependency ratios: 1) a youth dependency ratio is the number of children per full time equivalent worker, 2) an aged dependency ratio is the number of persons over 60 per full time equivalent worker, 3) a non-working aged dependency ratio is the number of non-working persons over 60 per full time equivalent worker, and 4) a more general dependency ratio is defined that takes as its numerator the total non-working population, including children.[16] That of interest here is the one of most widespread policy interest, the non-working aged dependency ratio. Where $N^t_{a,g,r}$ is the population in year *t* of age group *a*, gender *g*, in region *r*:

(9) $$R^{ANW}_{r,t} = \frac{\sum_{g=m}^{f} \left(N^t_{60+,g,r} - L^t_{60+,g,r} \right)}{\bar{L}^t_r} .$$

The base line population projection:

The regional levels and age structures of the base line population projections accord closely with corresponding United Nations projections, notwithstanding our simple, four-age-group model.[17] Corresponding base line projections of labour force levels and age structure are summarised in Table 1, showing substantial ageing of labour forces in all regions. Indeed, the extent of the widespread ageing is especially clear from the trends in non-working aged dependency ratios listed in Table 2. Finally, base line projections of total populations and labour forces for a selection of regions are displayed in Figure 2. The latter show divergences in the growth paths of

[15] No data has yet been sought on part time work in non-OECD member countries. In these cases the diversity of OECD estimates is used to draw parallels between countries and regions and thus to make educated guesses. The results are listed by Chan et al. (2005: Tables 11 and 12).
[16] All these dependency ratios are defined in detail by Chan et al. (2005).
[17] See United Nations (2003) and the detailed comparison provided in Chan et al. (2005).

populations and labour forces that are particularly important in projecting effects of economic performance.

3. Extensions to the Standard *GTAP Dynamic* Model

To capture the economic consequences of the projected demographic changes, we adapt a standard long-term dynamic model of the world economy, namely *GTAP-Dynamic* (Ianchovichina and McDougall, 2000). Its structure enables us to capture the economic effects of population and labour force growth changes in the long run. Yet the single regional households of standard *GTAP-Dynamic* are a major weakness. To capture the effects of demographic change we have included multiple age and gender groups in line with the structure of the demographic sub-model (Figure 1). These eight age-gender groups differ in their consumption preferences, saving rates, labour supply and skill composition. This extension allows the model to capture not only the aggregate impact of population growth, but also the effects of ageing.

Unlike the standard *GTAP* models, in which regional incomes are split between private consumption, government consumption and total saving via an upper level Cobb-Douglas function, we first divide regional income between government consumption and total private disposable income. That income is then split between the eight age-gender groups in a manner informed by empirical studies of age and gender specific income and expenditure behaviour. For each age-gender group we then use a Keynesian consumption equation to split disposable income between saving and consumption expenditure.[18] Saving rates differ by group as does the responsiveness of per capita consumption expenditure to per capita disposable income in each group. Once consumption expenditure is known, the standard *GTAP* CDE[19] consumption preferences are applied for each group, with parameters varying to reflect age-gender differences in tastes.

Income Splitting:

The first step is to split government from private disposable income. For this we retain the original Cobb-Douglas system, this time in a two-way split, and the governments' income shares from the original database.[20] Total regional disposable income is then split between the eight age-gender groups. For this we draw from other studies the distribution of disposable income between age-gender groups for "typical" advanced and developing countries. To ensure that changes in the age-gender distribution of each region's population alter the corresponding age-gender distribution

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[18] This is an empirically based reduced form approach to the underlying intertemporal optimization problem solved by individuals in each group.
[19] This refers to the "constant difference of elasticities of substitution" demand system. See Huff et al. (1997).
[20] This implies the assumption that all governments balance their budgets and that all saving in the original database is private.

of income, we define a set of weights, $W_{a,g,r}$, that represent the ratio of the per capita disposable income of group (a, g), to that of the (15-39, m) group, chosen as an arbitrary standard.[21] The share of the disposable income of region r enjoyed by people of gender g, and age group a is thus:

$$(10) \qquad \frac{Y^D_{a,g,r}}{Y^D_r} = \frac{W_{a,g,r} N_{a,g,r}}{\sum_{a=0-15}^{60+} \sum_{g=m}^{f} W_{a,g,r} N_{a,g,r}} \; .$$

The adopted values of $W_{a,g,r}$ are listed in Table 3. Their selection is guided by the empirical studies of the age distribution of income and consumption noted in the table.

Splitting savings and consumption expenditure from group disposable income:

Our reduced form approach to the intertemporal optimisation problem faced by each individual centres on an exponential consumption equation that links group per capita consumption expenditure to per capita disposable income and the real interest rate, r:

$$(11) \qquad c_{a,g,r} = \frac{C_{a,g,r}}{N_{a,g,r} P^C_{a,g,r}} = A \left(\frac{Y^D_{a,g,r}}{N_{a,g,r} P^C_{a,g,r}} \right)^{\varepsilon_c} r_r^{\varepsilon_r} \; ,$$

where $P^C_{a,g,r}$ is a group consumption price index, group consumption expenditure is $C_{a,g,r}$ and parameters ε_c and ε_r are income and interest elasticities. This equation is calibrated for each group and region based on the set of initial (1997) age-specific saving rates from per capita disposable income listed in Table 4. These estimates are drawn from the same empirical studies of the age distribution of income and consumption as the income weights of Table 3. They are recalibrated for consistency with the overall private saving rate in each region indicated in the GTAP database.[22]

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[21] To date we have not realised the opportunity to have the age-gender distribution of income depend on the income's factor origin. Despite intuition suggesting a link, such as that the aged in advanced countries receive retirement income stemming from capital ownership, consistent empirical work on this distribution is unavailable.

[22] The elasticities of consumption expenditure to disposable income suggested by the empirical literature seem to be poor choices as reduced forms for saving behaviour in the long term since they imply high marginal saving rates. We calibrate these elasticities according to the following scenario: (a) North American per capita disposable income grows at 3%/yr for 100 years, (b) growth in all other regions is sufficient to attain North America's per capita disposable income levels within that period, (c) when the other regions catch up, all regions attain identical group-specific saving rates, and (d) the income, consumption and saving transitions are smooth and exponential. Our reduced form consumption equation (11) can be simplified for a single age-gender group to: $c = A\, y^{\varepsilon_c} r^{\varepsilon_r}$, where c is per capita consumption expenditure, y is per capita disposable income and r is the real interest rate. To focus on the key elasticity, ε_c, imagine that the real interest rate is constant through time, so that the interest term can be embedded in the constant. Then, if per capita disposable income grows at rate, g_y, the rate of growth of consumption expenditure is $\varepsilon_c\, g_y$. And, if per capita consumption expenditure is initially c_0 and per capita disposable income is initially y_0, we can calculate the group's average saving rate in period t and invert the resulting expression to find the elasticity that is consistent with the target saving rate after T years: $\varepsilon_c = 1 + \frac{1}{g_y T} \ln\left(\frac{1-s_T}{1-s_0}\right)$. For further detail, see Shi and Tyers (2005).

Consumption preferences:

The construction of the CDE demand system requires the calibration of two sets of parameters by the method detailed by Huff et al. (1997). Its advantage over the CES, or constant elasticity of substitution, system is that it is non-homothetic and therefore allows income elasticities of demand to vary between commodities. Elasticities of demand then depend on CDE "expansion" and "substitution" parameters, which are calibrated for each region's aggregate household in the GTAP Database. We retain the calibrated values of these parameters for the eight age-gender groups. To complete the demand system we then need expenditure shares for each of the eight different age-gender groups in each region.

For these shares we turn, once again, to the consumption analysis literature. Studies of consumption preferences by age group are available for a few of the identified countries and those are used as a guide in the construction of the complete matrix of expenditure shares listed in Table 5. That by Weber et al. (2002) is the most detailed and it shows only very modest variation in expenditure shares by age group when commodities are highly aggregated. Although there is considerable variation when comparisons are at a high level of detail, such as between fresh food and restaurant meals or between health and other services, the broad shares are remarkably similar.[23] For presentational economy, we focus in this paper on the three product version.[24] Age-gender group expenditure shares are drawn initially from the literature indicated in Table 5, then rendered consistent with group expenditures on the one hand and *GTAP* Database values for aggregate expenditure shares on the other by using RAS techniques to concord the shares with row and column sums in the matrix of expenditures.

Elasticities of substitution:

It is well known that general equilibrium simulation results are particularly sensitive to the assumed degree of differentiation between home and foreign goods and services. In models such as this one, where products are highly aggregated, some of this differentiation reflects regional differences in sectoral product composition. Both the complementarity of product compositions and true regional product differentiation are therefore represented in the model via the choice of the elasticities of substitution between home and foreign products. Controversy has raged over the merits of various estimates and the view is commonly expressed that the "standard" GTAP estimates, which range between 1.0 and 4.0, are too small. We concur with this view since, when

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[23] It is of concern that some expenditure shares for detailed products and services appear to be changing very rapidly through time. Weber et al. show that the health share is rising rapidly for the aged and that this is associated with very rapid growth in the share of expenditure on drugs by all groups but particularly the aged.

[24] The *GTAP* commodity classification is production-oriented, based on the International Standard Industrial Classification (ISIC), and so it differs from the classification used in expenditure surveys. We use the *GTAP* commodities throughout, weakening the sensitivity of our analysis to differences in preferences.

these elasticities are used, our base line simulation yields substantial divergence between the paths of home and trading prices in different regions. In the absence of any new trade distortions, global markets appear far more segmented in 2030 than they are at present. Newer estimates by Harrigan (1993), Trefler and Lai (1999) and Obstfeld and Rogoff (2000) all support much higher values. We therefore use 7.0 for food products, 4.0 for manufactures and 2.2 for the less tradeable services, and we retain the traditional "rule of two" for substitutability of imports by region of origin.

4. Four Scenarios through 2030

The analysis to be presented is centred on the base line projection of populations, labour forces and their structures described in Section 2, and a corresponding base line economic projection from our modified *GTAP-Dynamic*. Three other demographic scenarios are then introduced and populations and labour forces projected for each case using the demographic sub-model. Corresponding economic simulations are then constructed and each is compared with the base line scenario. The alternative population scenarios are:

1) *Accelerated aging*: life expectancies at 60 in all regions grow faster than in the base line case, by two per cent per year, consistent with the conjecture of Booth (2004) that projections of our base-line type may be too pessimistic about mortality.

2) *Increased aged participation*: concern with the growth of aged dependency ratios in Western Europe, Japan, North America and Australia induces the governments of these regions to increase retirement ages so that aged labour force participation is just sufficient to hold non-working aged dependency ratios constant from 2000 onwards.

3) *Replacement migration*: similar concern in the advanced migrant-accepting regions of Western Europe, North America and Australia, induces the governments of these regions to permit sufficient "replacement" migration to hold non-working aged dependency ratios constant from 2000 onwards.

