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Demographic Change and Policy Responses: Implications for the Global Economy*

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Abstract

The fertility declines associated with the final phase of the global demographic transition have led to slower population growth and accelerated ageing in developed countries and in several advanced developing countries. A global demographic and economic is used to assess the implications of these changes for population sizes, age-gender distributions, labour force growth and their implications for economic performance. A base line projection that incorporates declining fertility is compared with a hypothetical constant population growth scenario. The results show that slower population growth and ageing reduces average saving rates in industrial regions, yet global investment demand is also slowed and saving rates rise in developing regions, so there is no net tightening of financial markets. Increased aged labour force participation, considered one solution to the resulting rise in aged dependency in advanced regions, is found to redistribute investment in favour of the industrialised regions and hence to accelerate their per capita income growth, while conferring on the other regions compensatory terms of trade improvements. The alternative of replacement migration is found to require inconceivably large population movements. It also impairs real per capita growth in destination regions but by least in Western Europe, where the terms of trade is improved by the immigration.

1. INTRODUCTION

Recent changes in global demographic behaviour, including fertility, mortality and migration, have been sharper than had been 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.[1] The declines in birth rates anticipated as part of the final phase of this transition have been sudden, first in developed countries and recently in many developing countries.[2] 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.[3]

We examine the economic implications of these changes to population sizes and structures using a complete demographic model that is constructed for integration with a

[1] The demographic transition refers to that from combined high birth and death rates prior to development through a phase in which death rates decline due to public health innovations and, finally, to one in which birth rates also decline. The rates of population growth are low in both the initial and final phases but high in the interim. A clear explanation of this pattern is offered by Bloom and Williamson (1998).
[2] IMF (2004: Chapter 3), Lee (2003), Duncan and Wilson (2004).
[3] Bryant and McKibbin (1998), United Nations (2003).

dynamic model of the global economy. The latter model is a development of *GTAP-Dynamic*, the standard version of which has single households in each region and therefore no demographic structure.[4] The new version has regional households that are disaggregated by age group and gender. Compared with other studies of global demographic change, the explicit incorporation of a demographic sub-model facilitates not only the conventional analysis of changes in fertility and life expectancy but also of changes in labour force participation and migration. 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 labour force participation rates and migration flows than by natural population increases.[5] In countries where demographic changes will soon yield declining labour forces, there will be pressure to substantially raise guest worker and net immigration rates.[6] This new wave of "replacement" migration flows will have important implications for economic structure in regions of both origin and destination.

Our analysis offers a base line projection through 2030 that incorporates the final phase of the global demographic transition. Consistent with earlier forecasts, not only are populations and labour forces projected to decline in Europe and Japan, but the simulations also show this to occur in China within the coming decade. Moreover, where populations are to decline, labour forces will decline sooner and faster. This base line projection is then compared with a hypothetical one in which regional populations grow at constant rates and their age-gender compositions remain unchanged. This comparison draws out the effects of the fertility slow-down and the ageing of regional populations. We then consider the effects of alternative policy responses to the associated rise in aged dependency ratios in the major industrial regions. First, we examine a scenario in which governments raise retirement ages and, thereby, increase aged labour force participation rates. Second, we assume the governments take advantage of the relative youth of immigrants by adopting "replacement" migration policies.

Section 2 offers a brief overview of the demographic sub-model and economic model used. A description of the base line projection to 2030, and of its construction, is then provided in Section 3. In Section 4, a hypothetical "balanced population growth" scenario is

[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). Earlier applications of the standard model to the issues raised in this paper is that by Shi and Tyers (2004) and Duncan, Shi and Tyers (2005).

[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).

constructed and compared with the base line projection, so as to distinguish the effects of embodied ageing and population slow-downs. Then, in Section 5, we look at the impact of some policy responses to population ageing and labour force decline. The base line is compared with scenarios in which aged dependency in the older industrial economies is constrained first by increased aged labour force participation and, second, by expanded immigration. Section 6 offers concluding remarks.

2. MODELLING DEMOGRAPHIC CHANGE AND ITS ECONOMIC EFFECTS

The construction of a full demographic sub-model on 14 regions avoids reliance on a fixed set of population projections.[7] As is clear from Bongaarts, J. and R.A. Bulatao (2000) and from the stochastic bounds presented by Duncan and Wilson (2004), previous forecasts have routinely over-projected future population growth and hence they have underestimated the implications of slowing growth and ageing. Yet, complete incorporation of demographic behaviour within a global economic model requires some loss of detail. The demographic sub-model offered here tracks populations in four age groups: the dependent young, adults of fertile and working age, older working adults and the mostly-retired over 60s, and two genders; a total of eight age-gender groups. The 14 regions are chosen so as to single out countries that are populous or groups of countries of particular demographic and economic interest (Table 1).[8] The sub-model is described first and then this section turns to the global economic model to which it is attached.

a. The Demographic Sub-Model

Each age-gender group is a homogeneous sub-population with group-specific death and migration rates. The final age group (60+) has duration equal to measured life expectancy at 60, which varies across genders and regions. The model represents full matrices of migration flows between the 14 regions, for each age and gender group. In projections where migration policies are assumed to remain unchanged, each of these flows depends on a fixed migration *rate*, defined on the population of the destination age-gender group and region.[9] The key parameters, then, are regional birth rates and sex ratios at birth,

[7] Many studies use the standard projections by the United Nations Population Division (2003).
[8] The demographic sub-model has been used in stand alone mode for the analysis of trends in labour forces and aged dependency ratios. For a more complete documentation, see Chan and Tyers (2006) and Tyers et al. (2005).
[9] 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. There is, however, evidence that migration flows can be inversely

age and gender specific death, immigration and emigration rates and life expectancies at 60. The migration *rates* are based on recent migration records.[10] The birth rates, life expectancy at 60 and the age and gender specific mortality rates all trend through time asymptotically. For each age-gender group, and region, a target rate is identified. These tend to be levels observed in advanced regions, toward which other regions might be expected to converge. The parameters then approach these target rates with initial growth rates determined by historical observation.

One of the important consequences of population ageing is its negative impact on the labour force size. To capture this, the number of "full-time equivalent" workers is estimated. First, labour force participation rates, by gender and age group, are assembled for each region, from ILO statistics on the "economically active population". The proportion of workers that are part time and the hours they work relative to each regional standard for full time work are then accounted for from regional sources.[11] The age and gender specific rates of participation and part-time work are then applied to populations in each age and gender group to derive the numbers of full time equivalent workers. With these in hand, a range of dependency ratios can be defined. That used here is the "non-working aged" dependency ratio, which is the number of non-working persons over 60 per full time equivalent worker.

The regional levels and age structures of the base line population projections are summarised in Table 2. The totals accord closely with corresponding United Nations projections, notwithstanding our simple, four-age-group model.[12] Corresponding base line projections of labour force levels and age structures are summarised in Table 3, showing substantial ageing of labour forces in all regions and declines in labour force levels in Western and Central Europe, the former Soviet Union and Japan. The widespread ageing of populations is especially clear from the trends in non-working aged dependency ratios listed in Table 4. Finally, base line projections of total populations and labour forces for a selection of regions are displayed in Figure 1. This figure draws attention to the contrasts between regions with growing and contacting populations and labour forces and, for individual

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proportional to indigenous population growth, driven, for example, by the need to maintain labour forces in the face of declining rates of natural increase. More sophisticated migration behaviour has been incorporated in an extended version of this model, as represented in Tyers et al. (2006).

[10] Records of gross migration flows are weak at best in most countries. The matrices are constructed from detailed records available from Australia, Western Europe and North America, combined with immigrant stock matrices constructed by Parsons et al. (2005), as described in Vedi (2005) and Tyers et al. (2006).

11 For sources, see Chan and Tyers (2006). In projecting participation and part-time work rates, as for birth and death rates, they are assumed to trend through time asymptotically toward a target, with the rate of approach determined by the initial rate of change. Target rates are chosen from countries considered "advanced" in terms of labour force behaviour.

[12] See United Nations (2003) and the detailed comparison provided in Chan and Tyers (2006).

regions, between the trends in populations and labour forces. Contracting populations and labour forces are prominent and important, contrasting with the world view of mid to late 20th century. Moreover, the old practice of assuming constant labour force participation, and hence that populations and labour forces grow at the same rates, is shown to create substantial errors when demographic change is taking place. Where populations are declining they are also ageing and this causes their labour forces to decline even faster. The opposite is true when populations are growing rapidly.

b. Extensions to the GTAP-Dynamic Model

To capture the economic consequences of the projected demographic changes we adapt the now standard *GTAP-Dynamic* long-term dynamic model of the world economy (Ianchovichina and McDougall, 2000). It is based on the widely-used *GTAP Database*, which permits a very high level of country and commodity detail. We use the 14 regions indicated in Appendix 1 and, because our focus is not sectoral, products and services are aggregated into just three groups: food (including processed foods), industrial goods (mining and manufacturing) and services. These product groups are differentiated by region of origin, so that the "food" produced in Australia is not the same as that produced in other regions. Consumers substitute imperfectly between regional food aggregates as they do between food, industrial products and services. As in other dynamic models of the global economy, in *GTAP-Dynamic* the endogenous component of simulated economic growth is physical capital accumulation. Technical change is introduced in the form of exogenous trends. One important consequence of this is that the model exhibits the property of all dynamic models of the Solow-Swan type, namely that a slowdown in population growth also slows GDP growth but raises the time path of per capita income (see Chapter 4 in Pitchford, 1974).

