PRELIMINARY DRAFT
Results under revision

Global Demographic Change and Economic Performance: Implications for Agricultural Markets*

Ming Ming Chan, Qun Shi and Rod Tyers**

Faculty of Economics and Commerce
Australian National University

Presented at the 49th annual conference of the Australian Agricultural and Resource Economics Society, Coffs Harbour, 9-11 February 2005.

* Funding for the research described in this paper is from Australian Rural Industries Research and Development Corporation grant No. ANU-51A, to address "Global Demographic and Income Trends: Their Implications for Food Consumption". Thanks are due to Heather Booth and Siew Ean Khoo for helpful discussions about the demography, to Jeff Davis, Brett Graham, Ron Duncan, Robert McDougall and Hom Pant for contributions to the economic analysis and to Terrie Walmsley for technical assistance with the GTAP Database. Jahnvi Vedi and Jyoti Pant provided research assistance in the later stages of the study.

** Ming Ming Chan is an ANU graduate in actuarial studies who is now with Mercer Human Resource Consulting of Melbourne, Qun Shi is postdoctoral fellow in economics and Rod Tyers is professor of economics.

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Abstract:

Errors in projecting demographic change have been considerable in recent decades. The fertility declines and increased longevity associated with the concluding global demographic transition have been surprisingly rapid, leading to accelerated ageing of populations in developed countries and in several advanced developing countries. This paper introduces a global demographic model for the analysis of these changes, from which emerge their implications 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 a global economic model in which regional households are disaggregated into eight components comprising four age groups and two genders. Demographic change is found to act most significantly through variations across age groups in savings behaviour and its effects on aggregate savings and investment and their international distribution. Corresponding variation in labour force participation is also significant, acting through labour supply growth and the pattern of comparative advantage. Secondary effects arise from variations in consumption preferences across age groups.

1. Introduction

The world economy is being shocked by changes in demographic behaviour, including to fertility, mortality, migration and the sex ratio at birth, some of which 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]

[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.

has been path-breaking in that it has demonstrated the very substantial implications of demographic 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 using a complete demographic model in 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 in those regions, relative to Australia, and for Australia's economic relations with them.

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. We then consider the effects of alternative demographic scenarios. 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

[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.

departures from the base line and each has important implications for overall economic performance as well as the behaviour of global agricultural product markets.

The key mechanisms by which demographic change affects agriculture transmit via both the demand and supply sides. Population growth raises aggregate and hence agricultural demand, with relative price effects then depending on both income elasticities of demand the growth rate of supply in the agricultural relative to other sectors. 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, which advantages agriculture. When population growth is associated with ageing, however, the composition of consumption also changes, with the net effects on agricultural demand unclear. On the supply side, changes in the size and composition of the population correspondingly change the size and composition of the labour force. 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, when demographic changes change the age distribution, the overall saving rate alters. 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 of 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 global markets for agricultural products. Section 5 then offers 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

[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).

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 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. 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, though this awaits inter-linkage with the broader model of the global economy.

In any year, for each age group, *a*, gender group *g*, region of origin, *r* and region of destination, *d*, the volume of migration flow is:

$$M^{t}_{a,g,r,d} = \delta^{t}_{d} M^{R}_{a,g,r,d} N^{t}_{a,g,d}, \quad \forall a,g,r,d \ , \tag{1}$$

where δ^{t}_{d} is a destination-specific factor reflecting immigration policy in region *d*, set to unity in all but counterfactual experiments, M^{R}_{agrd} is the migration rate between *r* and *d* expressed as a proportion of the group population in region *d*, N_{agd}.

Given the migration matrix, M_{agrd}, the population in each age and gender group and region can be constructed. We begin with the population of males aged 0-14 in region *d* (*a=014, g=m, r=d*).

$$\begin{aligned} N^{t}_{014,m,d} = {} & N^{t-1}_{014,m,d} + \frac{S^{t}_{d}}{1+S^{t}_{d}} B^{t}_{d} N^{t-1}_{1539,f,d} - D^{t}_{014,m,d} N^{t-1}_{014,m,d} \\ & + \sum_{r} M^{t}_{014,m,r,d} - \sum_{r} M^{t}_{014,m,d,r} - \frac{1}{15}\left[N^{t-1}_{014,m,d} - D^{t}_{014,m,d} N^{t-1}_{014,m,d} \right], \quad \forall d \end{aligned} \tag{2}$$

where S^{t}_{d} is the sex ratio at birth (the ratio of male to female births) in region *d*, B^{t}_{d} is the birth rate and $D^{t}_{014,m,d}$ the death rate. The final term is survival to the corresponding 15-39 age group. For females in this age group the corresponding equation is:

$$N^t_{014,f,d} = N^{t-1}_{014,f,d} + \frac{1}{1+S_d} B^t_d N^{t-1}_{1539,f,d} - D^t_{014,f,d} N^{t-1}_{014,f,d} + \sum_r M^t_{014,f,r,d} - \sum_r M^t_{014,f,d,r} - \frac{1}{15}\left[N^{t-1}_{014,f,d} - D^t_{014,f,d} N^{t-1}_{014,f,d} \right], \quad \forall d \tag{3}$$

For adults of gender *g* in the age group 15-39 the equation is:

$$N^t_{1539,g,d} = N^{t-1}_{1539,g,d} + \frac{1}{15}\left[N^{t-1}_{014,g,d} - D^t_{014,g,d} N^{t-1}_{014,g,d} \right] - D^t_{1539,g,d} N^{t-1}_{1539,g,d} + \sum_r M^t_{1539,g,r,d} - \sum_r M^t_{1539,g,d,r} - \frac{1}{25}\left[N^{t-1}_{1539,g,d} - D^t_{1539,g,d} N^{t-1}_{1539,g,d} \right], \quad \forall g,d \tag{4}$$

where the second term is the surviving inflow from the 0-14 age group and the final term is the surviving outflow to the 40-59 age group. The population of adults of gender *g*, in age group 40-59 follows as:

$$N^t_{4059,g,d} = N^{t-1}_{4059,g,d} + \frac{1}{25}\left[N^{t-1}_{1539,g,d} - D^t_{1539,g,d} N^{t-1}_{1539,g,d} \right] - D^t_{4059,g,d} N^{t-1}_{4059,g,d} + \sum_r M^t_{4059,g,r,d} - \sum_r M^t_{4059,g,d,r} - \frac{1}{20}\left[N^{t-1}_{4059,g,d} - D^t_{4059,g,d} N^{t-1}_{4059,g,d} \right], \quad \forall g,d \tag{5}$$

For adults in the 60+ age group, the corresponding relationship is:

$$N^t_{60+,g,d} = N^{t-1}_{60+,g,d} + \frac{1}{20}\left[N^{t-1}_{4059,g,d} - D^t_{4059,g,d} N^{t-1}_{4059,g,d} \right] - \frac{1}{L^t_{60+,g,d}} N^{t-1}_{60+,g,d} + \sum_r M^t_{60+,g,r,d} - \sum_r M^t_{60+,g,d,r}, \quad \forall g,d \tag{6}$$

where the third term indicates that deaths from this group each year depend on its life expectancy at 60, $L^t_{60+,g,d}$.

Sources and structure:

The demographic sub-model and the economic model both cover the 14 regions, *r,* listed in Table 1. 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[9] and are held constant through time.[10]

Asymptotic trends in other parameters:

[9] 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.

[10] The migration rates and the corresponding birth rates are listed in detail in Chan and Tyers (2004: Tables 2-5).

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:

$$B_r^t = B_r^0 + \left(B_{Tgt}^0 - B_r^0\right)\left(1 - e^{\beta t}\right) , \tag{8}$$

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

$$B\dot{x}_r^0 = \frac{B_r^1 - B_r^0}{P_r^0} = \frac{\left(B_{Tgt}^0 - B_r^0\right)\left(1 - e^{\beta}\right)}{B_r^0} , \text{ so that} \tag{9}$$

$$\beta = \ln\left[1 - \frac{B_r^0 \hat{P}_r^0}{B_{Tgt}^0 - B_r^0}\right] . \tag{10}$$

The birth rates and death rates, thus calculated, are presented in detail by Chan and Tyers (2004). The corresponding life expectancies at 60, with which we experiment later in this paper, are listed in Table 2.

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:

$$\bar{L}_r^t = \sum_{a=1539}^{60+} \sum_{g=m}^{f} L_{a,g,r}^t \text{ where } L_{a,g,r}^t = \mu_{a,r}^t P_{a,g,r}^t F_{a,g,r} N_{a,g,r}^t . \tag{7}$$

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.[11]

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:

$$P_{a,g,r}^t = P_{a,g,r}^0 + \left(P_{Tgt}^0 - P_{a,g,r}^0\right)\left(1 - e^{\beta t}\right) , \tag{8}$$

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

[11] Although part time hours may well also be trending through time, we hold *F* constant in the current version of the model.