Each of these scenarios causes significant departures from base line levels. The *accelerated aging* scenario raises projected populations and labour forces and causes very large increases in projected non-working aged dependency ratios, as shown in Table 6. With *increased aged participation* in the advanced economies sufficient to hold non-working aged dependency ratios constant, labour forces rise in the advanced economies, as indicated in Table 7. This requires that 60+ participation rates in the North America, Western Europe and Australia approach those currently observed in Japan, as shown in Figure 3. The replacement migration solution requires still more dramatic change, as indicated in Table 8. Migration rates would be required to increase many-fold and, particularly in North America, the resulting population growth would be extremely large. Still more dramatic would be the impacts of this migration on the source regions, as indicated in Figure 3. Some, including Central Europe and the former Soviet Union, would have their working aged populations seriously depleted by 2020. We discuss the economic consequences of each of these scenarios in turn.

The base line:

The *base line* scenario provides a reference projection against which the others are compared. It is particularly sensitive to assumptions about the sources of growth that are exogenous to the model. These are summarised in the form of factor-specific productivity growth shocks that are presented in detail by Shi and Tyers (2005).[25]

The productivity growth rates we adopt are disaggregated by primary factor to an extent rarely supported by the empirical studies but in a way that offers a more complete characterisation of productivity growth and the potential for further experimentation with technology. They imply that agricultural productivity grows more rapidly than that in the other sectors in Australia, China, Indonesia, Other East Asia, India and Other South Asia. In Australia, this is assumed to be due to increasing land productivity, while in the other regions it is due to increased labour productivity in agriculture and the associated shedding of labour to the other sectors. In the other industrialised regions, the process of labour relocation has slowed down and labour productivity growth is slower in agriculture. In the other developing regions, the relocation of workers from agriculture has tended not to be so rapid even in the poorest of these regions, so labour productivity in agriculture is assumed to grow more slowly.

Aside from exogenous productivity growth, a key aspect of the base line projection is the allocation of investment across regions. The model takes no explicit account of investment risk and so tends to allocate investment to regions that have high marginal products of physical capital. These tend to be labour-abundant developing countries whose labour forces are still expanding rapidly. It finds Indonesia a particularly attractive prospect for this reason, yet we know that risk considerations limit the flow of foreign investment into Indonesia at present and that these are likely to remain important in the future. To account for this we have constructed a "pre-base line" simulation in which we maintain the relative growth rates of investment across regions. In this simulation, global investment rises and falls but its allocation between regions is thus controlled. A risk premium variable (*GTAP Dynamic* variable *SDRORT*) is made endogenous. This creates

[25] The empirical literature is inconsistent about productivity growth across sectors. Ianchovichina et al. (2001) conclude from their own survey that productivity growth is generally faster in agriculture than in other sectors. This is credible, particularly in rapidly growing developing countries where the agricultural workforce is declining, often rapidly, while agricultural output continues to grow. More recent empirical studies focusing on advanced countries, such as those by the Productivity Commission (2001) and Stiroh (2001), suggest the opposite, however. Since the early 1990s, productivity growth in the advanced regions appears to have been slower in agriculture than in manufacturing and services. Our own survey of this literature suggests a set of factor productivity growth rates detailed in Shi and Tyers (2005).

wedges between the international and regional interest rates that imply high risk premia for the populous developing regions of Indonesia, India, South America and Sub-Saharan Africa. Premia tend to fall in other regions, where labour forces are falling or growing more slowly.[26]

The final base line simulation then frees up investment, but maintains the time paths of the regional risk premia as exogenous. As with the factor productivity growth rates, these risk premia are then held constant in all subsequent "policy" simulations. In these simulations, no allowance is made for feedback from factor productivity, investment risk or economic performance more generally, to the underlying demographic shocks. Overall base line economic performance is suggested by Figure 4, which shows the projected levels of GDP in selected regions. Because of its continuing rapid population growth, India is projected to take over from China as the world's most rapidly expanding region. China grows rapidly nonetheless, as does Indonesia and "other East Asia", while the older industrial economies continue to grow more slowly.

Accelerated ageing:

The effect of this is to raise the population over 60 in every region, while leaving younger populations the same as in the base line. GDP tends to increase everywhere because at least some of these additional aged people work and so labour forces rise. Japan enjoys the largest GDP rise since the resulting absolute increase in its aged population is largest and since it has the highest aged labour force participation rate. In North America, Western Europe, Central Europe and the former Soviet Union and Australia, accelerated ageing raises the share of income in the hands of the over 60s, who tend to have negative saving rates. In these regions, therefore, average saving rates decline as shown in Figure 7. Regions whose labour forces expand most as a consequence of accelerated ageing, and particularly Japan, enjoy increased real investment. This investment is reassigned from China and Western Europe, whose labour forces are declining in part because their aged populations have lower labour force participation rates. In all regions, however, aged dependency ratios rise (Table 6) and per capita incomes fall. The tendency for older and poorer people to consume more basic food products, advantages the producers of the less income elastic food commodities yielding the increases in relative food prices and land rents shown in Table 9.

Increased aged participation:

This raises labour forces in Australia, North America, Japan and Western Europe sufficiently to hold the line on non-working aged dependency ratios (Figure 9). It does not change population sizes relative to the base line. The leisure consequences of this change are ignored here.

[26] Most spectacular is the fall in the Chinese premium. This is because, in our base line projection, we maintain China's currently high share of global investment despite the eventual decline in its labour force. A possible consequence of this is that our base line investment in China, and therefore China's projected economic growth rate, is optimistic.

As the supply of labour grows, crowding the fixed factors in the four affected regions, both land and natural resource rents increase substantially relative to wages (Table 10). Indeed, wages most often fall relative to all prices and this advantages labour-intensive sectors, mainly manufacturing. More abundant labour raises marginal products of physical capital in the affected regions and they therefore attract larger shares of global investment (Figure 10). Again, the largest share of this investment is diverted from China in the long term. Because their populations do not increase, the rise in incomes also raises per capita incomes in the four affected regions (Figure 11), though this comes at the cost of reduced leisure for the old. This also shifts demand toward more income elastic manufactured products. In the older industrial countries manufacturing sectors therefore expand relative to agriculture and services as do their manufactured exports. There is no Rybczyinski contraction of other sectors, however. Increased income raises global aggregate demand, so that output volume increases in all sectors of the affected regions, along with employment.

Replacement migration:

Replacement migration requires the relocation of substantial parts of the populations of some destination regions, most particularly “Central Europe and the former Soviet Union” and the “Rest of the World” but also “Other East Asia”. Their populations fall, most dramatically in the working age groups, so their labour forces and their economic outputs contract (Figures 12 and 15). The opposite is true of destination regions, and particularly North America. Their GDP levels expand substantially, as indicated in Figure 15. In the expanding regions there is a tendency for the real wage to fall, reducing the costs of tradeable goods and depreciating their real exchange rates. At the same time, this raises the marginal products of physical capital in these regions so that they attract greater shares of the world’s investment, further bolstering their growth. The balance of payments effects of the new investment are offset by strong rises in average saving rates in the recipient regions and a substantial fall in saving in the “rest of the world”, where populations in high-saving age groups are depleted. The regions of origin have higher real wages, reduced investment and real appreciations relative to the base line.

In this case, the tendency for population increases to suppress per capita income is offset at least partially for some regions by increased investment. This is most prominent in Western Europe, for example, where the labour force would be larger by half in 2030, wages fall, and per capita income would be expected to fall also. It does so but by only a few per cent over two decades. In North America, however, investment also expands substantially but this is not sufficient to offset the weight of the increased population on per capita income. The increased population pressure in these regions does, however, raise land and resource rents substantially as it does the relative prices of food. In the regions of origin, however, the opposite occurs. Land and natural resource rents fall, as do relative food prices.[27]

5. Conclusion

An analysis of demographic change and labour force participation demonstrates that not only are the populations in several key regions, including Western Europe, Japan and China, likely to decline in the near future but that their labour forces are likely to decline sooner and more dramatically. This will change their patterns of comparative advantage and hence the pattern of global trade. More importantly, it will raise aged dependency ratios which will, in turn, stimulate policies to arrest the declines in their workforces, policies that may have far-reaching economic consequences. These policies include increased labour force participation by the aged and expanded immigration.

This demographic analysis is combined with applications of a dynamic model of the global economy that has multiple age-gender groups. The principal mechanisms by which demographic change affects economic performance are via the average saving rate, the size and age composition of the labour force and the product pattern of consumption expenditure. Projected slower population growth worldwide tends to raise per capita incomes and to shift consumption away from less income elastic “food”. If, as some demographers anticipate, life expectancies rise rapidly due to health science breakthroughs, however, this shift could be offset in the advanced countries and per capita incomes would rise more slowly. Should governments seek to raise aged labour force participation rates, per capita incomes will increase while aged leisure consumption will decline. More investment will be attracted as a consequence, bolstering the gains to the high-participation regions at the expense of the rest of the world.

Replacement migration to regions with rising aged dependency would have very substantial demographic and economic impacts. In recipient regions, real wage rates would fall and more investment would be attracted but the expanded population would further “crowd” fixed factors. Land and natural resource rents would therefore rise. Only in Western Europe would the tendency for the increased population to suppress per capita income be substantially offset by the diversion of investment from other regions. There, increased immigration suppresses per capita income only slightly, though even this occurs at the expense of output and income in other regions, particularly Central Europe and the former Soviet Union.

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[27] These behaviors may be overstated as a result of the assumption that all technical change is disembodied – it is independent of the rate of physical capital accumulation. A vintage capital approach with embodied technical change would reduce but not eliminate it entirely. Such an approach would be technically feasible but so demanding of scarce data that it is beyond the scope of this study.