Compared with other economy-wide models, the *standard version* of *GTAP-Dynamic* has a number of idiosyncrasies, on some of which improvement has been required. First, it has recursive multi-regional dynamics in which investment, and its distribution across regions, is driven by adaptive expectations about capital returns.[13] This approach is suited to the long term analysis of demographic change, so we have retained it. Second, the base period equilibrium is not usually a steady state and there are no restrictions on the steady

[13] This is unlike the McKibbin models, for example, since they offer roles for agents with perfect foresight. See Bryant, R.C. and W.J. McKibbin (1998, 2001).

states ultimately reached following shocks.[14] We have not found this property to cause any aberrant behaviour and so have retained it, also. Third, the process of physical capital accumulation is region-wide and not sector-specific. This requires the assumption that physical capital is perfectly mobile between industries in the very short run.[15] Again, while this could be problematic for short run analysis, the long run nature of demographic change renders it unimportant here. Finally, rates of saving from regional incomes are fixed, as are government shares of expenditure. This property of the standard model is problematic for demographic analysis, since the ageing of populations raises the proportion of retirees and reduces the average saving rate. Our adaptation alters this behaviour substantially.

The most substantial alteration is to sub-divide each regional household into eight age-gender groups, in parallel with the demographic sub-model. In the adaptation of *GTAP-Dynamic*, these eight age-gender groups differ in their consumption preferences, saving rates, labour supply and skill composition. Regional income is divided between government consumption and total private disposable income. Private disposable income is then split between the eight age-gender groups in a manner informed by empirical studies of age and gender specific consumption behaviour. For each age-gender group we then use a Keynesian consumption equation to split disposable income between saving and consumption expenditure.[16] Group private saving rates then become endogenous, depending on real disposable income and the real interest rate. Once group consumption expenditures are known, the standard *GTAP* CDE[17] consumption preferences are applied to each, with preference parameters varying to reflect age-gender differences in tastes. These modifications enable saving rates and consumption bundles to be responsive to both economic and demographic change.[18]

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[14] All regions have open capital accounts so that all inter-regional payments always balance. When a region's savings falls relative to its investment the gap between them is financed by foreign savings. If this happens over a sustained period the region's current account deficit can "blow out", implying that foreign claims on a region's domestic assets become large in relation to regional income.

[15] Most global dynamic models make this assumption. An exception at the regional level is Australia's MONASH model (Dixon and Rimmer 2002). This model has very substantial sectoral detail and physical capital accumulation is sector-specific. As yet, this behaviour has not been given global scope.

[16] This is an empirically based reduced form approach to the underlying intertemporal optimization problem solved by individuals in each group.

[17] This refers to the "constant difference of elasticities of substitution" demand system, which offers a practical approach to allowing non-homotheticity of preferences in large models. See Hertel et al. (1997).

[18] Direct taxation is not represented in the model and so government deficits are not endogenous. The distortionary effects of fiscal policy responses to ageing are therefore not considered in this paper. Their representation would not only require the incorporation of direct tax regimes but also the splitting of services so as to capture age-related demand (education, health and aged care, for example). While these changes are possible, they are not essential to the analysis of aggregate economic performance offered in this paper.

3. THE BASE LINE SCENARIO

The demographic module and the modified version of *GTAP-Dynamic* are used in combination to construct a total of four projections through 2030. The central projection is labelled the base line. It is designed as a "business as usual" projection, to serve as a reference when changes in demographic behaviour are introduced. It embodies all the future demographic change that is built into base period regional age distributions and exogenous trends in birth, death and migration rates. Importantly, however, all the further projections to be discussed differ from the base line in their demographic and labour force participation behaviour. All therefore have in common a number of assumptions about economic behaviour and the exogenous determinants of economic growth. Most important amongst these are the variation across regions of exogenous factor productivity growth and investment risk premia.

a. Exogenous Factor Productivity Growth

The *base line* scenario is particularly sensitive to assumptions about the exogenous sources of growth. They enter the model as factor productivity growth shocks, applied separately for each of the five factors of production.[19] The higher these are for a particular region, the larger is that region's marginal product of capital. The region therefore enjoys higher levels of investment and hence a double boost to its per capita income growth rate. Yet 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 (Ruttan 2002). More recent empirical studies focusing on advanced countries, such as those by the Productivity Commission (1999) 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.

The factor productivity growth rates assumed in all scenarios are drawn from a survey of recent empirical literature (Tyers et al. 2005). While our factor-specific rendering is only partially supported by this literature it offers a more complete characterisation of productivity growth and the potential for further experimentation with technology in the future.

[19] These are the standard primary factors from the GTAP global database: land, natural resources, physical capital, production (unskilled) labour and professional (skilled) labour.

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.

b. Investment Risk Premia

Aside from exogenous productivity growth, a key aspect of the base line projection is the allocation of investment across regions. The standard *GTAP-Dynamic* model takes no explicit account of interest premia associated with financial market immaturity and incompleteness or risk and so tends to allocate investment to regions that have the strongest growth in marginal products of physical capital. These tend to be the labour-abundant developing countries whose labour forces are still expanding rapidly. It finds Africa and Indonesia attractive prospects for this reason, yet we know that risk considerations limit the flow of foreign investment into these regions 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. To do this a risk premium variable (the *GTAP Dynamic* variable *SDRORT*) is made endogenous. This creates wedges between the international and regional interest rates. These interest premia are high for the populous developing regions of Indonesia, India, South America and Sub-Saharan Africa. They tend to fall over time in other regions, where labour forces are falling or growing more slowly, most prominently in China. The Chinese interest premium decline may be feasible, however, as a consequence of on-going financial reforms.[20]

The final base line simulation then frees up investment, but maintains the time paths of the regional interest premia as exogenous. As with the exogenous technical change represented by factor productivity growth rates, these premia are then held constant in all

[20] Maintaining investment growth in China despite the eventual decline in its labour force requires a substantial decline in China's interest rate relative to that paid in, say, North America. If this decline is beyond that achievable through financial reforms, our base line investment in China, and therefore China's projected economic growth rate, may be over-estimated. For more work on the implications for the Chinese economy, see Tyers and Golley (2006).

subsequent simulations. No allowance is therefore made for feedback between demographic change and either factor productivity or investment premia.

c. The Projection

Overall base line economic performance is suggested by Table 5, which lists the projected increments to regional real per capita incomes by 2030. In part because of its comparatively young population and hence its continuing rapid labour force growth, India attracts substantial new investment and is projected to take over from China as the world's most rapidly expanding region. This investment, combined with exogenous factor productivity growth, ensures that India is also projected to deliver the largest improvement in real per capita income through 2030. China's growth is slower in aggregate, because of its declining labour force, but its declining interest premium maintains a high level of investment growth sufficient to deliver the second largest proportional increase in real per capita income. Indonesia and "other East Asia" are also strong performers, while the older industrial economies continue to grow more slowly. The African and Middle Eastern regions enjoy good GDP growth performance but their high population growth rates limit their performance in per capita terms.

Slower population growth and ageing, through their effects on the supply of skilled and unskilled labour, alter regional patterns of comparative advantage and hence of trade. As labour forces decline in the older industrial regions (Figure 1), the shares of manufactures in their exports fall, especially in North America and Western Europe. In North America, this is accompanied by an increase in export share of agriculture, which is intensive in land and capital compared with manufacturing, while in Western Europe it is associated with an increased export share of services, which are capital intensive. The projected trend of international prices shows stable manufacturing and service prices but, relative to these, food product prices rise by about 15 per cent over the three decades.[21]

Among the major developing regions, India's rapidly expanding population, and especially the growth of its unskilled labour supply, drives the export share of its heavily labour-intensive food industry from 16 to 33 per cent by 2030. In the meantime, the share of industrial products falls from about two thirds to roughly half. The slow down and eventual

[21] Rising relative food prices appear to depart from the perspective of Lewis (1952) and Grilli and Yang (1988) which envisions declining raw commodity prices and consequent deterioration in the terms of trade of the world's poorest regions. When adjustments were made by Lipsey (1994) for changes in the quality of manufactures and the expansion in the consumer services provided by manufactured products, raw commodity prices are seen to be rising through time.

decline in China's population (Figure 1) is projected to reduce its unskilled labour force, while its supply of skilled labour continues to grow. Industrial products therefore continue to dominate China's exports with the share of relatively labour intensive food and agricultural products declining slightly.