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

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

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.[12]

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

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

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).[13]

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.[14] That of interest here is the one of most widespread policy interest, the non-working aged dependency ratio:

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

[12] The resulting participation rates are listed by Chan and Tyers (2004: Table 10).
[13] 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 and Tyers (2004: Tables 11 and 12).
[14] All these dependency ratios are defined in detail by Chan and Tyers (2004).

Population and labour force projections by scenario

The regional levels and age structure of the base line population projections are summarised in Table 3. The totals accord closely with corresponding United Nations projections, notwithstanding our simple, four-age-group model.[15] Corresponding base line projections of labour force levels and age structure are summarised in Table 4, 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 5. Total population trends for a selection of regions are displayed in Figure 2. For comparison with this base line, the demographic sub-model is then used to construct three alternative population projections:

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 but 60+ participation rates in the other advanced regions must approach those currently observed in Japan, as shown in Figure 3. The migration solution requires still more dramatic change, however, as indicated in Figure 4. 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 5. Some would have their working aged populations seriously depleted.

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

[15] See United Nations (2003) and the detailed comparison provided in Chan and Tyers (2004).

and McDougall, 2000). Its structure enables us to capture both population growth changes and any associated Engel effects on consumption demand, of the type emphasised by Coyle et al. (1998) and Gehlhar and Coyle (2001), at a high level of country and commodity disaggregation.[16] We are therefore able to assess the effects of changes in the international distribution of population and income on the demand for products in the full range from inferior through income-elastic. Yet, for examining the economic effects of long-term demographic changes, standard *GTAP-Dynamic* has a major weakness. It includes only a single representative household in each identified region. Each region's population and (skilled and unskilled) labour force is projected exogenously at constant growth rates.

To capture the effects of demographic change we have modified the standard *GTAP-Dynamic* model to include multiple age and gender groups in line with the structure of the demographic sub-model. 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. 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.[17] 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[18] consumption preferences are applied for each group, with parameters varying to reflect age-gender differences in tastes. Finally, consumption volumes are totalled across groups to obtain final demand for each product.

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.[19] Total regional disposable income is then split between the eight age-gender groups. Our approach to this is to draw from other studies the distribution of disposable

[16] The regional aggregation we use is as for the demographic sub-model, detailed in Table 1.
[17] This is an empirically based reduced form approach to the underlying intertemporal optimization problem solved by individuals in each group.
[18] This refers to the "constant difference of elasticities of substitution" demand system. See Hertel et al. (1997).
[19] This implies the assumption that all governments balance their budgets and that all saving in the original database is private.

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 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.[20] The share of the disposable income of region *r* enjoyed by people of gender *g*, and age group *a* is thus:

$$(13) \qquad \frac{Y^D_{a,g,r}}{Y^D_r} = \frac{W_{a,g,r} N_{a,g,r}}{\sum_{a=0-15}^{60+} \sum_{g=m}^{f} W_{a,g,r} N_{a,g,r}} \ .$$

The adopted values of $W_{a,g,r}$ are listed in Table 7. Studies of the age distribution of income and consumption that are used as a guide in selecting these values are listed with the table.

Splitting savings and consumption expenditure from group disposable income:

Our reduced form approach to the intertemporal optimisation problem faced by each individual employs an exponential real per capita consumption equation. Group consumption expenditure is dependent on the level of real disposable income and the real interest rate, *r*:

$$(14) \qquad c_{a,g,r} = \frac{C_{a,g,r}}{N_{a,g,r} P^C_{a,g,r}} = A \left(\frac{Y^D_{a,g,r}}{N_{a,g,r} P^C_{a,g,r}} \right)^{\delta} r_r^{\beta} \ ,$$

where $P^C_{a,g,r}$ is a group consumption price index, group consumption expenditure is $C_{a,g,r}$ and parameters δ and β are income and interest elasticities. This equation is calibrated for each group and region based on the set of age-specific saving rates from per capita disposable income listed in Table 8. These estimates are drawn from the same set of studies of the age distribution of income and consumption from which the income weights of Table 7 are drawn. They are recalibrated for consistency with the overall private saving rate in each region indicated in the GTAP database.

The income elasticity of per capita consumption, δ, is also drawn from the studies of the age distribution of income and consumption. Some of these studies disaggregate households by income class. In these cases the income elasticity follows from this cross-sectional relationship. Others follow cohorts through time, during which per capita income varies. In these cases the elasticities are drawn from comparisons across cohorts in each age group. The resulting values are listed in Table 9. The interest elasticity of per capita consumption is set at $\beta = -0.1$ for all age-gender

[20] 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 of advanced countries receive retirement income stemming from capital ownership, consistent empirical work on this distribution is unavailable.

groups, reflecting the prevailing tendency for saving to respond positively to real interest rate changes as indicated by macro-econometric studies.[21]

Consumption preferences:

The construction of the CDE demand system parameters for each group requires a set of target elasticities of demand and a set of expenditure shares. We retain a common set of target elasticities, equal to the standard *GTAP* set, and allow the expenditure shares to vary by age-gender group. For the 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 10. 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, as in Table 10. 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.[22] We construct two versions of the economic model, one with only three product groups (food including processed food products, other manufacturing and services), and one with 29 products as in the earlier analysis by Shi and Tyers (2004).[23] For presentational economy, we focus in this paper on the three product version. Age-gender group expenditure shares are drawn initially from the literature indicated in Table 10, 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.

4. Four Scenarios through 2030

As indicated previously, we consider four scenarios that differ in their embodied demographic behaviour and or in the assumed policy responses by governments. These are:
1) *The base line*, incorporating the concluding phase of the global demographic transition and hence the ageing of populations in all regions.

[21] This estimate of the interest elasticity is used by Rees and Tyers (2004).
[22] 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.
[23] 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. We believe, however, that the primary mechanisms through which demographic change affects broad economic performance act via savings behaviour and labour force participation.

2) *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.
3) *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.
4) *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.

In each case behavioural assumptions about the supply sides of the economies represented are held constant. Importantly, this implies that exogenous factor productivity changes are the same in all scenarios. The source of growth that is endogenous in the model is physical capital accumulation, financed by saving. When demographic behaviour changes, saving rates, consumption choices and labour forces all change and these alter the quantity and global distribution of savings and investment. This, in turn, contributes to corresponding changes in global and regional economic performance.

The base line:

The *base line* scenario provides a reference projection against which the others are compared. It is particularly sensitive to assumptions about factor productivity. If exogenous factor productivity growth is high, overall economic growth is strong but Engel effects create a tendency for the relative prices of food products to fall. The magnitude of these effects depends, of course, on how factor productivity growth is distributed across sectors and their primary factor inputs. From a survey of the relevant literature, we have compiled the set of factor productivity growth rates detailed in Table 11. Elements of this literature remain controversial. Ianchovichina et al. (2001) conclude from their own survey that productivity growth is faster in agriculture than in other sectors. This is credible, particularly in rapidly growing developing countries where the agricultural workforce is declining 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), do not support the assumption of Ianchovichina et al., however. For advanced regions in particular, our projections for exogenous productivity growth are generally more pessimistic for agriculture than for the other sectors.

As it turns out, we appear to have been particularly pessimistic about land productivity compared with that of other factors. Our base line simulation shows a rise in the price of food and

agricultural products relative to manufacturing and services and substantial growth in land rents, not only in Australia, as shown in Figure 6, but in all regions. In other respects the base line projection shows smooth growth in all regions with capital accumulation distributed realistically and relative growth performances that accord with expectation, as indicated in Figure 7.

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 absolute increase in its aged population is largest and, of the advanced regions, it has the highest aged labour force participation rate. In all regions, however, the greater population leads to reduced per capita incomes and higher aged dependency ratios (Table 6). This, and the tendency for older people to consume more basic food products, tends to advantage the producers of the less income elastic food and agricultural commodities, as indicated in the price trends in Figure 8.

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. It does not change population sizes relative to the base line. The leisure consequences of this change are ignored here. 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 (Figure 10). Indeed, wages fall relative to all prices and this advantages labour-intensive sectors, mainly manufacturing. The rise in incomes also raises per capita income in the four affected regions and this also shifts demand toward more income elastic manufactured products. Australia's manufacturing sector therefore expands relative to agriculture and services, as do Australia's manufactured exports. There is no Rybczyinski contraction of other sectors, however. Increased income raises global aggregate demand, so that employment in all sectors increases in Australia as does output volume (Figure 11).