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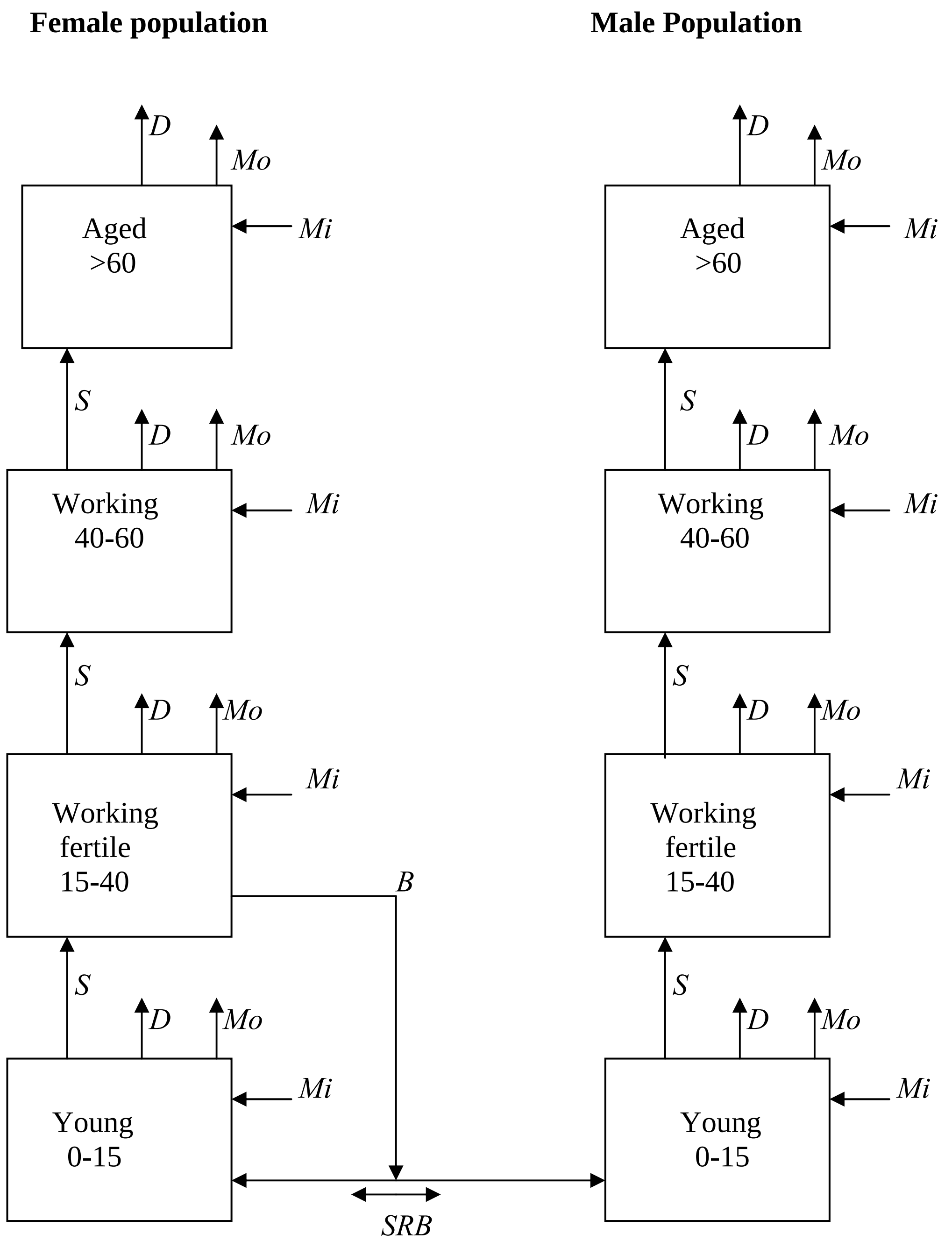
Figure 1



Glossary:

D	Deaths
S	Survival
B	Births
Mi	Immigration
Mo	Emmigration
SRB	Sex ratio at birth