4. THE ECONOMIC EFFECTS OF BASE LINE AGEING

The base line demographic and economic projections embody the continuation of the observed population slow-downs and ageing. They are subsequently to be compared with two alternative scenarios that are distinguished by changes in labour force regulation and migration policy. Before turning to these alternative scenarios, however, the effects of the ageing embodied in the base line are quantified by comparing it with a hypothetical "comparator" scenario in which the population growth and age distributions are held constant.

a. The Comparator Scenario

Most of the population ageing that appears in the base line through 2030 is already built in to the base year (1997) demographic structure, in the form of age-gender distributions and birth and death rates. Our hypothetical "comparator" scenario has the following properties.

- For each region, the populations of age-gender groups grow from 1997 at the annual rates recorded for the total regional population in that year
- Because all population groups within any region grow through time at the same rates, there are no changes in age distributions and therefore no age-driven changes in average saving rates, labour force participation or consumption
- Labour force participation rates are held constant so that, in each region, the labour force also grows at the population growth rate.

The annual growth rates used, and the 2030 regional populations in both the comparator and the base line projections are listed in Table 6. Note that, in the context of the range of stochastic projections of the global population reviewed by Duncan and Wilson (2004), the comparator scenario is high though within the 95 per cent confidence interval range, while the base line is very near the mean projection.

b. The Effects of the Ageing and Population Growth Slow-downs

Relative to the comparator projection, the base line embodies fertility declines and ageing in all, and slower population growth in almost all, regions. Since age distributions are fixed in the comparator simulation, it is possible for a base line population to grow faster,

though only temporarily. If the region has a very young population and it starts out with high fertility, its age distribution will change following the fertility decline so that an increased proportion survives into the fertile age group. Thus, even though births per woman decline, there is a temporary increase in the number fertile women. For similar reasons, it is more commonly true that base line labour forces show temporarily faster growth than the comparator. So long as a region's population is young at the outset, even if survival beyond 15 is not sufficient to outweigh the decline in fertility, the shift in the age distribution alone raises the labour force. This means that the consequences of fertility decline and ageing are quite different consequences for young populations in the developing regions than they are for the older industrialised regions.

It turns out that the only region for which the base line population grows faster than the comparator is Sub-Saharan Africa, which starts out with the highest fertility rate and the youngest population. As Table 6 shows, however, all base line populations, including that of Sub-Saharan Africa, fall below those of the comparator simulation by 2030. More regions have temporarily higher growth in labour forces, as is indicated by Figure 2, including Sub-Saharan Africa, India, Indonesia, South America and the Middle East and North Africa. Interestingly, the labour force of North America also expands temporarily. Amongst the developed regions it has a comparatively young population to begin with, and our incorporation of Mexico into North America strengthens this tendency. Yet, by 2030, only Sub-Saharan Africa has a base line labour force that is larger than the comparator. For some regions, the comparator and the base line are not greatly different. In particular, by the late 1990s population growth in Japan and Western Europe had already slowed and, in the case of Japan, begun to turn down. For these regions, the base line yields labour force levels that are only a few per cent smaller than those of the comparator.

While the popular discourse on ageing has focussed on its tendency to slow labour force growth and reduce saving in the industrialised world, this comparison shows that the opposite occurs in the developing world, at least up to 2020. Through 2030, at least, as average saving rates decline in rich regions they increase in developing regions because youthful populations survive into high-saving age groups, as shown in Figure 3. This, combined with the fact that slower population growth causes slower growth in aggregate demand and therefore in capital returns and investment demand, results in a smooth slow relative decline in regional average real rates of return on installed capital throughout the

world.[22] When we examine the actual volumes of global saving and investment, the relative significance of these effects is clarified (also shown in Figure 3). The dominant influence is clearly demand growth, which causes a slowdown in global investment relative to the comparator. This is almost matched by the fall in industrial country savings, the difference being made up by a comparatively small addition to savings volume from developing regions. Relative to the comparator simulation, then, slower population growth and reduced saving rates do not appear to cause any impending crisis in global capital markets.[23]

The pattern of GDP growth across the regions follows the trends in labour force growth relative to the comparator, as shown in Figure 4. Real GNP per capita tends to rise as population growth slows, a predisposition identified earlier. The one exception to this, however, is Western Europe, whose slow labour force growth tends to retard investment to such an extent that there is a slight decline in real per capita income relative to the comparator scenario. The volumes of output in each sector grow more slowly in the base line with the slowdown in production growth largest in food sectors globally. This is an Engel effect that follows from the increased per capita incomes in most regions and the slower population growth. Accordingly, the average global price of food products is lower relative to other product prices and this reduces growth in land and natural resource rents.

The effects on trade are also notable. In Western Europe and Japan, the slow down of population and labour force growth further weakens their manufacture sector. Western Europe's net imports of industrial products are larger by half, while Japan's are larger by a fifth. This is by contrast with North America, where the population and labour force actually rises slightly in the base line compared to that in the comparator. This shifts its comparative advantage towards labour-intensive industry and turns the region from a net importer of manufactured goods to a net exporter. As more resources are relocated to the industrial sector, North America's food production and exports fall. And since international food prices are lower in the base line, this improves North America's terms of trade. These changes notwithstanding, the most affected region is China. Its population and labour force are smaller in 2030 by more than a fifth. With less people to feed, China needs less food imports. Meanwhile the reduction in its supply of unskilled labour causes its manufactured sector to be

[22] The simulated decline relative to the comparator is a few per cent of the rate, or about 30 basis points.

[23] Poterba (2004) has similar findings of the impact of population ageing on the asset market in the United States between 2020 and 2050. In the long run, in most regions, the value of investment tends to fall off as population growth slows, maintaining rough capital account balance. In North America, however, there is a tendency for its young and expanding labour force to attract investment even while its aged population is growing and so its average saving rate is declining. The effect of this is for the North American current account deficit to widen. This is true to a much more modest extent in Western Europe, Japan and Australia while the savings to support this arises out of current account surpluses in East Asia.

smaller. Because China's aged tend to continue saving, and per capita income growth remains high, its substantial current account surplus is projected to continue. A numerical summary is provided in Table 7.

In sum, then, the introduction of ageing in all regions and associated slower population growth retards aggregate economic activity and savings, mainly in the industrialised regions. There is, however, a compensating boost in the developing regions sufficient to keep the global economy on a steady path, albeit with an increasing flow of financial capital from the developing to the industrialised regions and hence a tendency toward expanding current account deficits in the latter. All this structural change notwithstanding, real incomes per capita tend to be improved.

5. POLICY RESPONSES TO AGEING

While the global effects of slower population growth and ageing appear from the previous section to be non-destructive, they create challenges for governments. Since their budgets depend on tax bases and these depend, in turn, on GDP, slower GDP growth tends not to be favoured by them. Moreover, increased age dependency raises the fiscal burden in regions where health costs and retirement incomes are at least partially tax financed. These fiscal policy consequences are difficult to examine at a global level because the available databases, including the one used in this study, do not permit the clear delineation of age-specific service consumption. Nonetheless, it is possible to examine the broader economic implications of two policies designed to stem the effects of slower population growth and ageing, namely increased aged labour force participation (later retiring ages) and migration. To explore the possible implications of these for global economic performance, two further demographic scenarios are constructed for comparison with the base line. They are:

- *Increased aged participation*: the governments of Western Europe, Japan, North America and Australia increase retirement ages so that aged labour force participation is just sufficient to hold non-working aged dependency ratios constant from 2000 onwards
- *Replacement migration*: Western Europe, North America and Australia permit sufficient "replacement" migration to hold non-working aged dependency ratios constant from 2000 onwards.[24] This migration is permanent and so it is assumed that no migrant income is remitted to countries of origin.[25]

[24] For each destination region, the composition of migration flows across regions of origin, age and gender is held constant, while aggregate flows are inflated by a single factor. This factor is rendered endogenous by a

For *increased aged participation* in the advanced economies to be sufficient to hold non-working aged dependency ratios constant, 60+ participation rates in North America, Western Europe and Australia must approach those currently observed in Japan, while the Japanese aged male participation rate would need to rise to three quarters by 2030. The *replacement migration* solution requires still more dramatic change. Migration rates would be required to increase many-fold and, particularly in North America, the resulting population growth would be large. Still more dramatic would be the impacts of this migration on the source regions. Some, including Central Europe and the former Soviet Union, would have their working aged populations seriously depleted by 2020. Both these simulations are extreme and politically infeasible, yet they offer caricatures of policies under implementation or review, the analysis of which sheds light on future economic implications.

a. Increased Aged Participation

There are no changes in total populations relative to the base line, only more abundant labour in Australia, North America, Japan and Western Europe (Table 8). This raises marginal products of physical capital in the affected regions and they therefore attract larger shares of global investment, depleting the levels of investment in other regions (Figure 5). Again, the largest share of this investment is diverted from China in the long term. At the same time, these changes in the advanced regions confer terms of trade improvements on the other regions, which are clear from the rises in their home GDP prices relative to those of the advanced regions, as shown in Table 9. These terms of trade improvements are sufficient to ensure that the diversion of investment causes no substantial loss of real per capita income in the developing regions. Growth in the four industrialised regions is spurred by their added investment and they enjoy increased per capita incomes (also shown in Table 9). Of course, these increases come at the cost of reduced leisure for the old.