Replacement migration:

Replacement migration requires the relocation of substantial parts of the populations of some destination regions, Central Europe and the FSU and the "Rest of the World" in particular. Their populations fall, most dramatically in the working age groups, and their economic output therefore contracts. The opposite is true of destination regions, and particularly North America. Their GDP levels expand substantially, as indicated in Figure 12. 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. Again conversely, the regions of origin have higher real wages, reduced investment and real appreciations relative to the base line. These trends are indicated in the plots of GDP price changes, compared with the base line, in Figure 13.

The effects on Australia are dominated by the influx of new migrants. While the additional workers boost Australia's GDP, without change in factor productivity growth rates they reduce its income per capita. This shifts demand toward the less elastic food and agricultural products. Other things equal this would be expected to raise the home relative price of "food". Indeed, that relative price does rise, but the primary cause is increased land rents. The influx of workers crowds Australia's fixed factors (both land and natural resources), driving up the relative cost of food production and hence both the domestic supply price of food and Australia's export price (Figure 14). The presence of this constraining fixed factor slows the growth of food output relative to the other sectors, as indicated in Figure 15. This pattern of land rent and relative food price rises along side slower food production growth relative to the base line is evident in all of the migrant recipient regions and it appears most strongly in North America.[24]

5. Conclusion

An analysis of demographic change and labour force participation demonstrates that not only are the populations of several of Australia's key trading partners, 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 relative decline in their labour forces will change their comparative advantage relative to Australia, and hence the pattern of Australia's trade with them. 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, modified to represent 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. This analysis is preliminary and will be subject to further experimentation before final results can be prepared. Included in that experimentation will be a decomposition of the overall effects of demographic

[24] This behaviour 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 this behaviour 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.

change according to these three mechanisms. If the elemental behaviour of the model appears unrepresentative, some modification of its structure may be required. Nonetheless, this preliminary set of results suggests that labour force participation effects are particularly prominent.

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 food producers there could be advantaged. Should governments seek to raise aged labour force participation rates, per capita incomes will increase even if leisure declines. Again, the effect of this will be a shift away from less income elastic "food".

Replacement migration to regions with rising aged dependency would have very substantial demographic and economic impacts. In Australia, which would receive additional immigrants were it to choose this means to control its aged dependency, real wage rates would fall but the expanded population would further "crowd" Australia's fixed factors. Land and natural resource rents would therefore rise and this would slow the relative growth of Australia's agricultural sector.

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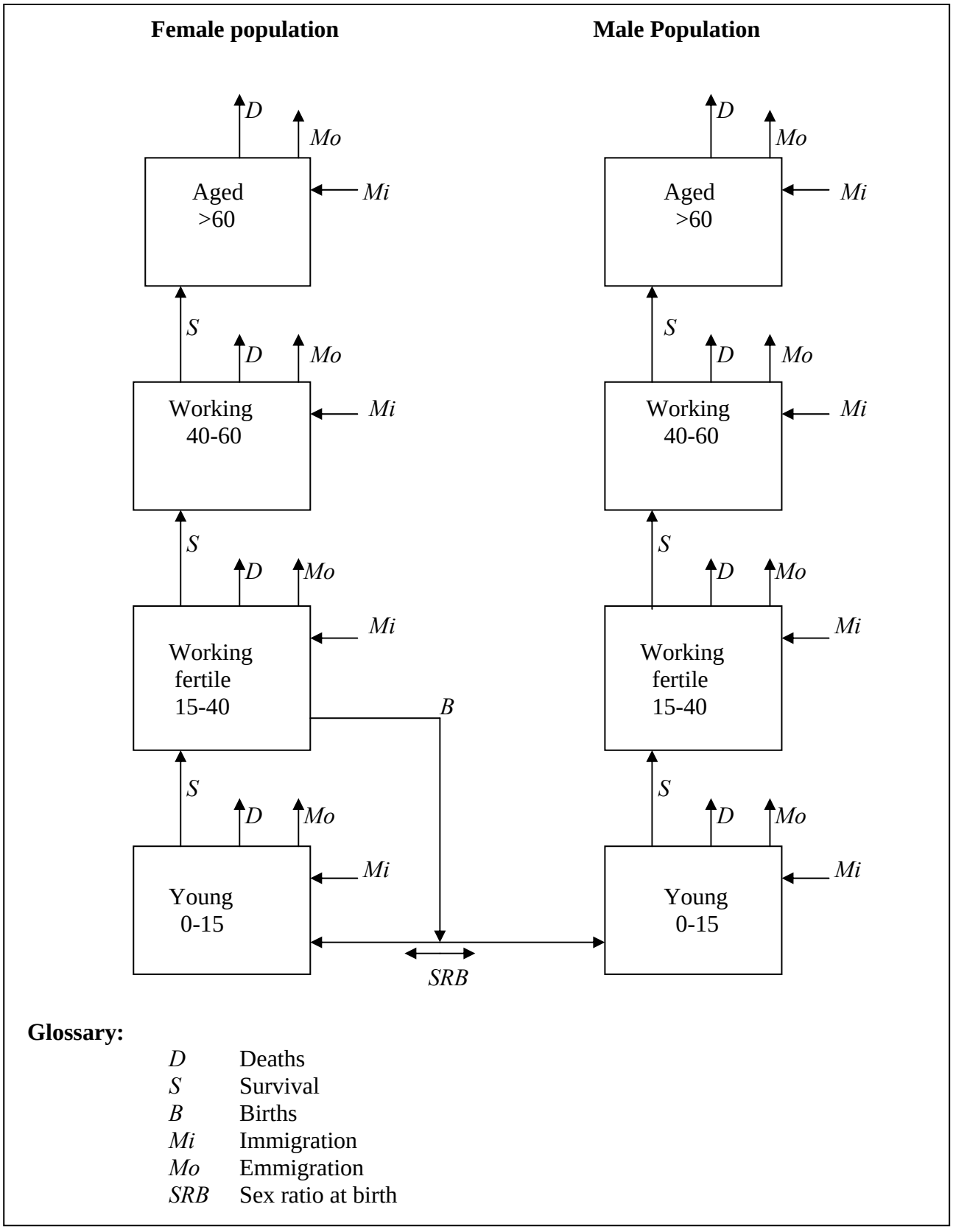
Figure 1



Glossary:

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

Figure 2: Projected Population Trends

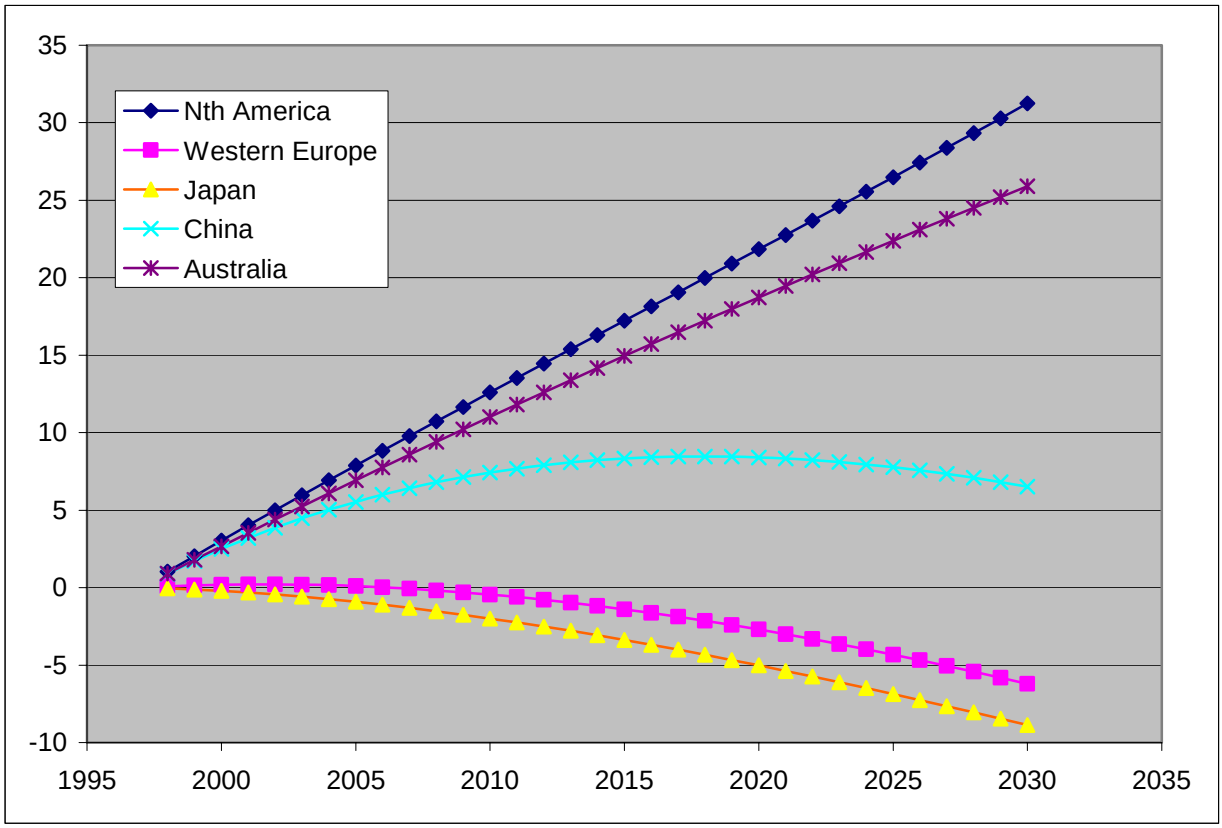
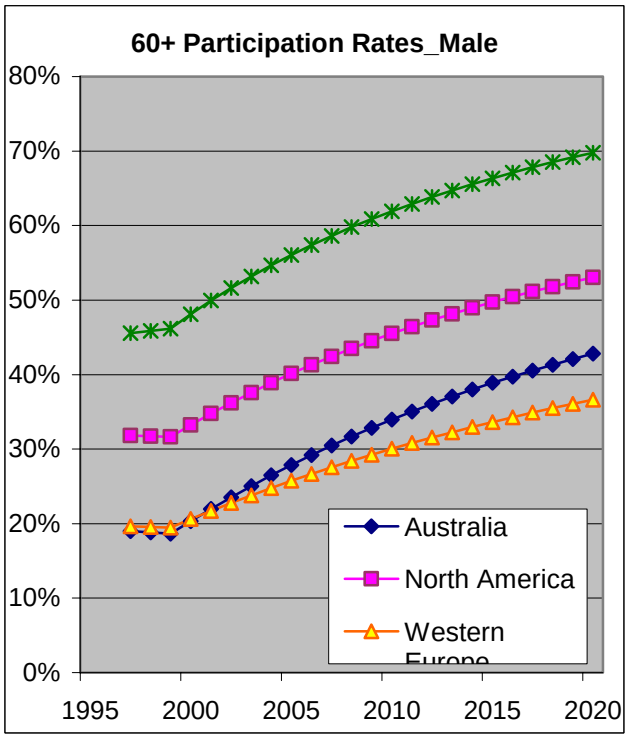


Figure 3: Increased Aged Participation Scenario



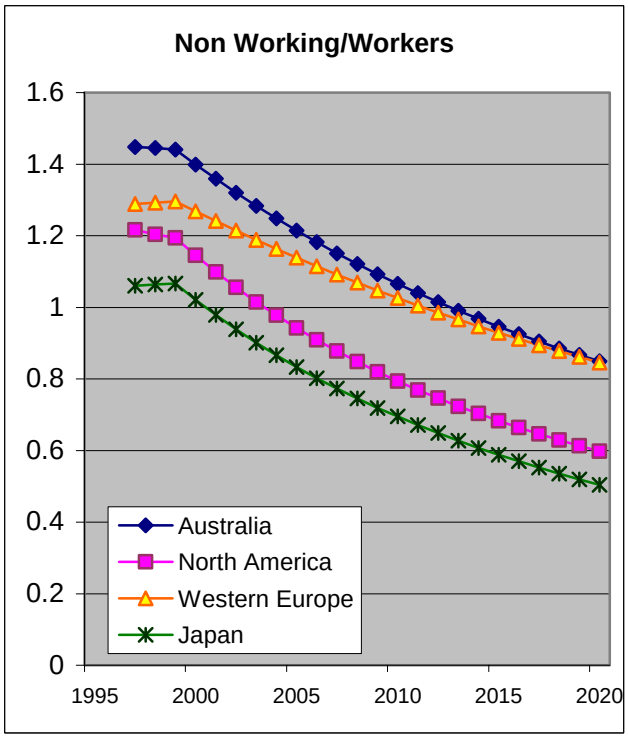
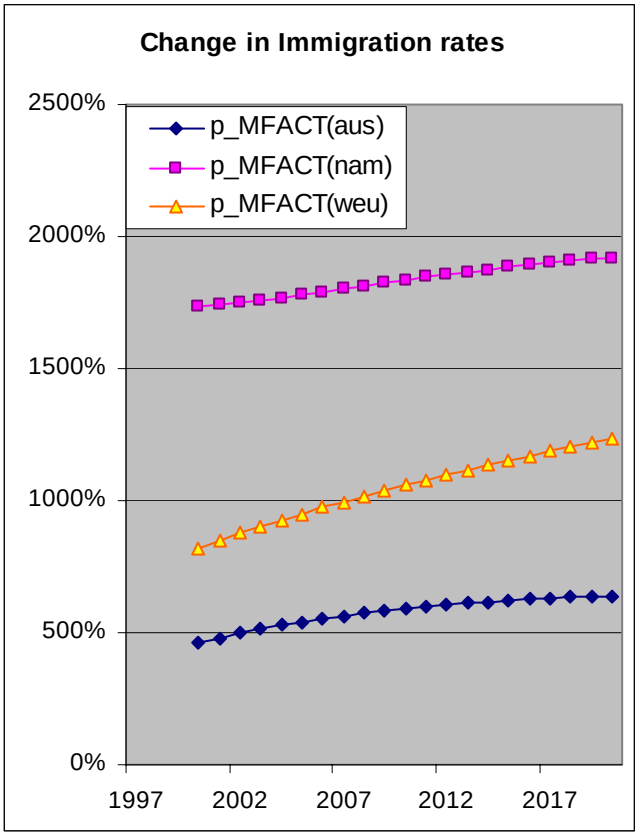


Figure 4: Replacement Migration Scenario



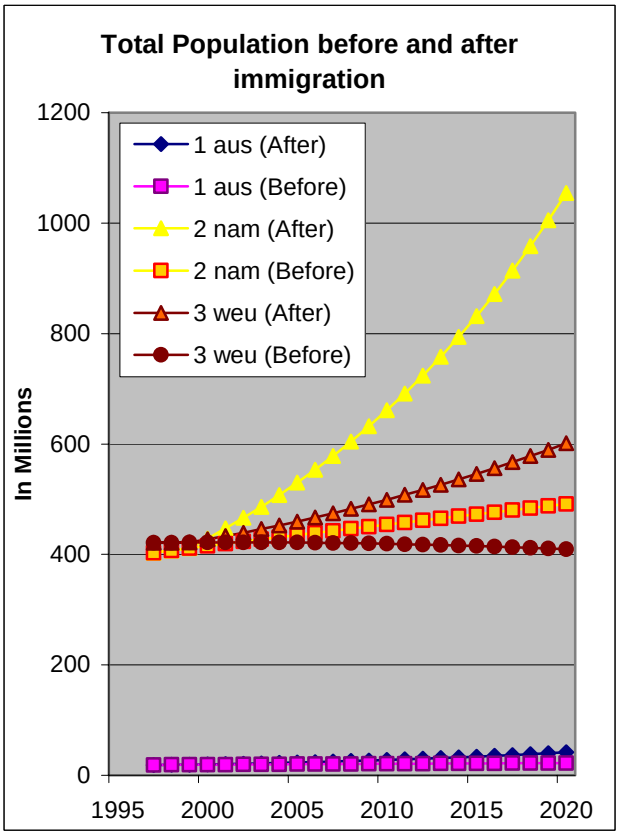
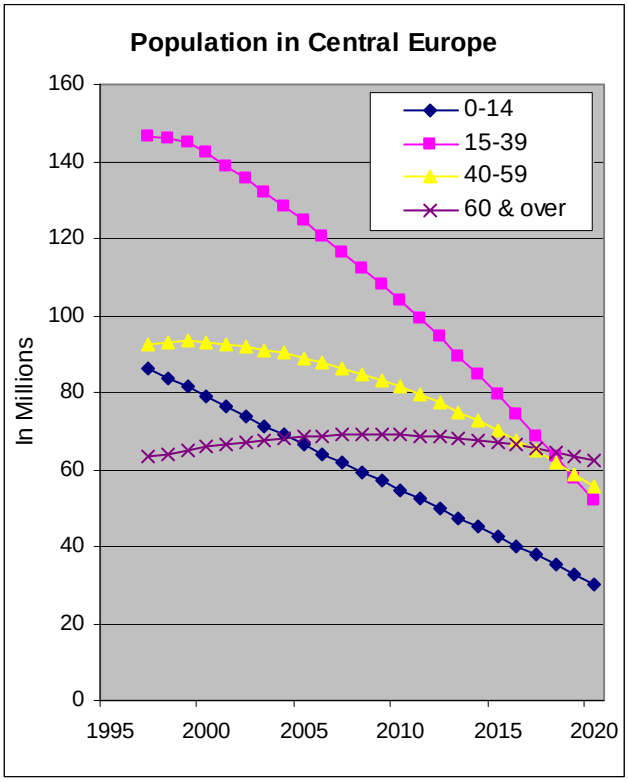