Figure 2: Base Line Population and Labour Force Projections

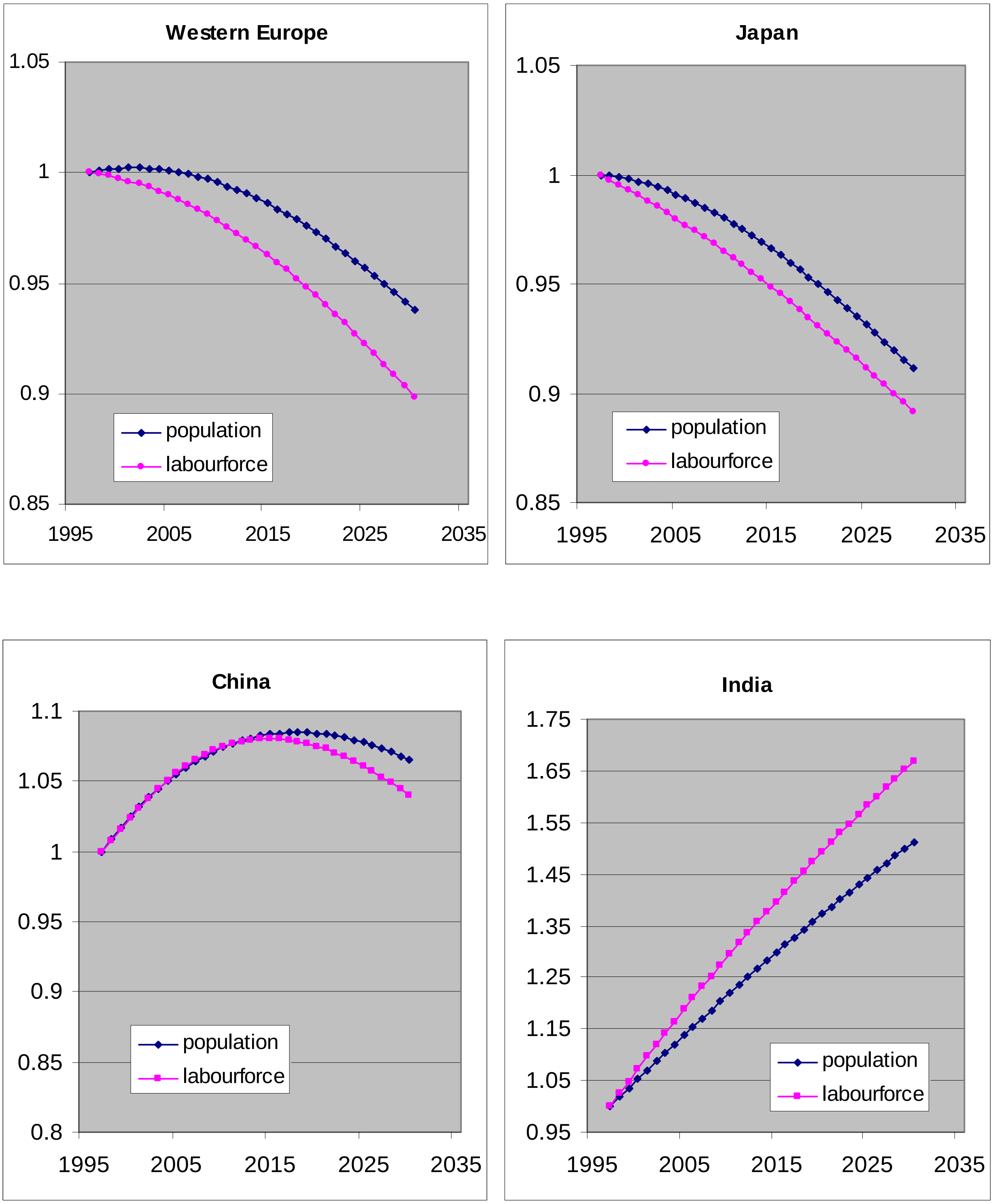


Figure 3: "Increased Aged Participation" and "Replacement Migration" Scenarios

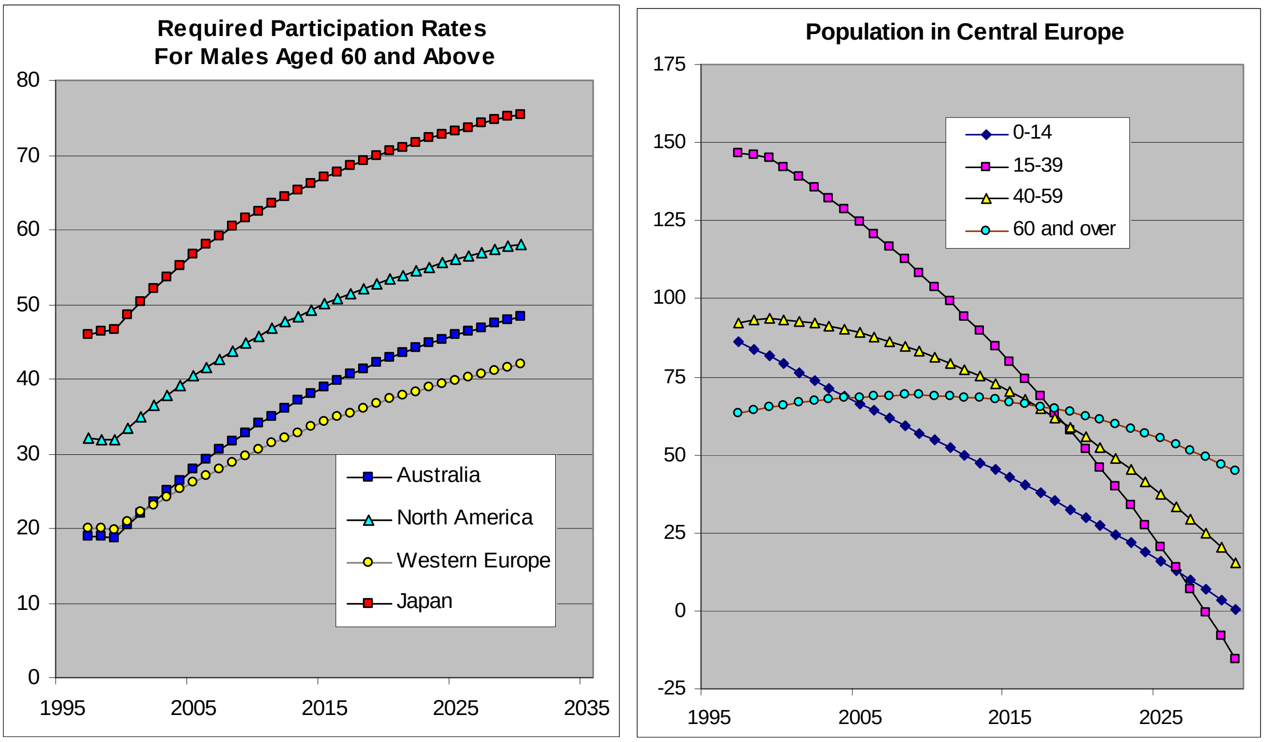


Figure 4: Base Line GDP Growth

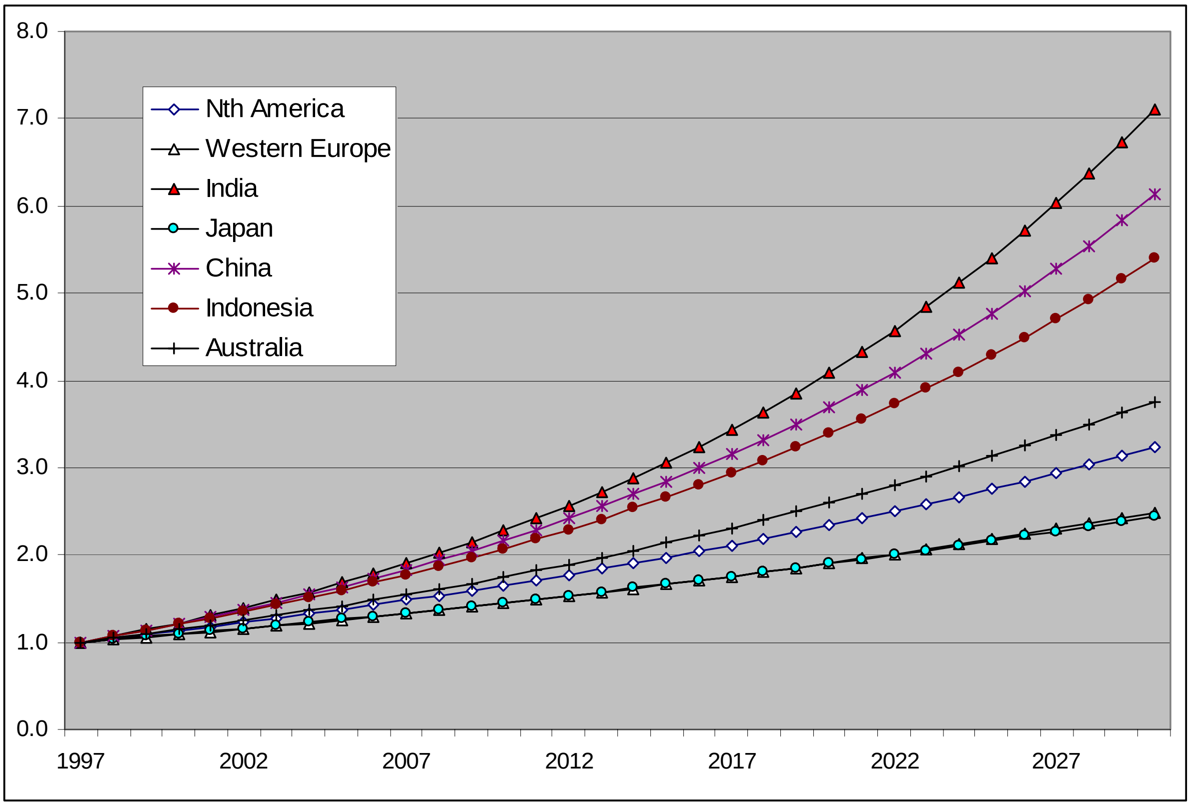
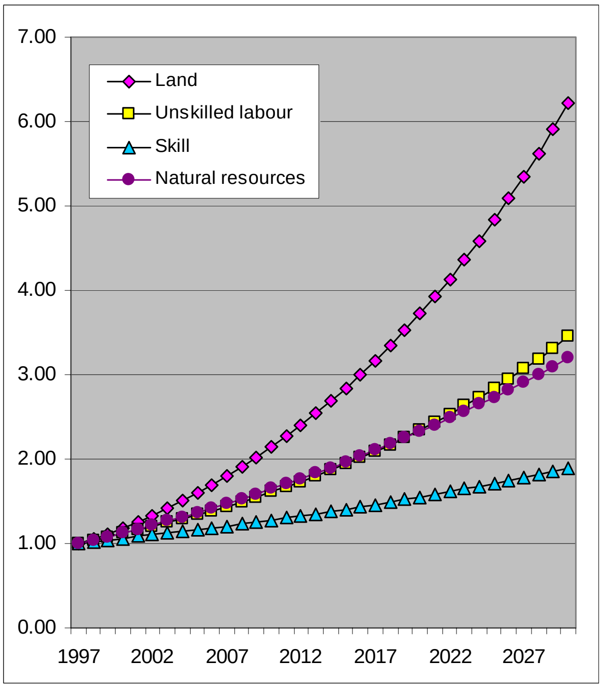
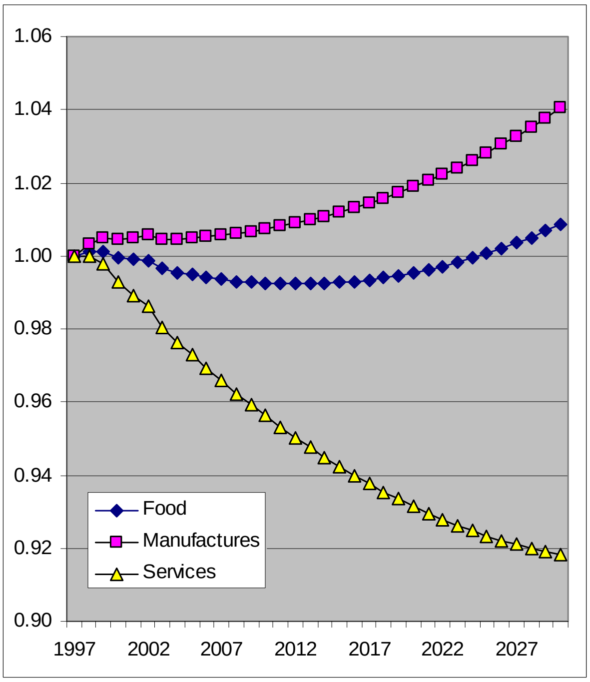


Figure 5: Base Line Prices and Unit Factor Rewards in North America[a]





a Relative to the GDP price. 1997 values normalised at 1.0.