These real income increases tend to shift demand in favour of more income elastic industrial products and services, a shift which is exacerbated by the ageds' comparatively large expenditure shares on services in those regions. This, combined with the increased labour supplies, ensures that industrial and service output expands relative to agricultural output, as do industrial exports. There are no Rybczyinski contractions of other sectors in the industrialised regions, however. Both employment and output volume increase in all sectors.

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closure change that holds the non-working aged dependency ratio exogenous and constant. For a more general set of experiments with migration flows, see Tyers et al. (2006).

[25] Faini (2003) shows that permanent migrants tend not to send remittances to their countries of origin.

In the developing regions the changes are smaller, transmitted through improvements in their terms of trade on the one hand and the increased cost of funds for investment on the other. As the supply of labour grows in the advanced regions real GDP and hence aggregate demand expands, crowding the fixed factors. In the affected regions, therefore, both land and natural resource rents increase relative to regional GDP prices. Land and resource rents fall in the developing regions but real wages fall in both.

b. Replacement Migration

Replacement migration requires the relocation of substantial fractions of the populations of some regions of origin, most particularly "Central Europe and the former Soviet Union", "Other East Asia", the "Middle East and North Africa" and the "Rest of the World". Because the scale of this relocation is vast in the long term, this simulation is run to 2020 only. Interestingly, the migrations have the effect of raising the average global saving rate, by relocating young, high-saving groups from regions where the old also save to regions where the old tend not to save, while at the same time raising the real incomes of these groups.

The effect of the migration is to increase the labour forces of the destination regions and, since the migrants are generally younger than the destination populations, reduce their non-working aged dependency ratios (Figure 6 and Table 10). Moreover, since the working-age groups have the highest saving rates and the elderly have negative saving in these regions, saving rates in the destination regions rise significantly (also shown in Figure 6) while they tend to fall in the main regions of origin. In the expanding destination regions there is a tendency for the real wage to fall (Table 11), reducing the costs of tradeable goods and depreciating their real exchange rates. The latter can be seen from comparisons of the paths of GDP prices in Figure 8 and the changes shown in Table 11. 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. Real GDP expands significantly in all the destination regions, relative to the base line, for both these reasons, as shown in Figure 7 and Table 11.

The redirection of investment to the destination regions might at the outset be expected to expand their current account deficits, but this tendency is offset by the strong rises in their average saving rates and the corresponding falls in those of regions of origin. The new scarcity of labour in the regions of origin raises real wages relative to the base line, causing real appreciations (which are, again, discernable from Figure 8).

The tendency for population increases to suppress real per capita income is at least partially offset, in the case of immigration, by increased investment. The scale of the new investment in the recipient regions is, nonetheless, insufficient to reverse the tendency, as is also shown in Figure 8. Yet the effects on the real per capita incomes of the destination regions are non-uniform, with Western Europe suffering a comparatively modest per capita income penalty. This is because of differences in the effects of the migration on the terms of trade. Note from the GDP price effects that Western Europe experiences a substantial real appreciation relative to the other destination regions. This also indicates an improvement in its terms of trade relative to those regions. It occurs because, compared with North America and Australia, Western Europe has greater trade with the regions from which its immigrants come. The flow therefore tends to reduce its import demand and export supply, shifting the terms of trade in its favour. In the other destination regions, trade is most intensive with non-source regions and their terms of trade are dominated by the effects of their wage reductions and hence their real depreciations against all trading partners. So Western Europe, by 2020, attracts a labour force expansion by more than half, its real GDP increases by almost half yet its real per capita income falls only by seven per cent.[26] Ignoring environmental and congestion externalities, this does suggest substantial benefits for indigenous Europeans.

Turning, finally, to the implications for product markets, the destination regions experience a surge in aggregate demand as new investment follows their rising labour forces. The supply of all products and services increases in these regions. Correspondingly, supply declines relative to the base line in the main regions of origin. Yet, for the world as a whole there is a substantial net increase in output in all three sectors. This has two sources. First, the average saving rate is higher following the migration, as indicated earlier, so the rate of global capital accumulation is greater following the migrations. Second, there is a productivity gain associated with moving workers from poor countries where labour productivity is low to rich countries where it is comparatively high. Of course the latter contribution rests on the assumption that immigrants assume the productivity level of indigenous workers in the region of destination.[27] In the food and industrial sectors this rise in net global output is smaller because of their dependence on the fixed factors land and

[26] This compares with the increase of 171 per cent projected for Western Europe over the level of per capita income in 1997.

[27] This assumption is borne out in the empirical literature, though there tends to be a lag of up to a decade following arrival for its full realisation (personal communication, Professor Tim Hatton, Australian National University).

natural resources. Land and natural resource rents rise substantially in the destination regions and fall by smaller proportions in the regions of origin.

6. CONCLUSION

An analysis of demographic change and labour force participation confirms that the populations in several key regions, including Western Europe, Central Europe, the Former Soviet Union and Japan, are likely to decline in the near future at rates previously unanticipated. Moreover, the population of China will also begin declining in the next decade and the labour forces of Western and Central Europe, the former Soviet Union, Japan and China are all likely to decline sooner and more dramatically. To analyse the economic effects of this, the global demographic analysis is linked to a dynamic model of the global economy that has multiple age-gender groups. A base line projection is constructed for the world economy through 2030, incorporating expected future demographic change. This base line is then compared with a constant and uniform population growth scenario. The comparison shows that the ageing of populations and labour forces that accompanies the population growth slowdowns will reduce the total volume of saving in the older industrial regions.

Yet the fear that this would lead to a tightening in world capital markets, a fall in asset values and a slow-down in per capita economic growth is not borne out. Slower population growth does slow the growth of aggregate demand and hence investment by almost as much as the ageing process reduces saving in the industrialised regions. The savings shortfall that emerges is then readily met by a rise in saving in the developing and middle-income regions, whose populations are now young and so have increasing saving rates as the very young survive to working age. The effect of the slower population growth and the ageing is therefore to cause global interest rates to be gently lower than they would otherwise be.

Another consequence of slower population growth and ageing in the industrialised regions is increased aged dependency ratios. These are likely to induce governments to attempt to arrest the declines in their workforces by increasing labour force participation by the aged and expanding immigration. Should governments in the advanced economies seek to raise aged participation rates, those economies would be larger as investment is attracted by their larger labour forces and so their per capita incomes would increase at the expense of aged leisure. Output would be higher in these advanced regions and fixed factor rents would rise there. Yet the developing regions would also gain from higher participation in the advanced regions, via improvements in their terms of trade.

Replacement migration to regions with rising aged dependency would have very substantial demographic and economic impacts. In most recipient regions, real wage rates would fall and more investment would be attracted but the resulting acceleration in capital accumulation would not be sufficient to offset the tendency for the labour supply increase to reduce real per capita income. Moreover, the expanded population would further "crowd" fixed factors, causing land and natural resource rents to rise. Only in Western Europe would the tendency for the increased population to suppress per capita income be substantially offset by a combination of the diversion of investment from other regions and an improvement in the terms of trade. Relative to other destination regions, Western Europe has a greater proportion of trade with the regions from which its migrants come. This migration is therefore a substitute for trade, reducing Western Europe's trade dependency so that the resulting terms of trade improvement would more than offset the effect of the labour force enlargement on costs and the real exchange rate. Real per capita income in Western Europe would therefore be impaired only slightly, though this comparative improvement over the performance of the other destination regions would occur at the expense of output and income in regions of origin, particularly Central Europe and the former Soviet Union.