Figure 5: Effects of "Replacement Migration" on Regions of Origin:



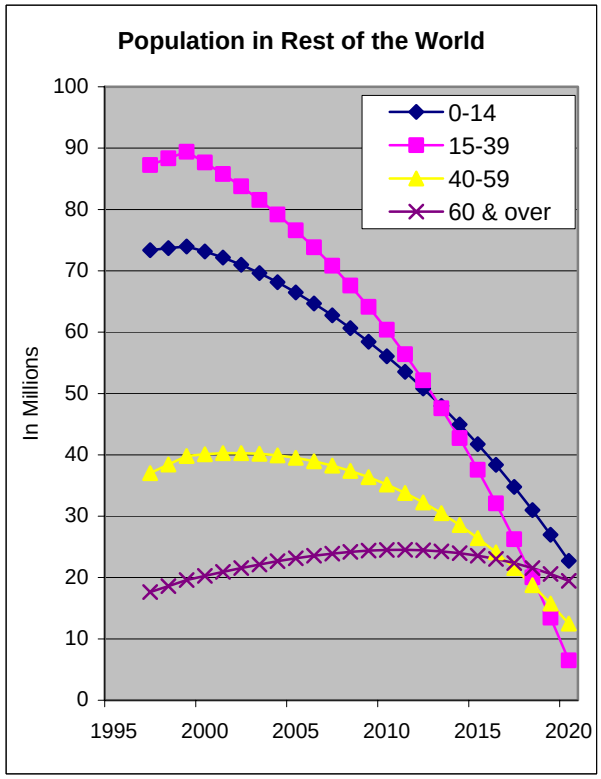


Figure 6: Base Line Australian Product and Factor Price Trends (Relative to the GDP price)

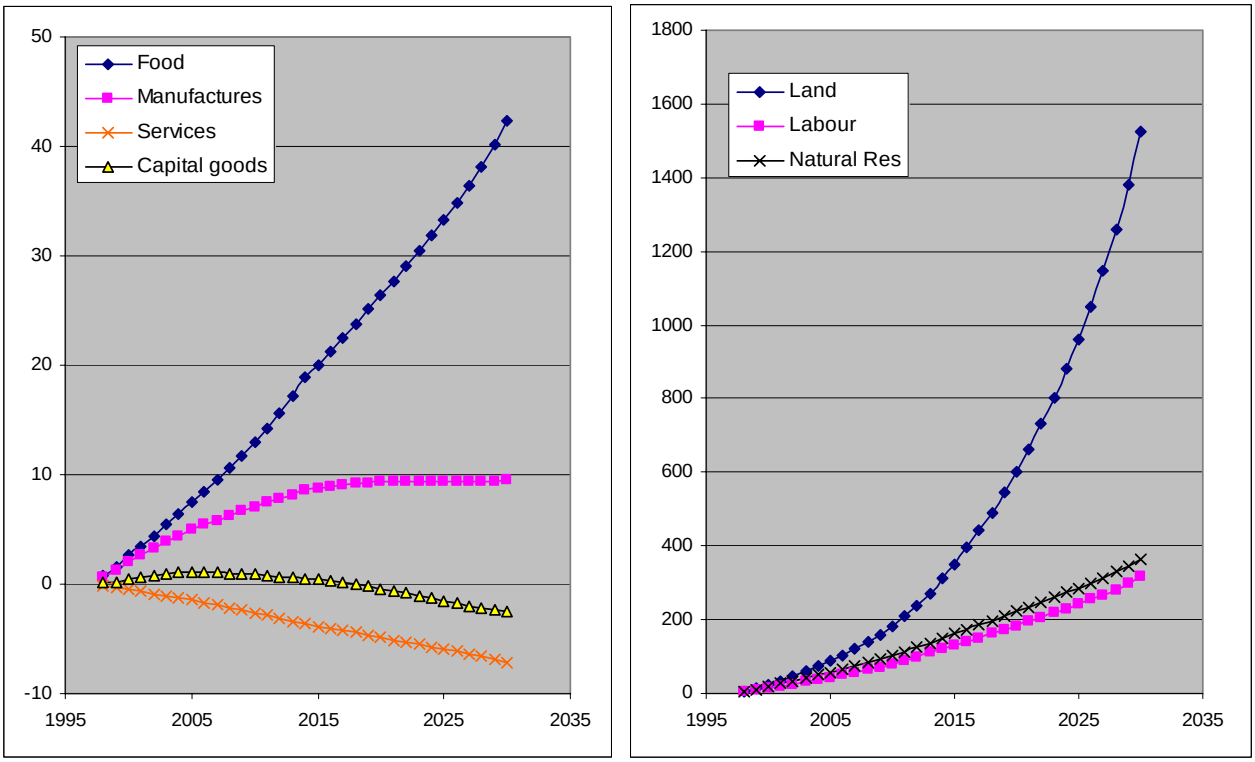


Figure 7: Base Line GDP Growth Trends

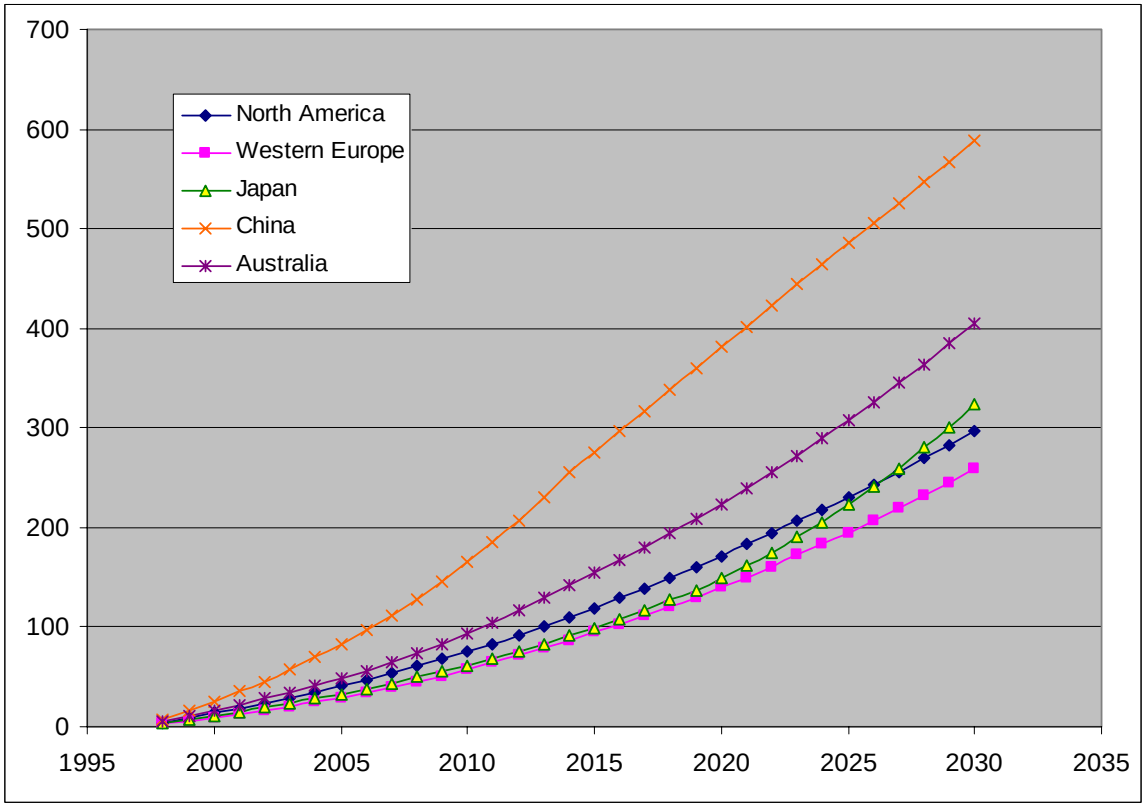


Figure 8: Australian prices relative to the base line, accelerated ageing (relative to GDP price)