Figure 6: "Accelerated Ageing" Labour Force, Departure from Base Line, %

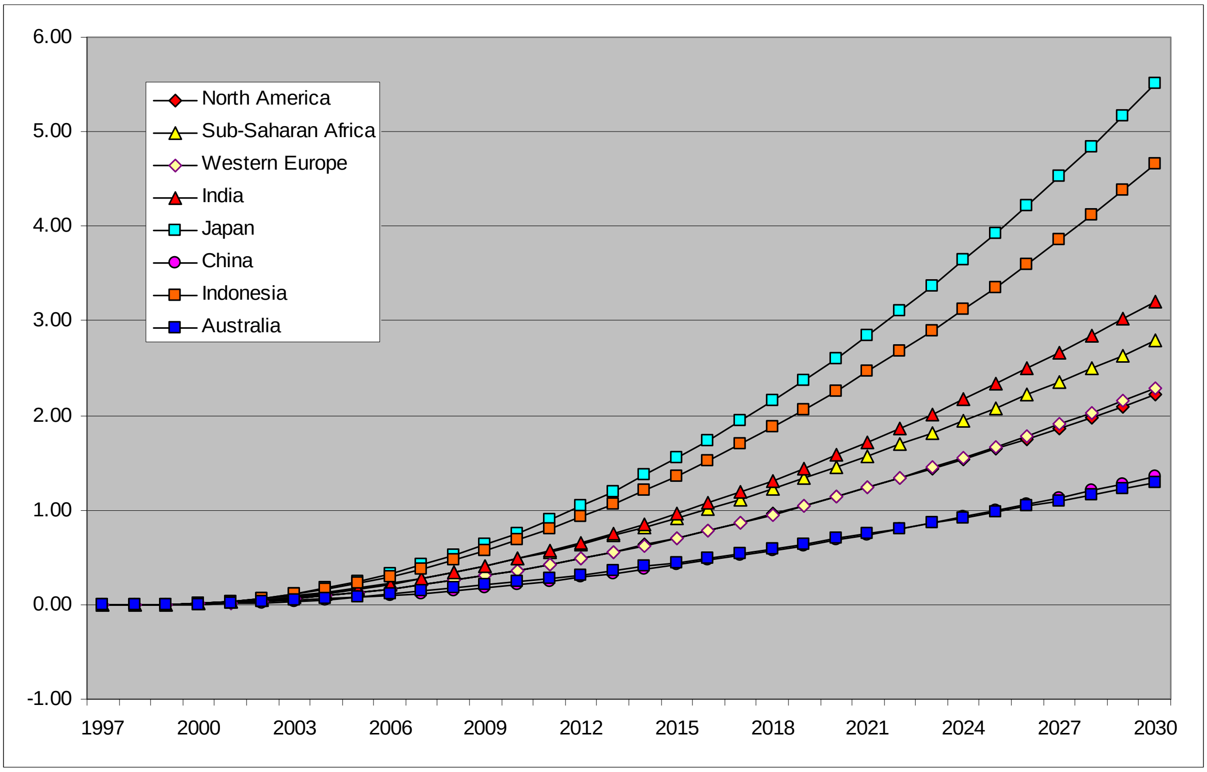


Figure 7: "Accelerated Ageing" Average Saving Rate, Departure from Base Line, %

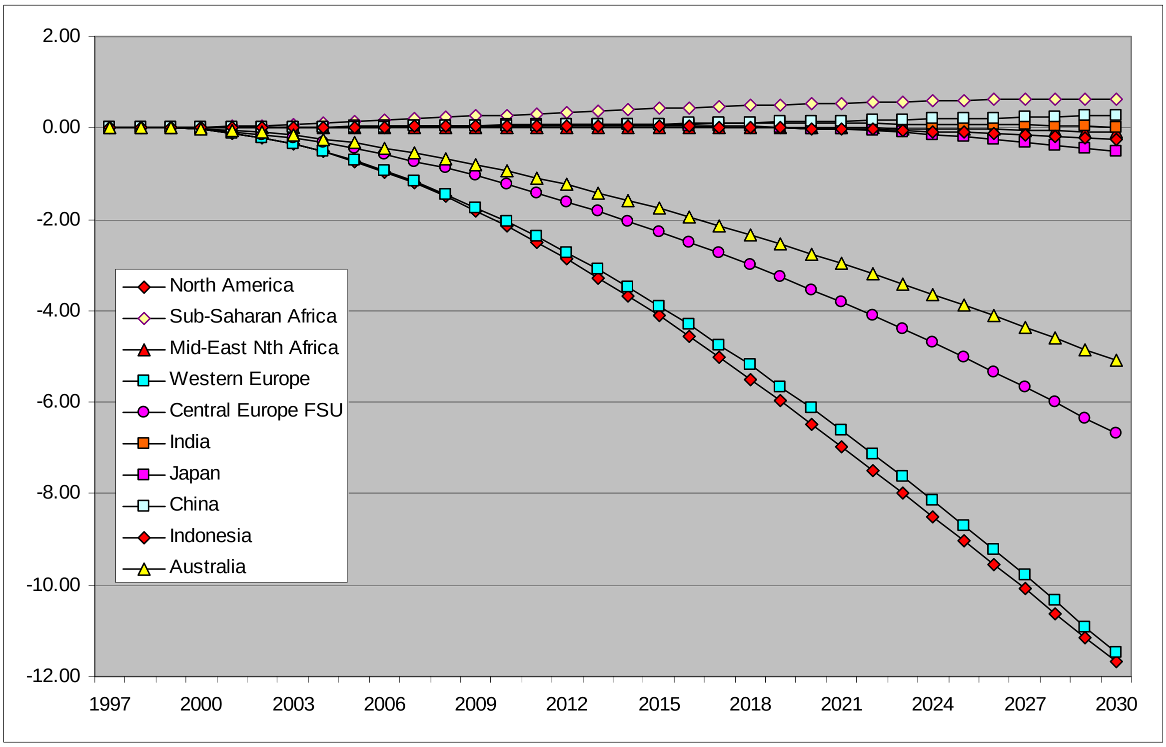


Figure 8: "Accelerated Ageing" Investment, Departure from Base Line, %

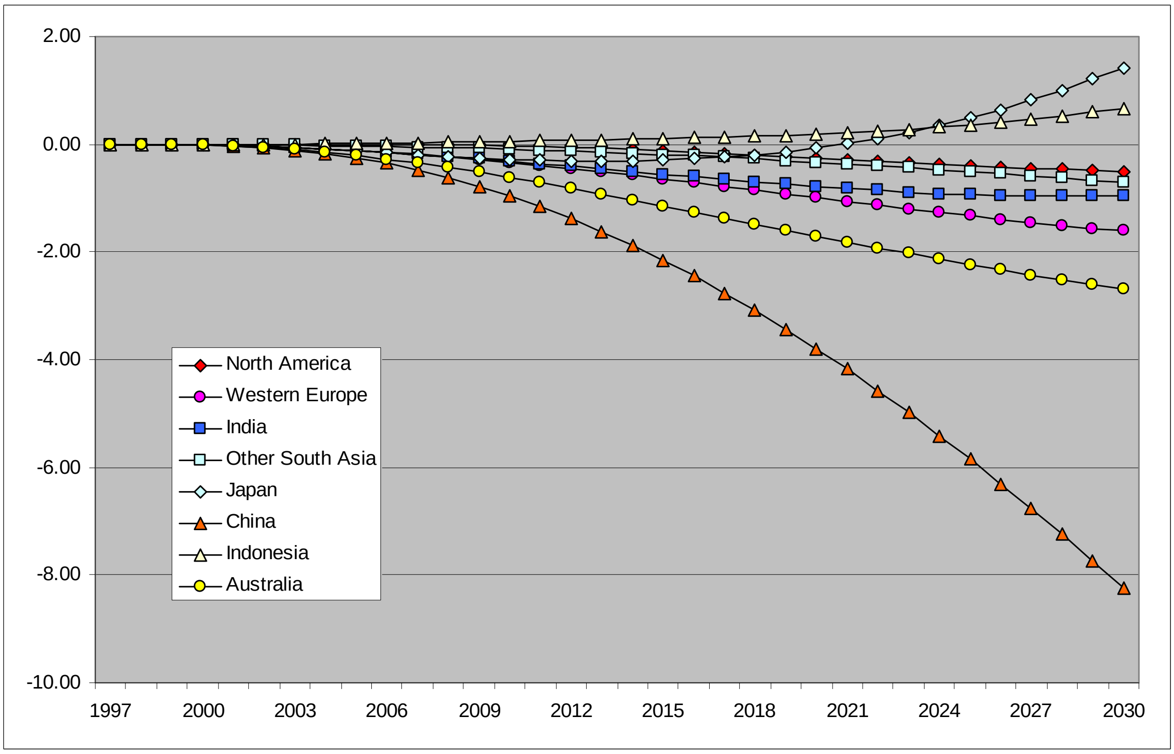


Figure 9: "Increased Participation" Labour Force, Departure from Base Line, %

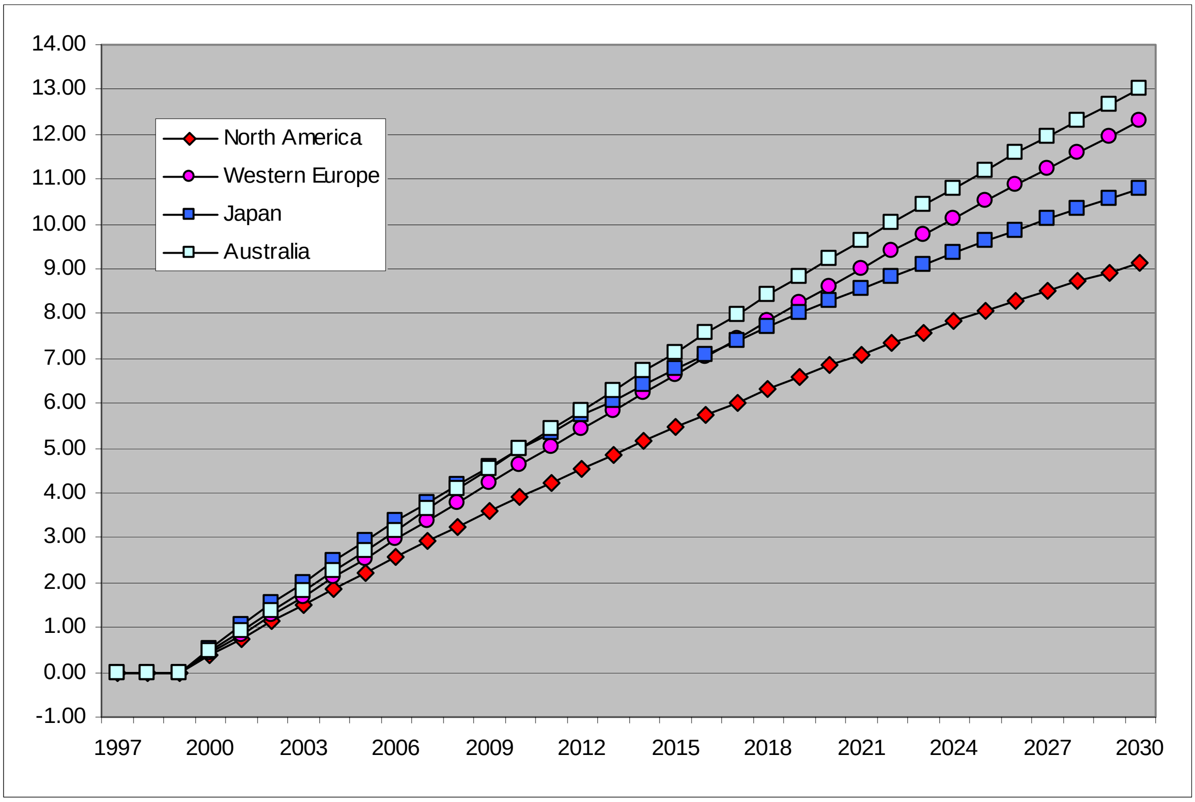


Figure 10: "Increased Participation" Investment, Departure from Base Line, %

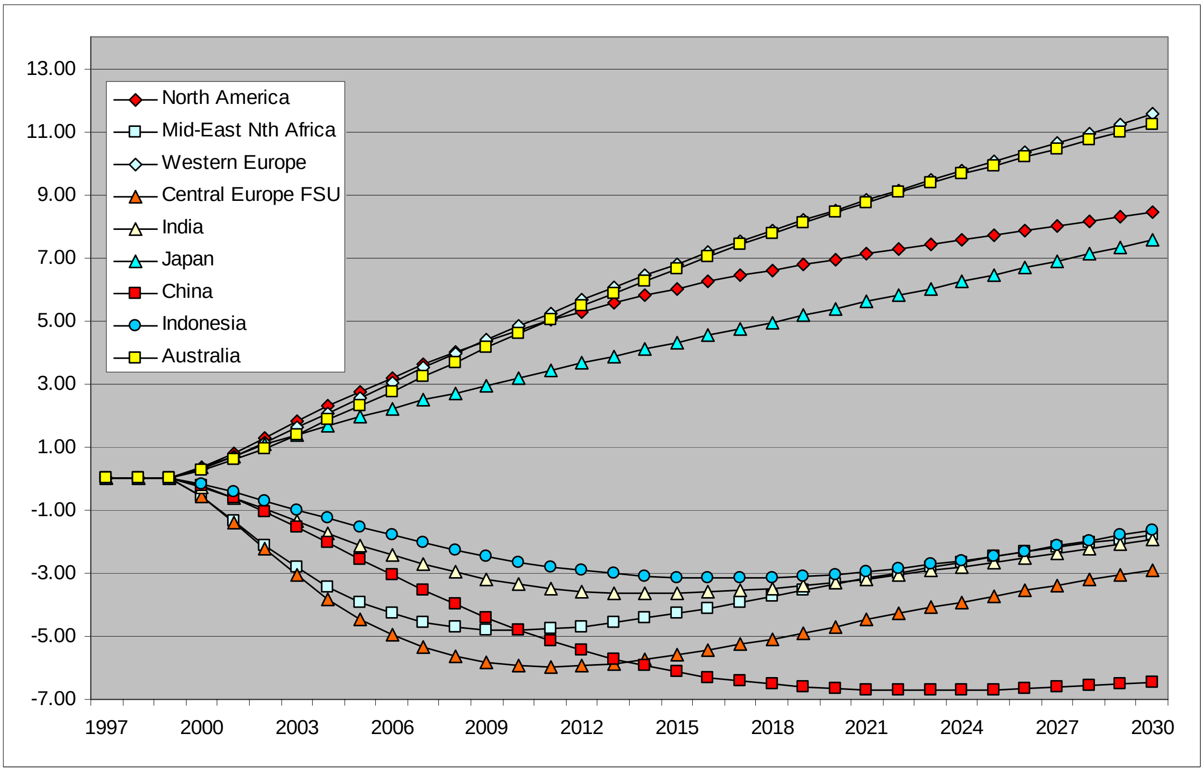


Figure 11: "Increased Participation" Per Capita Income, Departure from Base Line, %