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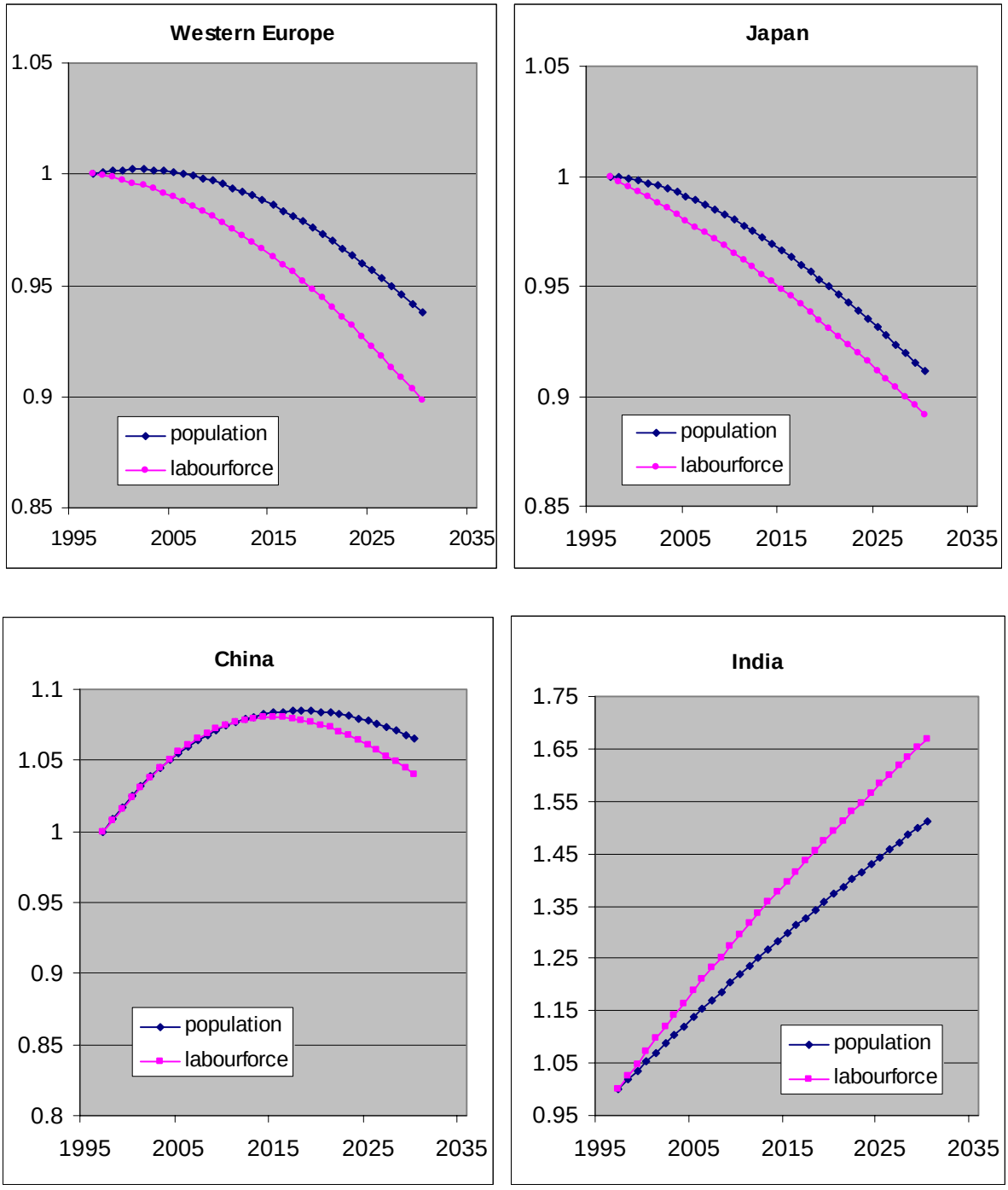

Figure 1: Base Line Population and Labour Force Projections

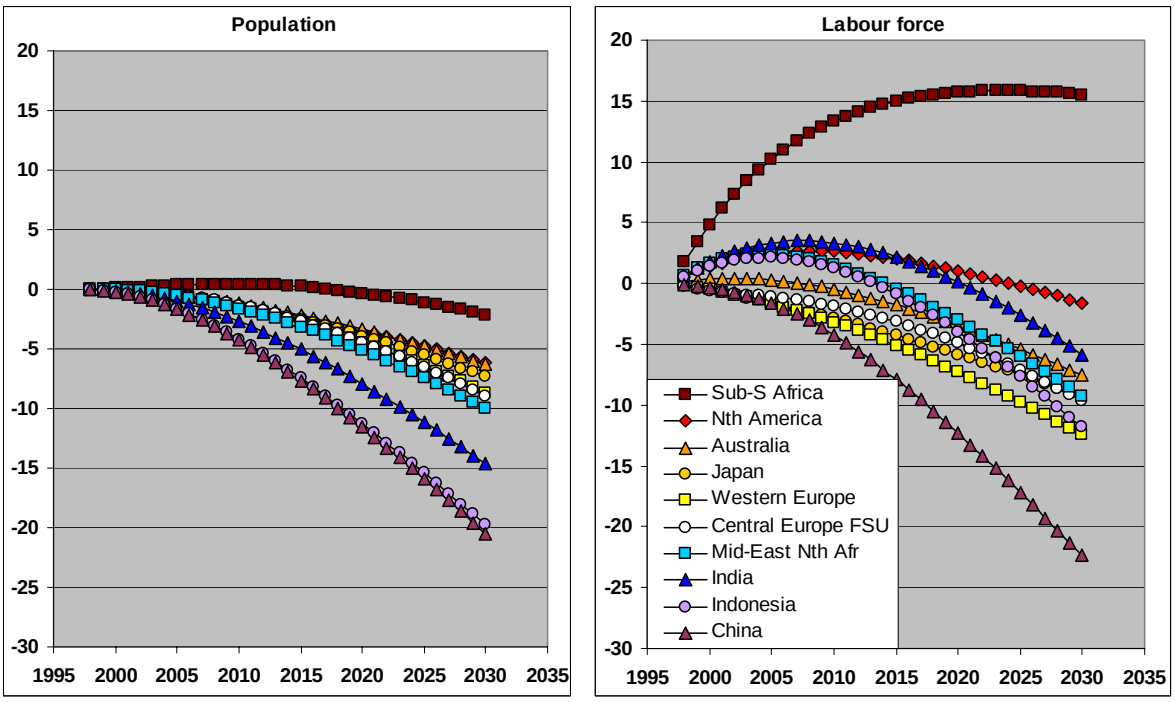

Figure 2: Base Line Relative to Comparator Populations and Labour Forces, (% departure)

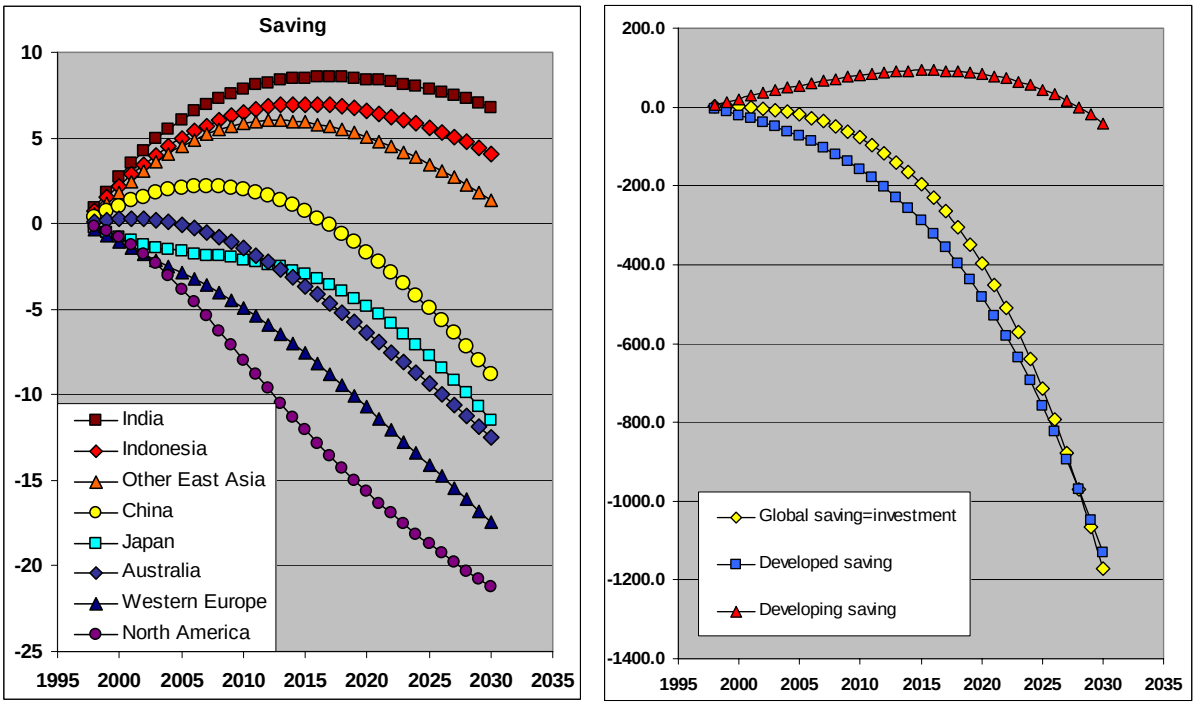

Figure 3: Base Line Relative to Comparator Savings and Global Investment
(% departure and difference in 1997 US$ billions)