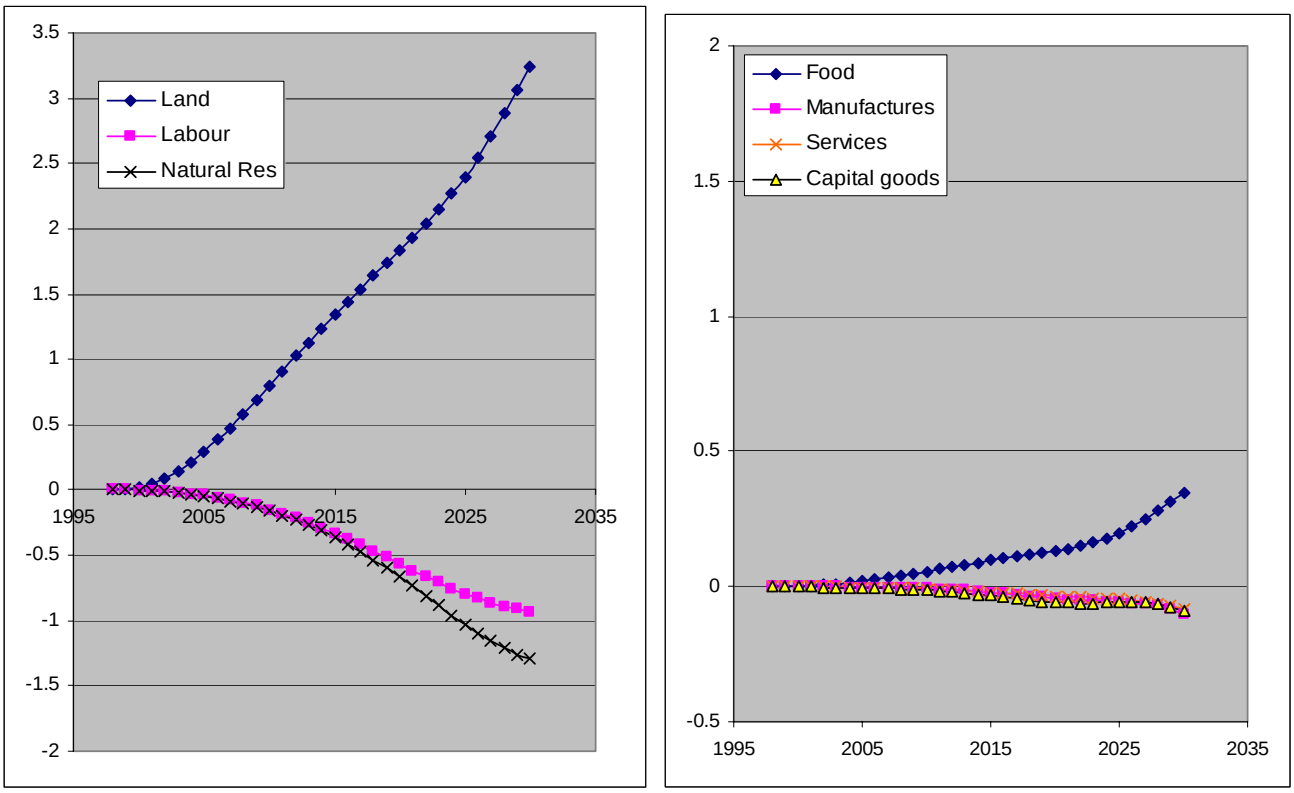


Figure 9: Australian output relative to base line, accelerated ageing

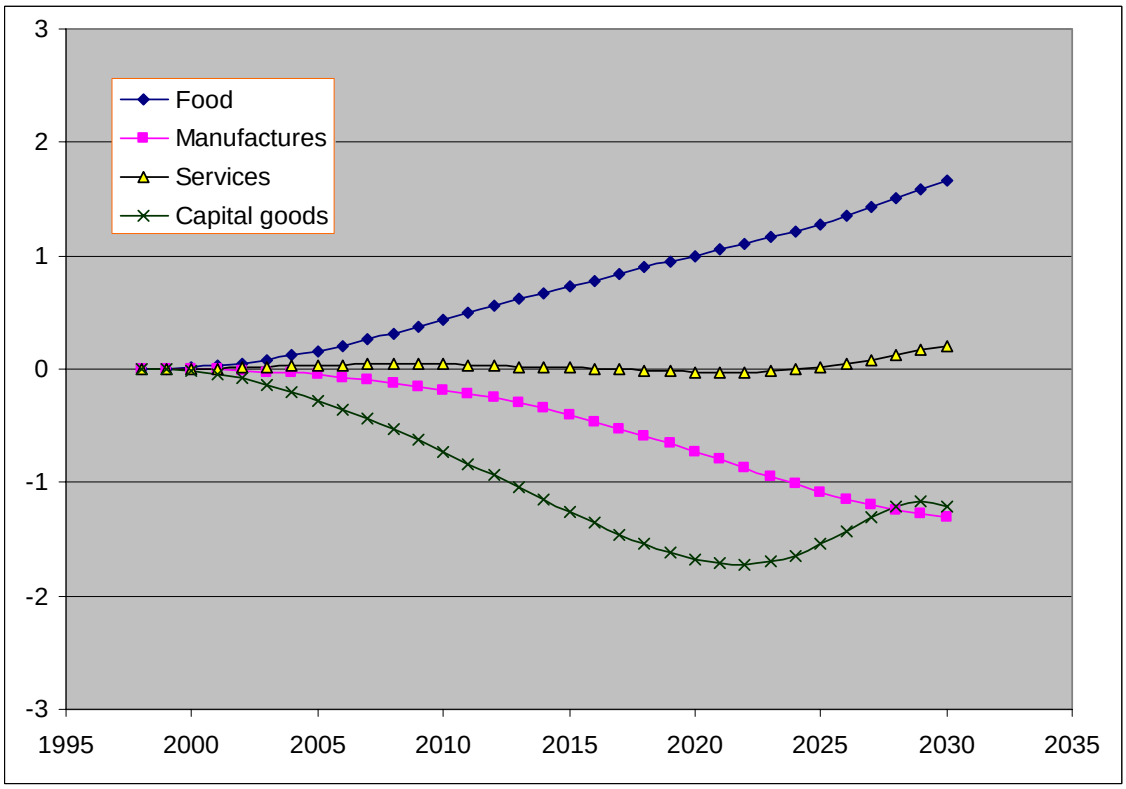


Figure 10: Australian prices relative to the base line, increased aged participation (relative to GDP price)