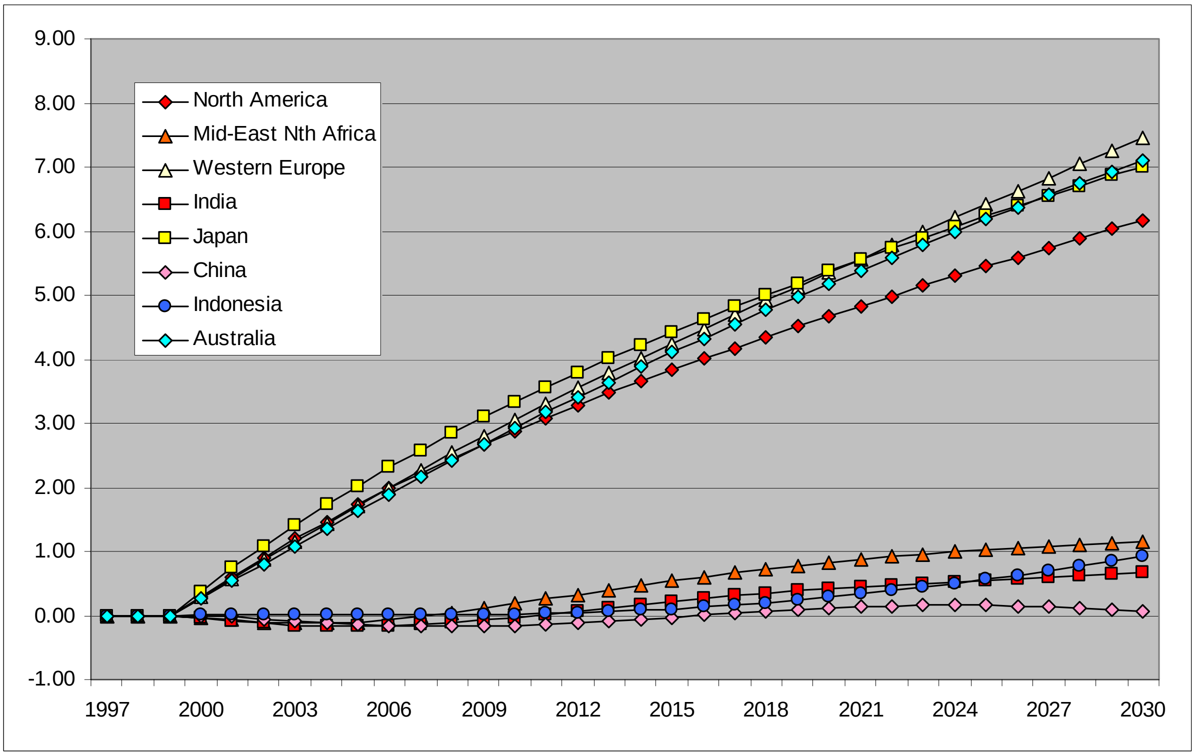


Figure 12: "Replacement Migration" – Labour Force, Departure from Base Line, %

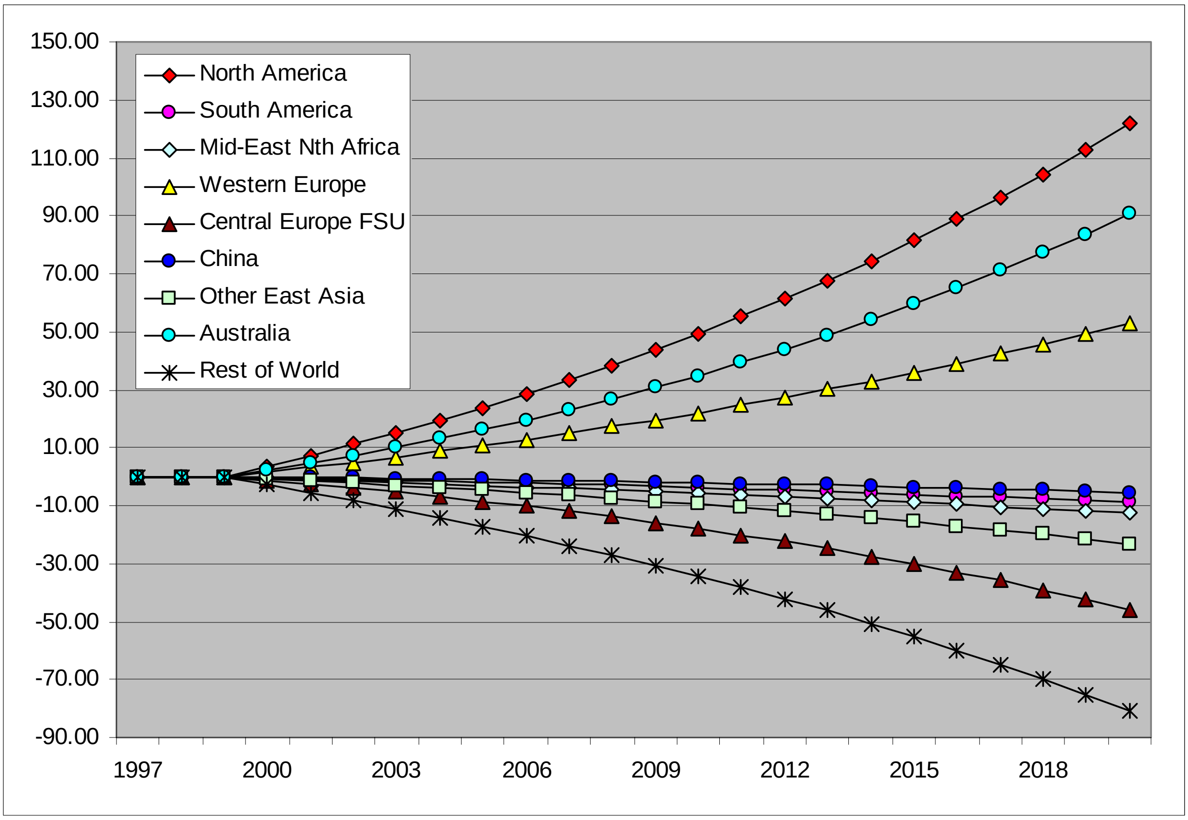


Figure 13: "Replacement Migration" Average Saving Rate, Departure from Base Line, %