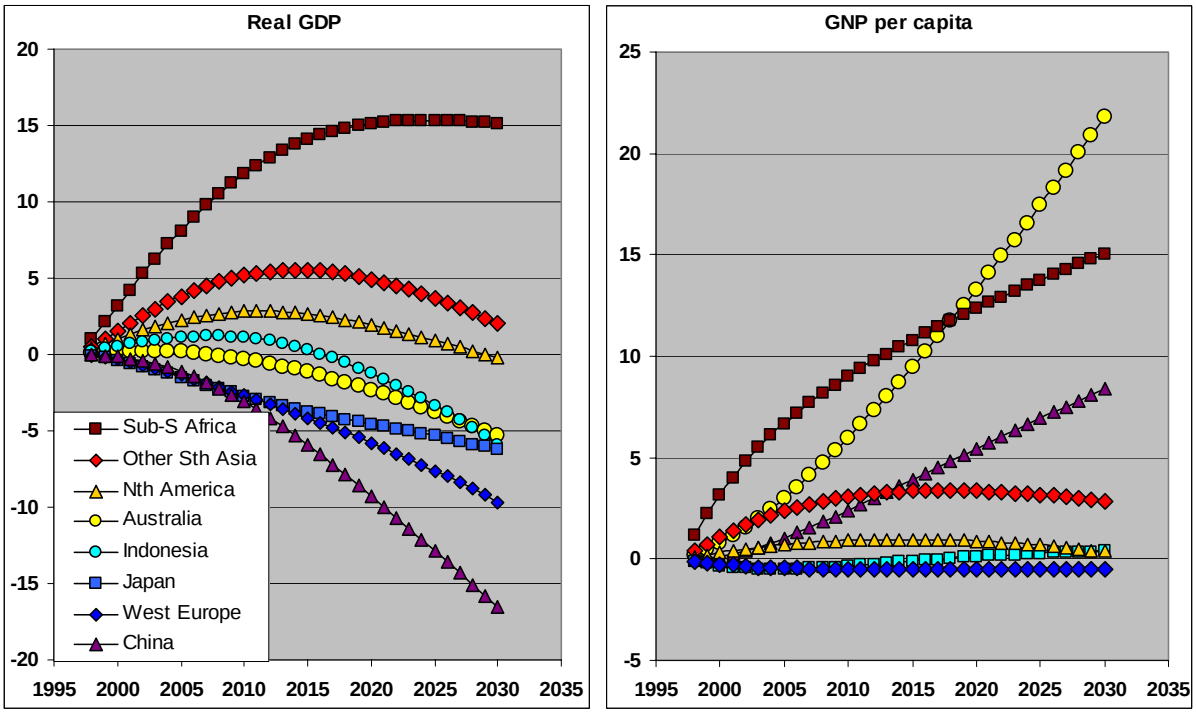

Figure 4: Base Line Relative to Comparator GDP and GNP per capita (% departure)

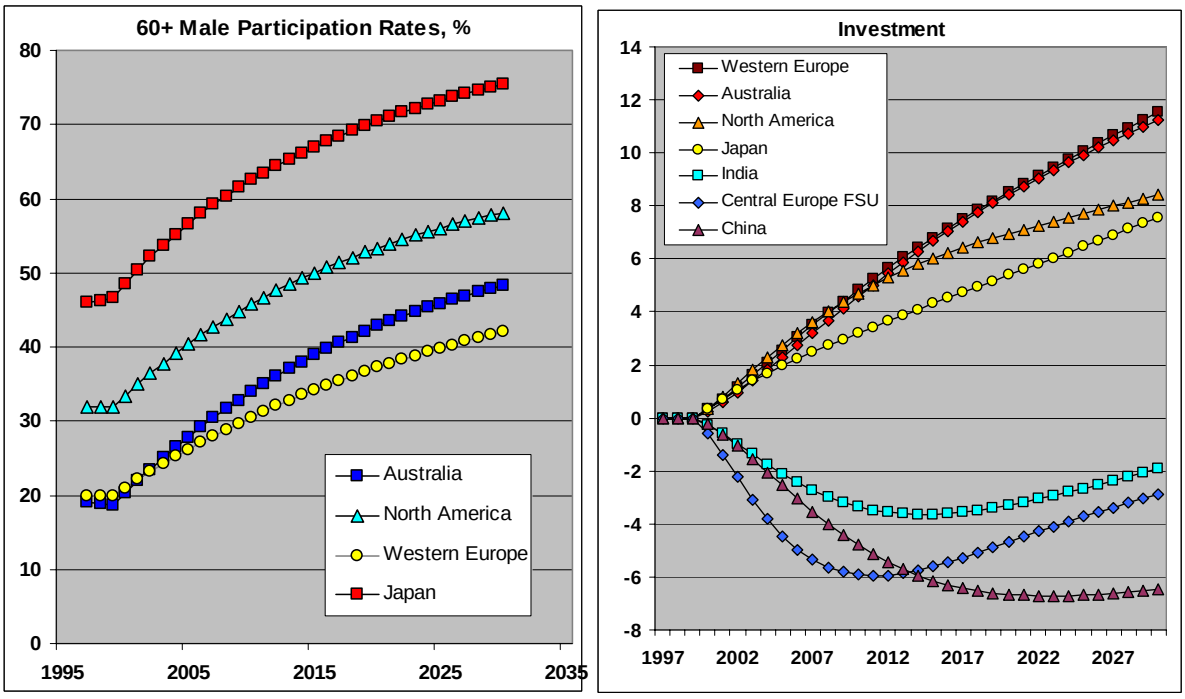

Figure 5: Increased Aged Participation Scenario

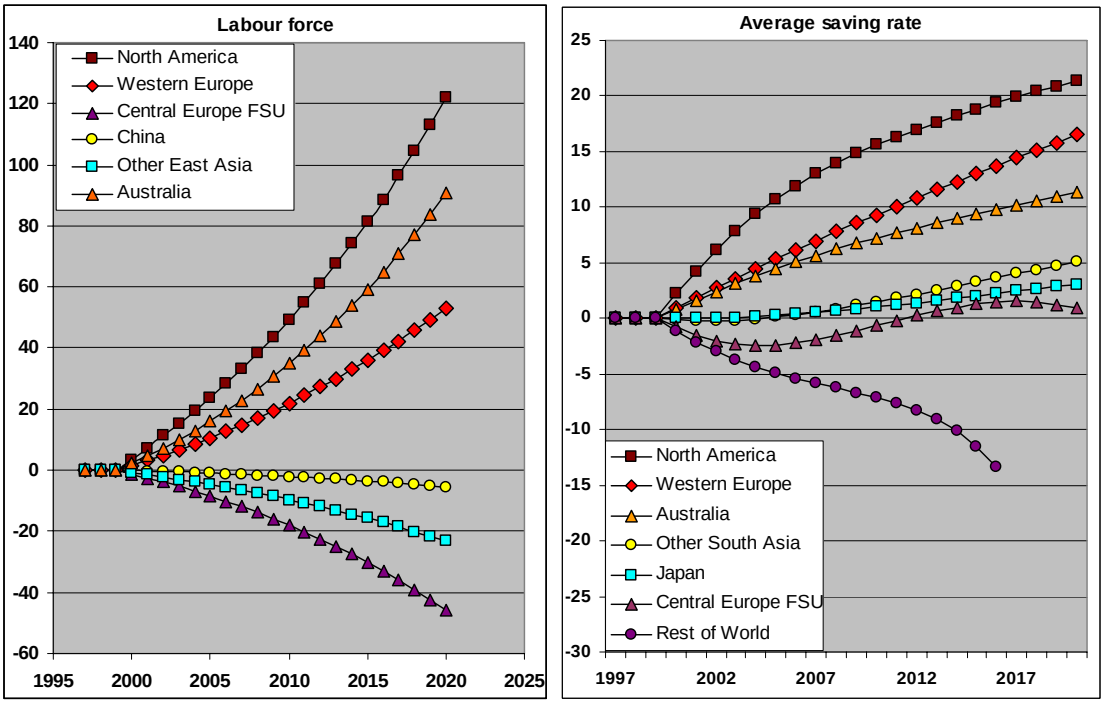

Figure 6: "Replacement Migration", Labour Force and Average Saving Rate, Departure from Base Line, %

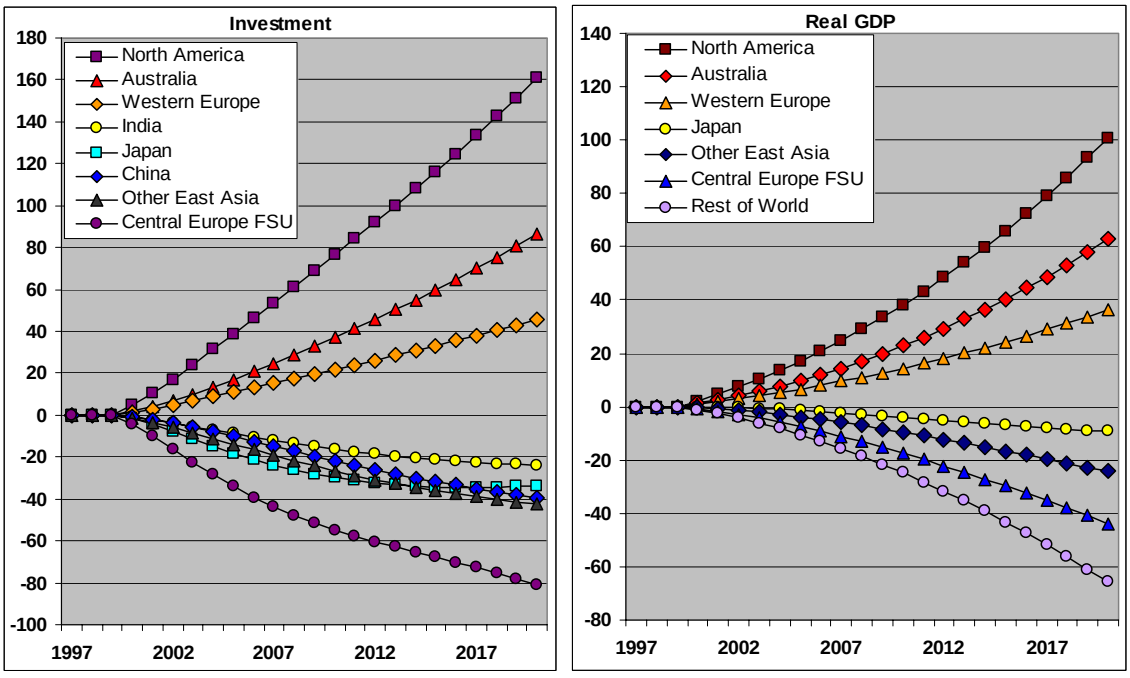

Figure 7: "Replacement Migration" Investment and Real GDP, Departure from Base Line %

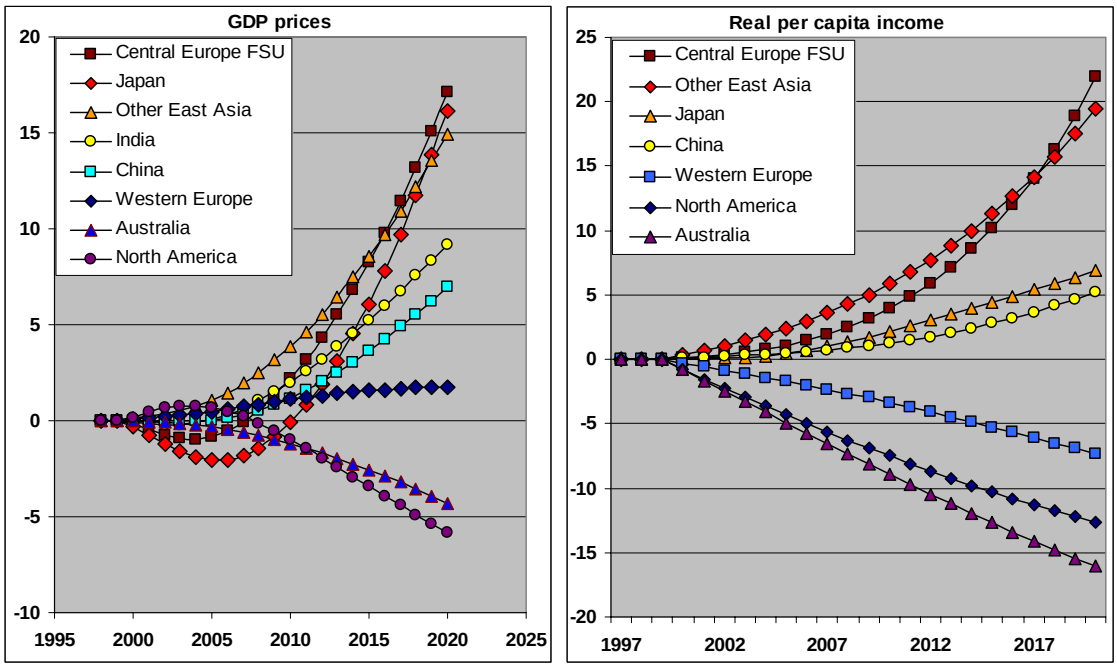

Figure 8: "Replacement Migration" GDP Prices and Real per Capita Income, Departure from Base Line, %

Table 1: Regional Composition

Region	Composition of aggregates
Australia	
North America	Canada, Mexico, United States
Western Europe	European Union, including Switzerland and Scandinavia but excluding the Czech Republic, Hungary and Poland
Central Europe and the former Soviet Union	Central Europe includes the Czech Republic, Hungary and Poland
Japan	
China	Includes Hong Kong and Taiwan
Indonesia	
Other East Asia	Republic of Korea, Malaysia, the Philippines, Singapore, Thailand and Vietnam
India	
Other South Asia	Bangladesh, Bhutan, Maldives, Nepal, Pakistan and Sri Lanka
South America	Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, Venezuela, Uruguay
Middle East and Nth Africa	Includes Morocco through the Islamic Republic of Iran
Sub-Saharan Africa	The rest of Africa
Rest of World	Includes the rest of Central America, Indochina, the small Island states of the Pacific, Atlantic and Indian Oceans and the Mediterranean Sea, Myanmar and Mongolia, New Zealand, the former Yugoslavia and the rest of Central America

Table 2: Base Line Projection of Population Levels and Compositions:

	Population, millions		**% Female**		**% 60+**	
	Initial	**2030**	**Initial**	**2030**	**Initial**	**2030**
Australia	19	24	50.2	50.9	16.1	23.9
North America	403	529	50.8	50.6	13.9	21.6
Western Europe	421	395	51.2	51.1	21.2	29.1
Central Europe	388	319	52.3	52.2	16.3	24.8
Japan	126	115	51.0	51.0	21.9	34.4
China	1272	1355	48.5	49.1	9.7	21.4
Indonesia	201	272	50.2	50.2	7.2	14.6
Other East Asia	282	380	50.2	5.00	7.6	16.9
India	955	1444	48.2	48.9	6.9	14.2
Other South Asia	372	664	48.8	48.6	5.7	11.5
South America	335	489	50.4	50.1	8.0	16.7
Mid East Nth Africa	331	561	49.1	49.2	6.1	13.2
Sub-Saharan Africa	586	1153	50.4	51.0	4.6	7.0
Rest of World	215	311	50.0	50.1	8.2	18.0

Source: Projection using the model described in the text and as presented in more detail by Chan and Tyers (2006).

Table 3: 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 Africa	103	176	24	23	30	42
Sub-Saharan Africa	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 and Tyers (2006).

Table 4: Base Line Non-Working Aged Dependency Ratios

Regions	**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 Africa	0.15	0.33
Sub-Saharan Africa	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 5: Base Line Real Per Capita Income Projection to 2030

(Ranked by performance)

	% change over 1997	Implied annual average growth rate, % per year
India	369	4.8
China	361	4.7
Indonesia	350	4.7
Other East Asia	341	4.6
Central Europe FSU	218	3.6
Japan	207	3.5
Australia	185	3.2
Western Europe	171	3.1
Other South Asia	156	2.9
South America	142	2.7
Rest of World	141	2.7
North America	139	2.7
Sub-Saharan Africa	125	2.5
Mid-East Nth Africa	88	1.9

Source: The base line projection described in the text.

Table 6: The Comparator and Base Line Demographic Projections[a]

Region	Comparator projection		Base line projection	
	Annual growth rate (base line 1997-8) %/yr	2030 population, millions	2030 population, millions	% departure from comparator projection in 2030
Australia	0.90	26	24	-6.4
North America	1.02	564	529	-6.2
Western Europe	0.08	433	395	-8.8
Central Europe	-0.31	350	319	-8.9
Japan	-0.05	124	115	-7.5
China	0.89	1704	1355	-20.5
Indonesia	1.59	338	271	-19.8
Other East Asia	1.49	459	380	-17.1
India	1.75	1694	1445	-14.7
Other South Asia	2.09	736	665	-9.7
South America	1.61	568	489	-13.9
Mid East Nth Afr	1.94	625	562	-10.1
Sub-Saharan Africa	2.14	1180	1153	-2.3
Rest of World	1.77	384	311	-19.1
Total, world	1.27	9184	8012	-12.8

a The comparator projection has annual growth rates constant for each region at the 1997-8 rate. There are no changes in age-gender distribution and labour forces grow at the same rate as populations. This projection is a contrivance to demonstrate the effects of ageing and slower growth in the base line projection.

Source: The comparator projection is as described in the text and the base line results are more fully documented in Tables 2 and 3.