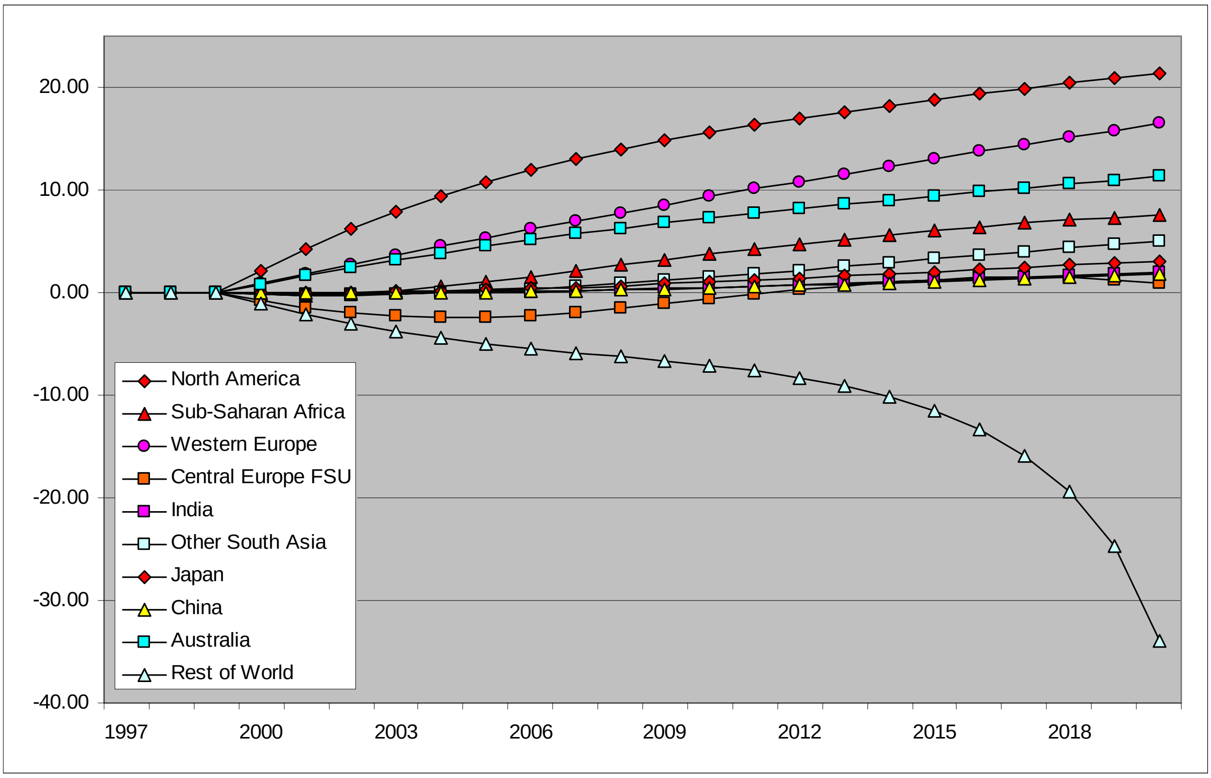


Figure 14: "Replacement Migration" Investment, Departure from Base Line, %

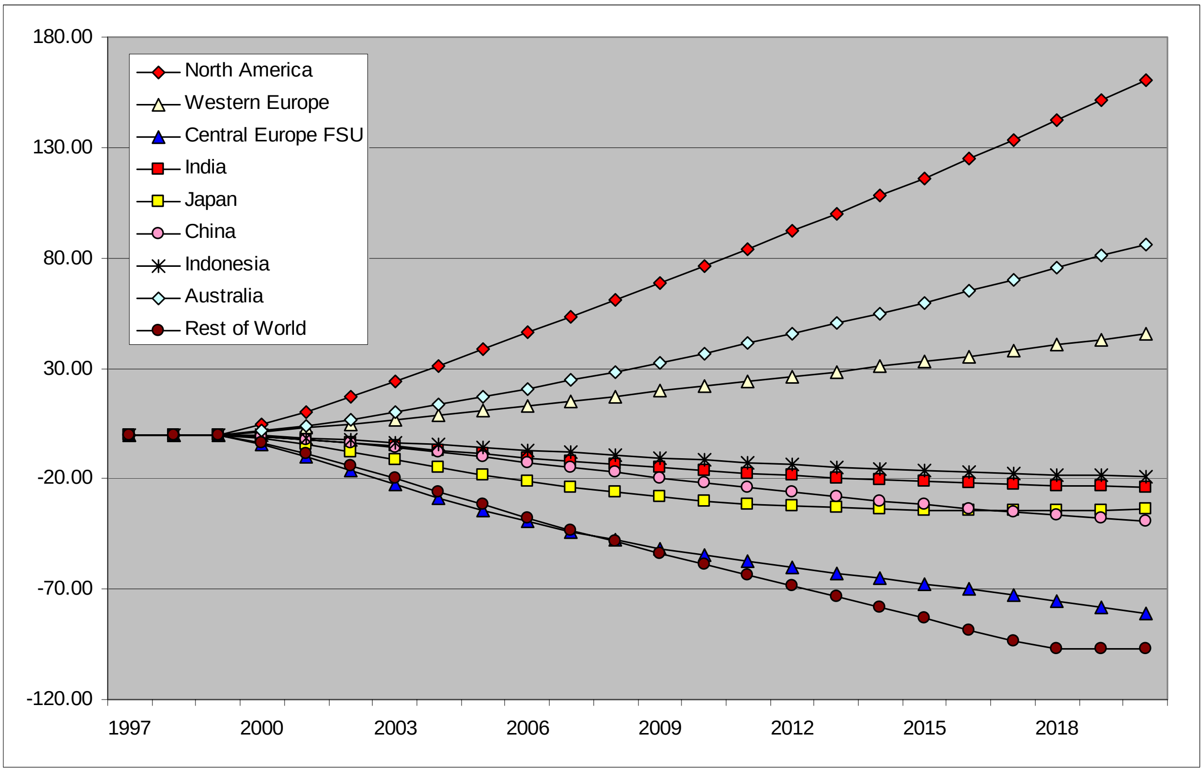


Figure 15: "Replacement Migration" GDP, Departure from Base Line, %

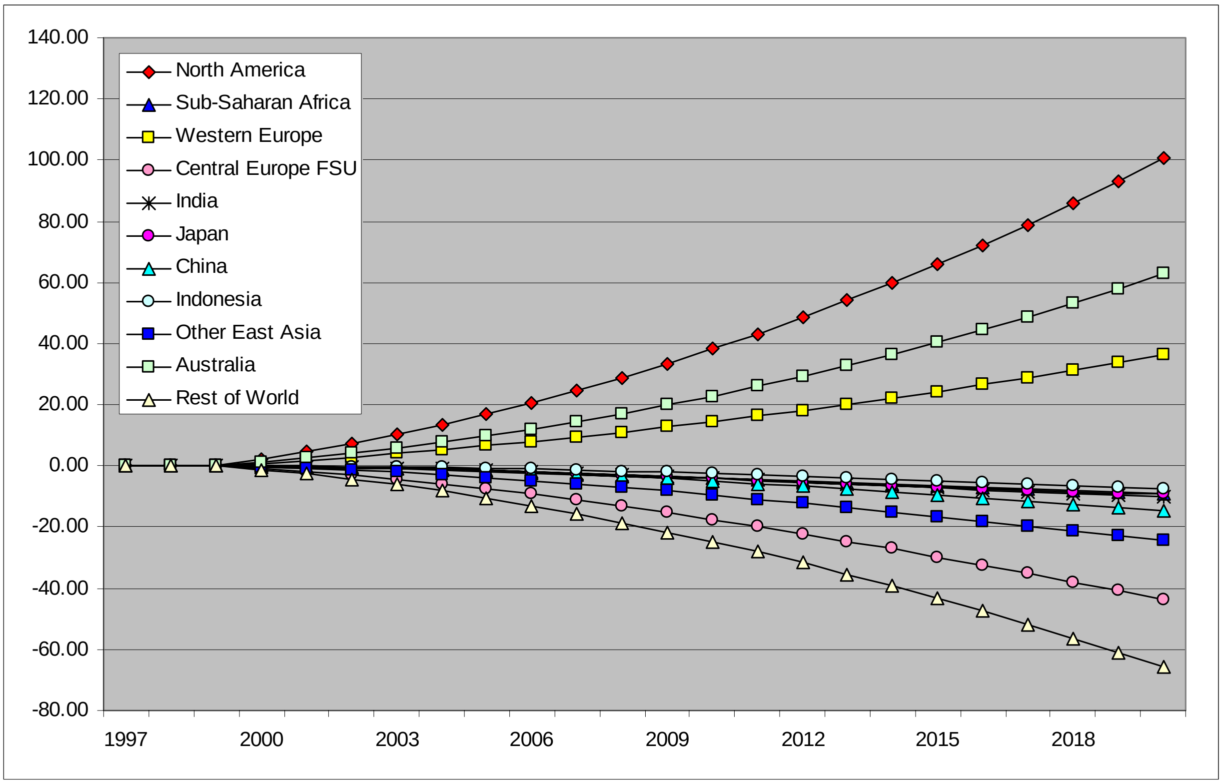


Figure 16: "Replacement Migration" Income Per Capita, Departure from Base Line, %

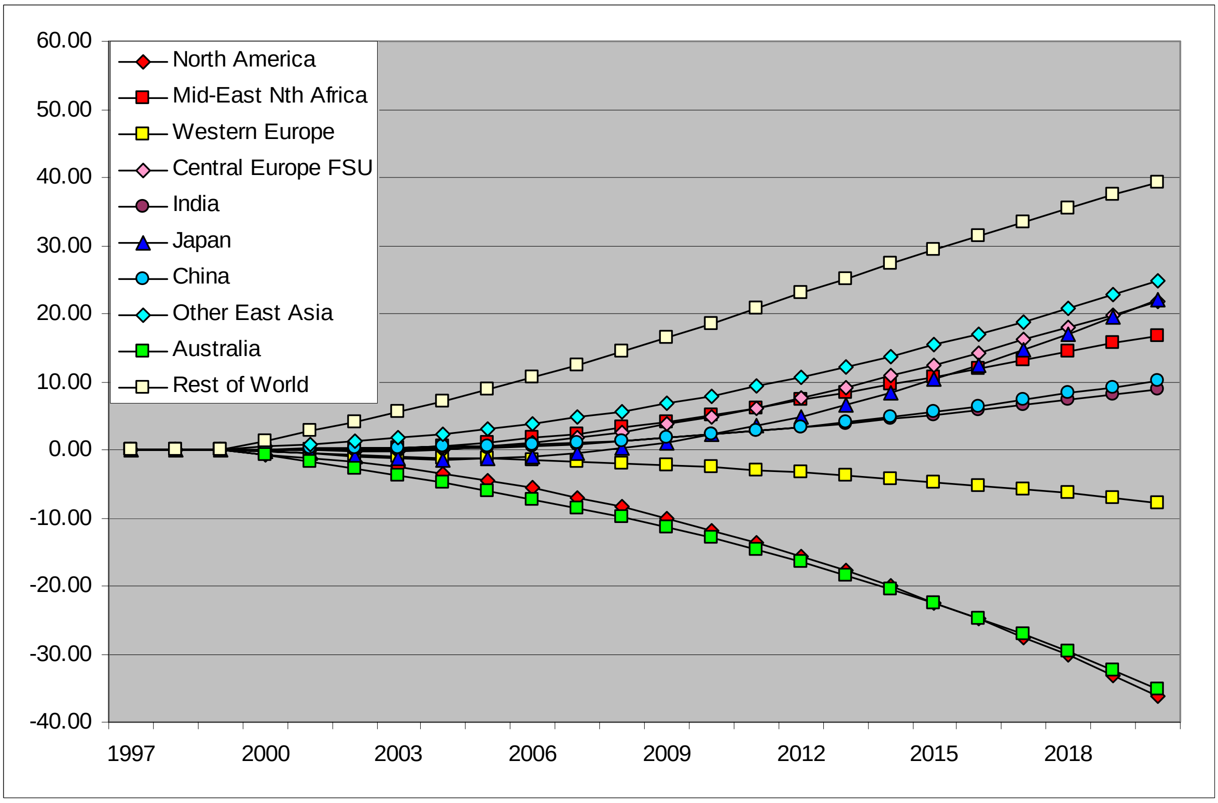


Table 1: Base Line Projections of Labour Force Size and Structure

	Labour force[a]		% Female		% 40+	
	Initial	2030	Initial	2030	Initial	2030
Australia	8	10	37	40	42	48
North America	182	250	40	42	42	47
Western Europe	184	165	40	44	47	55
Central Europe	181	148	47	46	44	53
Japan	61	55	37	37	58	65
China	570	592	37	36	34	47
Indonesia	87	130	38	38	40	54
Other East Asia	127	178	41	40	37	51
India	356	594	27	28	36	47
Other South Asia	134	265	28	28	32	44
South America	123	193	38	39	33	48
Mid East Nth Afr	103	176	24	23	30	42
Sub-Saharan Afr	150	349	28	29	29	36
Rest of World	79	131	36	34	38	48

a Measured in full time equivalent workers.
Source: Projection using the demographic model described in the text, as presented in detail by Chan et al. (2005).

Table 2: Base Line Non-Working Aged Dependency Ratios

	Non-working aged/working	
	Initial	2030
Australia	0.35	0.54
North America	0.24	0.36
Western Europe	0.42	0.61
Central Europe	0.29	0.42
Japan	0.32	0.48
China	0.19	0.44
Indonesia	0.09	0.16
Other East Asia	0.09	0.23
India	0.12	0.23
Other South Asia	0.09	0.18
South America	0.16	0.29
Mid East Nth Afr	0.15	0.33
Sub-Saharan Afr	0.13	0.15
Rest of World	0.15	0.27

Source: Base period statistics constructed from population statistics from United Nations (2003) and simulation results from the demographic model described in the text.

Table 3: Income Weights, $W_{a,g,r}$, by Age-Gender Group

	0-14		15-39		40-59		60+	
	Male	Female	Male	Female	Male	Female	Male	Female
Australia	0.60	0.60	1.00	1.00	0.86	0.86	0.67	0.67
North America	0.40	0.40	1.00	1.00	1.10	1.10	0.60	0.60
Western Europe	0.50	0.50	1.00	1.00	1.00	1.00	0.70	0.70
Central Europe, FSU	0.50	0.50	1.00	1.00	1.00	1.00	0.70	0.70
Japan	0.60	0.60	1.00	1.00	1.60	1.60	0.94	0.94
China	0.60	0.60	1.00	1.00	1.60	1.60	0.94	0.94
Indonesia	0.50	0.50	1.00	1.00	1.40	1.40	0.90	0.90
Other East Asia	0.60	0.60	1.00	1.00	1.60	1.60	0.94	0.94
India	0.50	0.50	1.00	1.00	1.40	1.40	0.90	0.90
Other South Asia	0.50	0.50	1.00	1.00	1.40	1.40	0.90	0.90
South America	0.40	0.40	1.00	1.00	1.05	1.05	1.10	1.10
Mid East Nth Africa	0.50	0.50	1.00	1.00	1.40	1.40	0.90	0.90
Sub-Saharan Africa	0.50	0.50	1.00	1.00	1.40	1.40	0.90	0.90
Rest of World	0.60	0.60	1.00	1.00	0.86	0.86	0.67	0.67

Source: Compiled from studies of consumption behaviour on particular countries, including US and UK: Attanasio and Banks (1998), Attanasio et al. (1999); Japan: Kitamura et al. (2001: Table 1); Mexico (standard for Latin America and an indicator for some other developing regions): Attanasio and Szekely (1998: Figure 1); New Zealand (standard for Australia and Western Europe): Gibson and Scobie (2001: Figure 1).

Table 4: Initial Saving Rates From Personal Disposable Income by Age Gender Group

Per cent	0-14		15-39		40-59		60+	
	Male	Female	Male	Female	Male	Female	Male	Female
Australia	0	0	7	7	31	31	-5	-5
North America	0	0	14	14	19	19	-30	-30
Western Europe	0	0	10	10	39	39	-20	-20
Central Europe, FSU	0	0	4	4	18	18	-6	-6
Japan	0	0	24	24	28	28	22	22
China	0	0	35	35	40	40	31	31
Indonesia	0	0	23	23	34	34	23	23
Other East Asia	0	0	36	36	40	40	32	32
India	0	0	19	19	28	28	19	19
Other South Asia	0	0	7	7	10	10	7	7
South America	0	0	7	7	17	17	6	6
Mid East Nth Africa	0	0	8	8	19	19	7	7
Sub-Saharan Africa	0	0	2	2	6	6	2	2
Rest of World	0	0	5	5	23	23	-5	-5

Source: Compiled from studies of consumption behaviour on particular countries, including Mexico: Attanasio and Szekely (1998); Japan: Kitamura et al. (2001); New Zealand: Gibson and Scobie (2001); US: Attanasio et al. (1999).