Table 7: Base Line Relative to Comparator – Selected Key Variables, per cent Departure in 2030

	Labour force	Average saving rate	Real invest-ment	Real GDP	GDP price[a]	Real per capita income	Produc-tion wage[b]	Land rent[b]	Resource rent[b]	Food Output	Industrial output	Services output
Australia	-7.5	-6.1	-6.2	-5.3	-1.1	0.4	0.9	-15.7	-4.2	-8.6	-3.4	-5.3
North America	-1.6	-16.5	-0.8	-0.3	-2.5	2.9	-0.4	-5.3	0.5	-1.6	3.2	-0.9
Western Europe	-12.5	-9.6	-11.2	-9.7	0.7	-0.5	3.2	-21.5	-9.3	-14.3	-11.8	-9.2
Central Eur, FSU	-9.6	0.4	-5.2	-6.3	-0.1	3.2	3.7	-14.6	-5.4	-8.6	-5.9	-6.3
Japan	-9.4	-6.6	-1.1	-6.2	2.3	0.4	6.2	-19.0	-6.7	-13.3	-10.2	-5.4
China	-22.4	5.6	-17.2	-16.5	1.1	8.4	9.4	-26.6	-13.3	-16.1	-17.1	-16.4
Indonesia	-11.8	6.8	-8.7	-5.9	0.2	21.8	9.4	-14.9	-5.4	-8.0	-6.5	-5.0
Other East Asia	-13.8	6.2	-10.4	-9.0	0.5	15.1	8.0	-16.7	-7.9	-8.9	-10.0	-8.4
India	-5.8	7.1	-1.0	-0.9	-0.9	18.0	4.4	-9.0	-0.2	-3.8	-0.3	-0.4
Other South Asia	0.1	2.5	1.1	2.0	-2.2	12.5	0.1	-3.4	3.0	-0.7	5.8	2.0
South America	-7.4	5.1	-7.7	-4.6	-0.5	12.6	3.5	-11.5	-4.3	-6.2	-4.8	-4.2
Mid East Nth Africa	-9.2	11.0	-6.8	-5.4	0.1	7.2	4.4	-12.4	-4.5	-8.2	-4.4	-5.7
SubSaharan Africa	15.5	9.6	16.0	15.1	-4.2	15.0	-4.7	13.3	13.7	10.0	19.9	14.6
Rest of World	-6.3	5.7	-6.5	-1.3	-1.5	22.9	4.2	-14.3	-1.2	-7.5	-0.2	-0.9

a The GDP price is measured relative to the common numeraire in *GTAP-Dynamic*. Note relative values only, indicative of real exchange rate changes.
b All domestic factor and product prices are measured relative to regional GDP prices.
Source: Simulations of the model described in the text.

Table 8: Effects in 2030 of "Increased Aged Participation" (to Retain Fixed Aged Dependency), Compared with Base Line Scenario

Per cent change	Labour force		Non-working aged dependency ratio
	Total	60+	Aged NW
Australia	13.0	248.3	-32.8
North America	9.1	98.9	-31.3
Western Europe	12.3	141.7	-29.0
Japan	10.8	43.2	-30.2

Source: Simulation results from the model described in the text.

Table 9: "Increased Participation" - Product and Factor Prices, per cent Departure from the Base Line in 2030

	Labour force	Av saving rate	Real invest-ment	Real GDP	GDP price[a]	Real per capita income	Produc-tion wage[b]	Land rent[b]	Resource rent[b]	Food Output volume	Industrial output volume	Services Output volume
Australia	13.0	0.4	11.2	9.9	-1.9	8.8	-1.2	13.7	10.2	7.6	11.0	10.0
North America	9.1	1.8	8.4	7.9	-1.3	7.3	0.7	8.2	8.1	4.2	9.2	7.8
Western Europe	12.3	0.6	11.5	9.6	-1.2	8.5	-0.9	12.3	9.4	7.5	11.4	9.4
Central Eur, FSU	0.0	1.9	-2.9	-1.7	0.9	0.0	-1.4	-3.3	-2.8	-1.5	-3.0	-1.3
Japan	10.8	-1.3	7.6	7.9	-0.7	7.6	-1.3	7.2	6.8	4.3	7.9	8.0
China	0.0	0.7	-6.5	-3.0	0.6	-0.1	-2.5	-2.6	-3.0	-0.5	-3.4	-3.3
Indonesia	0.0	0.3	-1.6	-1.4	0.9	0.4	-1.1	-2.4	-2.3	-0.9	-2.8	-0.8
Other East Asia	0.0	0.2	-2.3	-1.6	1.2	1.2	-1.2	-3.2	-2.9	-1.2	-3.6	-0.8
India	0.0	0.5	-1.9	-1.3	1.0	-0.1	-1.2	-2.5	-2.0	-0.7	-2.6	-1.2
Other South Asia	0.0	1.4	-2.4	-1.2	0.6	-0.1	-0.9	-2.2	-1.6	-0.7	-2.2	-1.1
South America	0.0	1.0	-2.2	-1.2	0.9	0.3	-1.1	-3.5	-1.8	-1.9	-2.1	-0.7
Mid East Nth Africa	0.0	1.1	-1.8	-1.0	0.9	0.7	-1.0	-3.6	-2.2	-2.0	-2.4	-0.5
SubSaharan Africa	0.0	1.3	-1.2	-0.6	0.4	0.3	-0.6	-1.9	-1.0	-1.0	-1.3	-0.2
Rest of World	0.0	1.0	-1.4	-1.0	0.9	0.3	-0.9	-2.8	-1.8	-1.3	-2.2	-0.5

a The GDP price is measured relative to the common numeraire in *GTAP-Dynamic*. Note relative values only, indicative of real exchange rate changes.
b All domestic factor and product prices are measured relative to regional GDP prices. Capital goods prices are omitted. Where these rise substantially, all three product prices can fall relative to the GDP price.
Source: Simulations of the model described in the text.

Table 10: Effects in 2020 of "Replacement Migration" (to Retain Fixed Aged Dependency), Compared with Base Line Scenario[a]

Per cent change	Population		Labour force		Non-working aged dependency 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 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 11: "Replacement Migration" - Product and Factor Prices, per cent Departure from the Base Line in 2020[a]

	Labour force	Average saving rate	Real invest-ment	Real GDP	GDP price[b]	Real per capita income	Produc-tion wage[c]	Land rent[c]	Resource rent[c]	Food Output volume	Industrial output volume	Services Output volume
Australia	90.6	11.3	86.4	62.8	-4.3	-16.1	-12.7	113.1	60.6	52.8	66.5	63.0
North America	121.8	21.4	160.8	100.8	-5.9	-12.7	-8.8	183.7	102.6	77.3	123.3	97.0
Western Europe	52.8	16.5	45.8	36.4	1.8	-7.3	-8.7	80.8	31.7	43.9	40.4	35.4
Central Europe,FSU	-45.8	0.9	-80.8	-43.9	17.1	22.0	5.5	-62.6	-47.2	-41.9	-49.7	-41.8
Japan	0.0	3.1	-33.8	-9.2	16.1	6.9	-6.7	-26.1	-22.3	-16.4	-25.3	-6.4
China	-5.5	1.8	-39.4	-14.8	6.9	5.2	-7.6	-12.8	-13.5	-4.3	-15.6	-16.8
Indonesia	-0.2	1.3	-19.0	-7.3	7.8	0.7	-5.4	-8.4	-9.7	-3.1	-11.5	-5.7
Other East Asia	-23.3	-1.5	-42.5	-24.2	14.9	19.5	1.0	-33.4	-29.1	-16.8	-33.9	-20.2
India	-4.6	2.0	-23.9	-10.1	9.2	1.3	-4.5	-12.8	-12.9	-4.3	-15.9	-10.1
Other South Asia	-9.3	5.0	-28.3	-11.8	9.2	3.6	-1.2	-16.5	-13.9	-6.8	-17.6	-12.0
South America	-9.0	4.8	-30.1	-12.6	9.4	3.9	-3.4	-21.0	-14.7	-12.2	-17.0	-11.2
Mid East Nth Africa	-12.6	4.8	-34.1	-15.1	11.0	9.9	-2.7	-30.9	-20.2	-19.6	-21.3	-12.6
Sub-Saharan Africa	-6.5	7.6	-22.6	-8.8	8.2	2.6	-2.0	-15.5	-11.1	-9.1	-12.6	-7.2
Rest of World	-80.7	-33.9	-97.1	-65.8	38.2	117.8	65.4	-89.4	-70.1	-72.6	-74.2	-61.3

a This simulation extends only to 2020. Thereafter, migration more than depletes some regional age-gender groups.
b The GDP price is measured relative to the common numeraire in *GTAP-Dynamic*. Note relative values only, indicative of real exchange rate changes.
c All domestic factor and product prices are measured relative to regional GDP prices. Capital goods prices are omitted. Where these rise substantially, all three product prices can fall relative to the GDP price.
Source: Simulations of the model described in the text.