Table 5: Private Expenditure Shares by Age-Gender Group

		0-14		15-39		40-59		60+	
		Male	Female	Male	Female	Male	Female	Male	Female
Australia	Food	0.18	0.18	0.10	0.10	0.10	0.10	0.18	0.18
	Manufactures	0.07	0.07	0.19	0.19	0.19	0.19	0.05	0.05
	Services	0.74	0.74	0.71	0.71	0.71	0.71	0.77	0.77
North America	Food	0.12	0.12	0.05	0.05	0.06	0.06	0.11	0.11
	Manufactures	0.12	0.12	0.16	0.16	0.16	0.16	0.09	0.09
	Services	0.76	0.76	0.79	0.79	0.78	0.78	0.80	0.80
Western Europe	Food	0.18	0.18	0.09	0.09	0.09	0.09	0.18	0.18
	Manufactures	0.12	0.12	0.30	0.30	0.30	0.30	0.09	0.09
	Services	0.70	0.70	0.61	0.61	0.61	0.61	0.73	0.73
Central Europe, FSU	Food	0.44	0.44	0.26	0.26	0.26	0.26	0.43	0.43
	Manufactures	0.10	0.10	0.27	0.27	0.27	0.27	0.07	0.07
	Services	0.47	0.47	0.47	0.47	0.47	0.47	0.50	0.50
Japan	Food	0.18	0.18	0.10	0.10	0.10	0.10	0.17	0.17
	Manufactures	0.07	0.07	0.18	0.18	0.18	0.18	0.05	0.05
	Services	0.75	0.75	0.72	0.72	0.72	0.72	0.78	0.78
China	Food	0.47	0.47	0.26	0.26	0.26	0.26	0.47	0.47
	Manufactures	0.13	0.13	0.35	0.35	0.35	0.35	0.10	0.10
	Services	0.40	0.40	0.39	0.39	0.39	0.39	0.43	0.43
Indonesia	Food	0.46	0.46	0.30	0.30	0.30	0.30	0.45	0.45
	Manufactures	0.07	0.07	0.26	0.26	0.26	0.26	0.05	0.05
	Services	0.48	0.48	0.44	0.44	0.44	0.44	0.50	0.50
Other East Asia	Food	0.30	0.30	0.17	0.17	0.17	0.17	0.29	0.29
	Manufactures	0.10	0.10	0.35	0.35	0.35	0.35	0.08	0.08
	Services	0.60	0.60	0.47	0.47	0.47	0.47	0.63	0.63
India	Food	0.57	0.57	0.37	0.37	0.37	0.37	0.56	0.56
	Manufactures	0.08	0.08	0.31	0.31	0.31	0.31	0.06	0.06
	Services	0.35	0.35	0.32	0.32	0.32	0.32	0.38	0.38
Other South Asia	Food	0.54	0.54	0.37	0.37	0.37	0.37	0.54	0.54
	Manufactures	0.07	0.07	0.27	0.27	0.27	0.27	0.05	0.05
	Services	0.39	0.39	0.36	0.36	0.36	0.36	0.41	0.41
South America	Food	0.36	0.36	0.21	0.21	0.21	0.21	0.36	0.36
	Manufactures	0.10	0.10	0.36	0.36	0.36	0.36	0.08	0.08
	Services	0.53	0.53	0.43	0.43	0.43	0.43	0.57	0.57
Mid East Nth Africa	Food	0.39	0.39	0.25	0.25	0.25	0.25	0.38	0.38
	Manufactures	0.07	0.07	0.27	0.27	0.27	0.27	0.05	0.05
	Services	0.54	0.54	0.48	0.48	0.48	0.48	0.57	0.57
Sub-Saharan Africa	Food	0.46	0.46	0.30	0.30	0.30	0.30	0.45	0.45
	Manufactures	0.07	0.07	0.28	0.28	0.28	0.28	0.05	0.05
	Services	0.47	0.47	0.42	0.42	0.42	0.42	0.50	0.50
Rest of World	Food	0.36	0.36	0.20	0.20	0.20	0.20	0.35	0.35
	Manufactures	0.10	0.10	0.27	0.27	0.27	0.27	0.07	0.07
	Services	0.54	0.54	0.53	0.53	0.53	0.53	0.58	0.58

Source: Constructed with guidance from the results presented by: Abdel-Ghany and Sharpe (1997), Blisard (2001a and b), Blisard (2003), Case and Deaton (2002), Paulin (2000), Regmi et al. (2001) and Weber et al. (2002). The shares are then modified using a RAS process to conform with aggregate expenditures by product in the *GTAP* database.

Table 6: Effects in 2030 of "Accelerated Ageing"[a] Compared with the Base Line Scenario

per cent change	Population		Labour force		Non-working aged dep ratio
	Total	60+	Total	60+	Aged NW
Australia	5.7	23.7	1.3	24.6	22.0
North America	5.1	23.6	2.2	24.0	20.9
Western Europe	7.5	25.8	2.3	26.3	22.9
Central Europe	7.8	31.4	3.6	32.5	26.6
Japan	7.4	21.4	5.5	22.1	14.8
China	5.9	27.4	1.4	29.0	25.5
Indonesia	4.5	31.0	4.7	31.2	25.0
Other East Asia	4.4	25.8	3.5	26.1	21.4
India	3.8	26.6	3.2	27.5	22.2
Other South Asia	3.1	26.6	3.0	26.7	22.7
South America	4.1	24.4	3.4	24.6	20.1
Mid East Nth Africa	3.3	25.3	2.3	25.8	22.3
Sub-Saharan Africa	2.4	34.5	2.8	36.2	30.0
Rest of World	3.6	20.1	3.3	21.0	15.8

a Growth in Target Life Expectancies at 60 by 2% per year
Source: Simulation results from the model described in the text.

Table 7: Effects in 2030 of "Increased Aged Participation"[a] Compared with Base Line Scenario

per cent change	Population		Labour force		Non-working aged dep ratio
	Total	60+	Total	60+	Aged NW
Australia	0.0	0.0	13.0	248.3	-32.8
North America	0.0	0.0	9.1	98.9	-31.3
Western Europe	0.0	0.0	12.3	141.7	-29.0
Central Europe	0.0	0.0	0.0	0.0	0.0
Japan	0.0	0.0	10.8	43.2	-30.2
China	0.0	0.0	0.0	0.0	0.0
Indonesia	0.0	0.0	0.0	0.0	0.0
Other East Asia	0.0	0.0	0.0	0.0	0.0
India	0.0	0.0	0.0	0.0	0.0
Other South Asia	0.0	0.0	0.0	0.0	0.0
South America	0.0	0.0	0.0	0.0	0.0
Mid East Nth Africa	0.0	0.0	0.0	0.0	0.0
Sub-Saharan Africa	0.0	0.0	0.0	0.0	0.0
Rest of World	0.0	0.0	0.0	0.0	0.0

a To Retain Fixed Aged Dependency
Source: Simulation results from the model described in the text.

Table 8: Effects in 2020 of "Replacement Migration"[a] Compared with Base Line Scenario[b]

Per cent change	Population		Labour force		Non-working aged dep ratio
	Total	**60+**	**Total**	**60+**	**Aged NW**
Australia	87.1	41.7	90.6	42.1	-25.7
North America	113.7	65.0	121.8	63.9	-25.5
Western Europe	46.8	18.9	52.9	19.0	-22.2
Central Europe	-42.1	-20.0	-45.8	-20.4	47.9
Japan	0.0	0.0	0.0	0.0	0.0
China	-5.3	-3.3	-5.5	-3.0	2.4
Indonesia	-0.3	-0.2	-0.3	-0.2	0.1
Other East Asia	-22.7	-16.7	-23.3	-16.4	8.4
India	-4.6	-3.6	-4.6	-3.4	0.9
Other South Asia	-9.1	-8.2	-9.3	-7.6	0.8
South America	-8.6	-5.5	-9.0	-5.8	4.0
Mid East Nth Africa	-12.8	-10.1	-12.6	-9.5	2.7
Sub-Saharan Africa	-6.2	-7.0	-6.5	-6.7	-0.6
Rest of World	-78.2	-55.8	-80.7	-54.1	124.0

a To retain fixed aged dependency.
b The projections under the replacement migration scenario run only to 2020 since, beyond that, the migrations more than deplete some age groups in source regions.
Source: Simulation results from the model described in the text.

Table 9: "Accelerated Ageing" - Product and Factor Prices, per cent Departure from the Base Line in 2030[a]

	Land rent	Wage	Res rent	Food	Manuf	Services
Australia	3.0	-0.6	-0.9	0.3	0.2	0.3
North America	5.2	-0.5	0.4	0.2	-0.2	-0.2
Western Europe	8.2	-0.8	-0.4	0.2	0.0	0.2
Central Europe, FSU	6.5	-1.8	0.2	0.2	-0.1	-0.2
Japan	8.3	-0.8	1.4	0.6	0.3	0.5
China	2.4	-2.7	-1.7	-0.7	-0.5	-0.5
Indonesia	4.3	-2.1	0.5	0.7	0.0	-0.2
Other East Asia	3.6	-1.8	-0.1	0.4	-0.1	-0.1
India	3.0	-1.9	0.1	0.7	0.0	0.1
Other South Asia	2.9	-1.8	0.5	0.6	-0.2	-0.4
South America	5.1	-1.3	0.9	0.4	-0.2	-0.4
Mid East Nth Africa	5.5	-1.3	-0.5	0.2	0.1	-0.1
Sub-Saharan Africa	6.0	-0.7	0.8	0.3	-0.1	-0.5
Rest of World	4.1	-1.6	0.5	0.3	-0.1	-0.3

a All prices are measured relative to regional GDP prices.
Source: Simulations of the model described in the text.

Table 10: "Increased Participation" - Product and Factor Prices, per cent Departure from the Base Line in 2030[a]

	Land rent	Wage	Res rent	Food	Manuf	Services
Australia	13.7	-1.2	10.2	1.0	0.6	-0.1
North America	8.2	0.7	8.1	0.8	0.2	0.0
Western Europe	12.3	-0.9	9.4	0.3	0.0	0.0
Central Europe, FSU	-3.3	-1.4	-2.8	-0.8	-0.4	0.0
Japan	7.2	-1.3	6.8	0.2	0.1	0.0
China	-2.6	-2.5	-3.0	-1.4	-0.2	0.1
Indonesia	-2.4	-1.1	-2.3	-0.9	-0.2	0.0
Other East Asia	-3.2	-1.2	-2.9	-1.0	-0.3	0.1
India	-2.5	-1.2	-2.0	-1.1	0.0	0.3
Other South Asia	-2.2	-0.9	-1.6	-0.7	0.1	0.2
South America	-3.5	-1.1	-1.8	-0.4	-0.1	0.0
Mid East Nth Africa	-3.6	-1.0	-2.2	-0.5	-0.3	0.0
Sub-Saharan Africa	-1.9	-0.6	-1.0	-0.2	0.0	0.0
Rest of World	-2.8	-0.9	-1.8	-0.7	-0.3	0.0

a All prices are measured relative to regional GDP prices.
Source: Simulations of the model described in the text.

Table 11: "Replacement Migration" - Product and Factor Prices, per cent Departure from the Base Line in 2030[a]

	Land rent	Wage	Res rent	Food	Manuf	Services
Australia	113.1	-12.7	60.6	5.3	2.8	-0.5
North America	183.7	-8.8	102.6	7.7	1.3	-0.1
Western Europe	80.8	-8.7	31.7	1.0	-0.7	0.4
Central Europe, FSU	-62.6	5.5	-47.2	-8.2	-4.2	0.9
Japan	-26.1	-6.7	-22.3	-3.3	-1.4	0.2
China	-12.8	-7.6	-13.5	-4.7	-0.5	0.5
Indonesia	-8.4	-5.4	-9.7	-3.1	-0.4	0.2
Other East Asia	-33.4	1.0	-29.1	-8.4	-3.1	0.1
India	-12.8	-4.5	-12.9	-5.0	0.1	1.6
Other South Asia	-16.5	-1.2	-13.9	-4.5	0.4	1.7
South America	-21.0	-3.4	-14.7	-2.3	-0.7	0.3
Mid East Nth Africa	-30.9	-2.7	-20.2	-2.7	-2.7	0.0
Sub-Saharan Africa	-15.5	-2.0	-11.1	-1.4	-0.7	0.1
Rest of World	-89.4	65.4	-70.1	-15.7	-9.0	1.2

a All prices are measured relative to regional GDP prices.
Source: Simulations of the model described in the text.