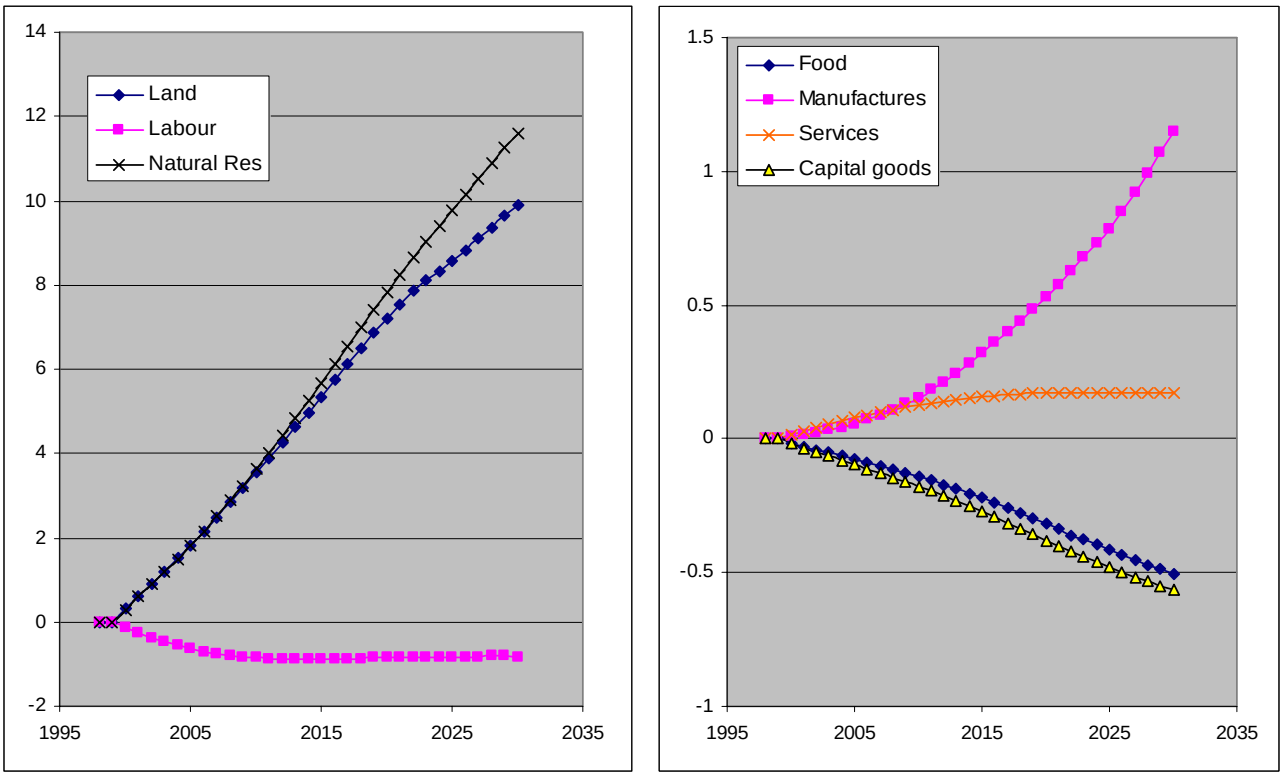


Figure 11: Australian output relative to base line, increased aged participation

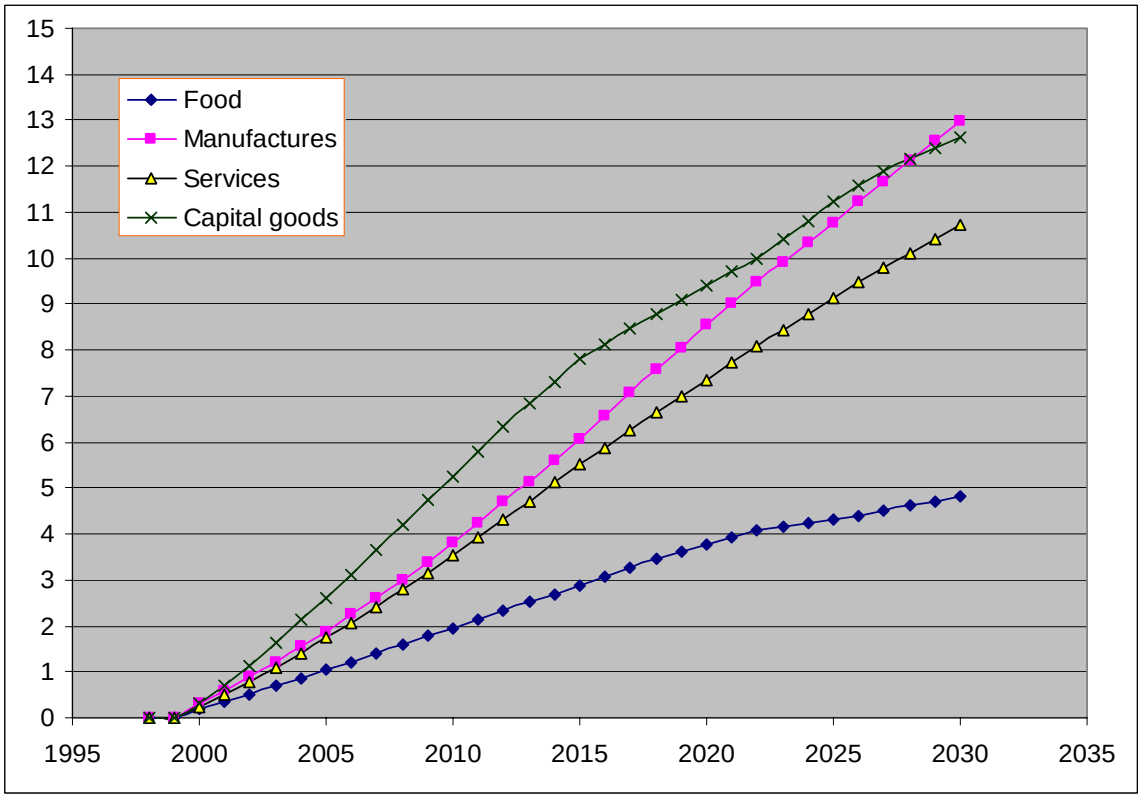


Figure 12: Effects of Replacement Migration on GDP Trends for Selected Regions

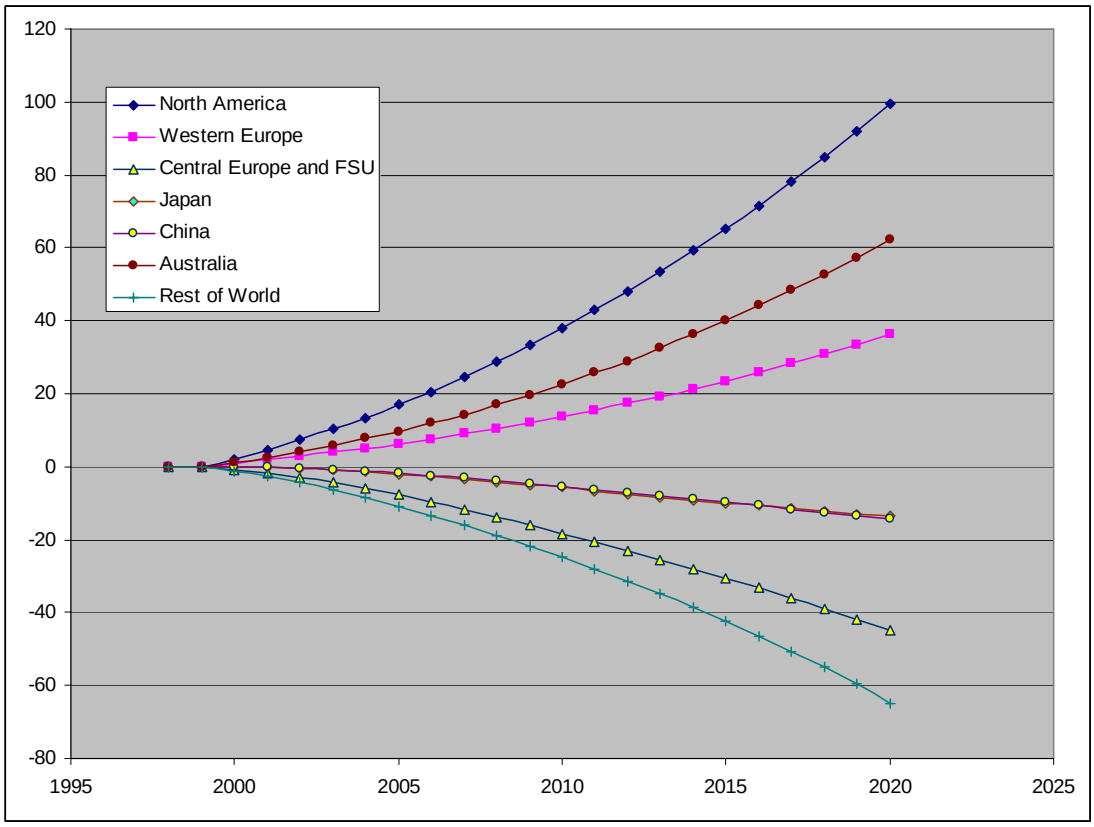


Figure 13: Comparing the Effects of Replacement Migration on GDP Prices

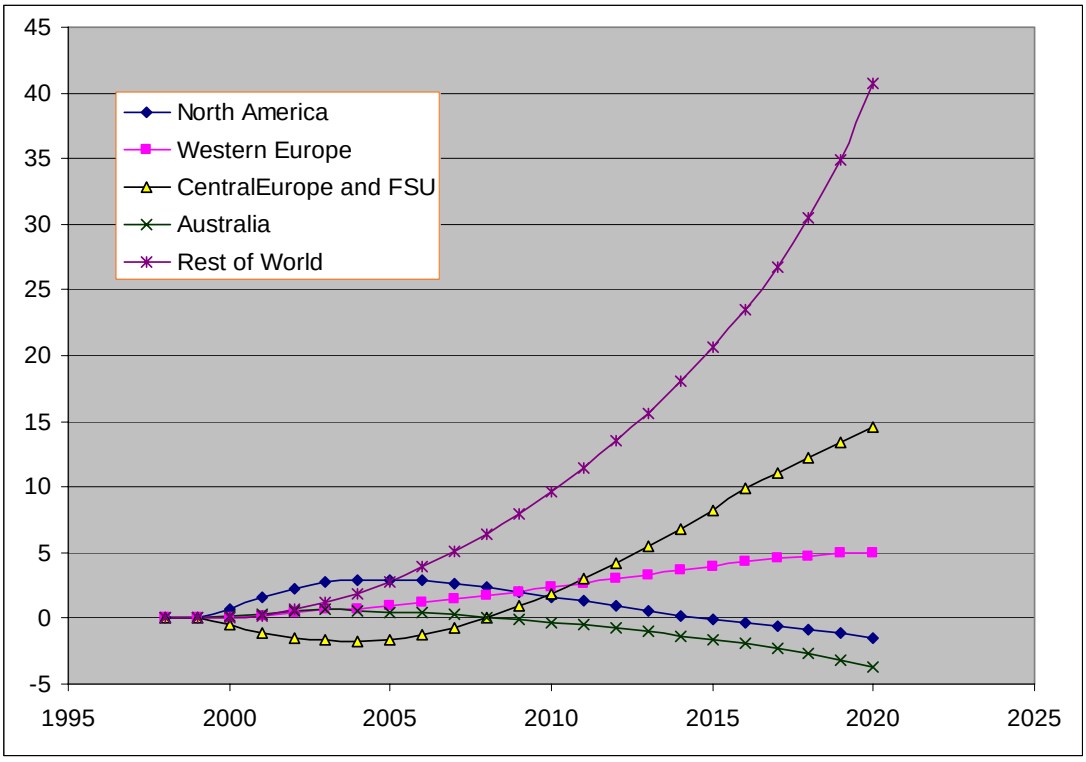


Figure 14: Australian prices relative to the base line, replacement migration (relative to GDP price)

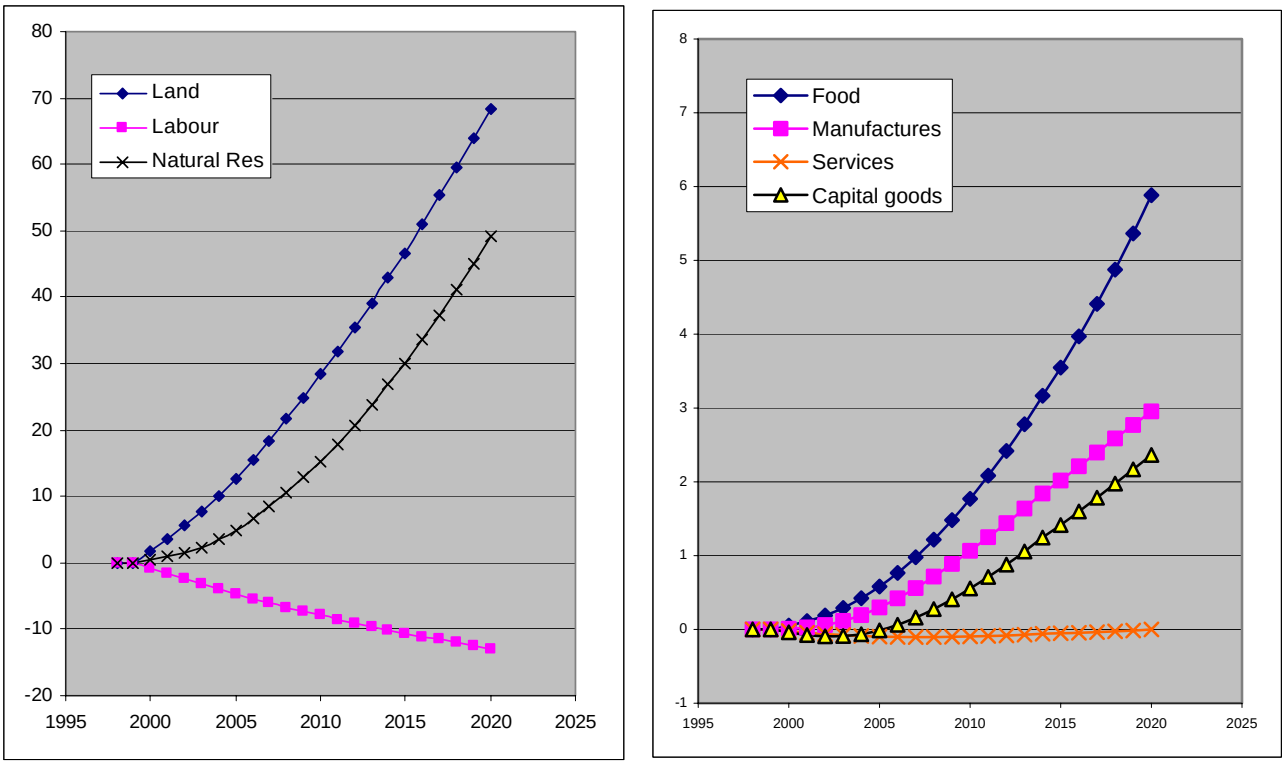


Figure 15: Australian output relative to base line, replacement migration

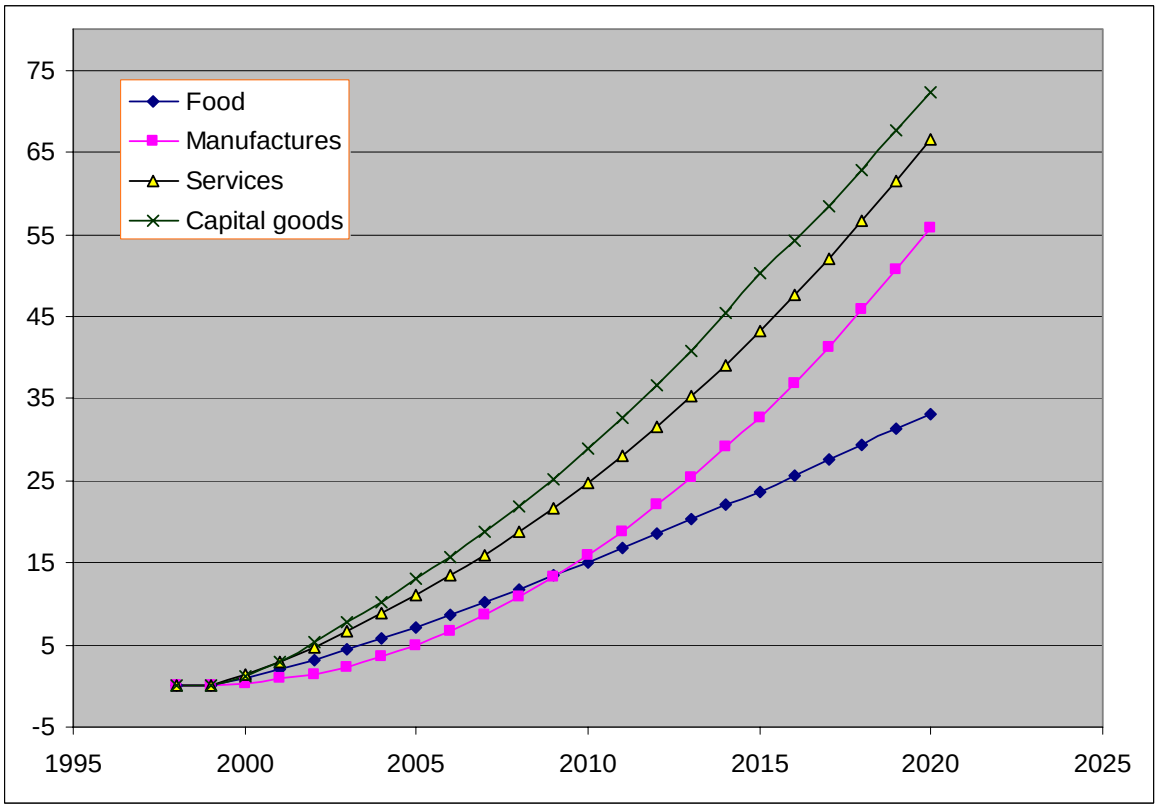


Table 1: Regional Composition

1. AUSTRALIA

2. REST OF WORLD (RoW)

Afghanistan Albania Andorra Anguila Antigua & Barbuda Aruba Bahamas Barbados
Belize Bermuda Bosnia and Herzegovina Brunei British Virgin Islands
Cambodia Croatia Cyprus Cayman Islands Costa Rica Cuba Dominica
Dominican Republic El Salvador Faroe Islands Federated States of Micronesia
Fiji French Polynesia Grenada Guatemala Gibraltar Greenland Guadeloupe Haiti
Honduras Jamaica Kiribati Lao People's Democratic Republic Macau Malta
Marshall Islands Monaco Mongolia Myanmar Nauru New Caledonia Netherlands Antilles
New Zealand Nicaragua Panama Papua New Guinea Saint Kitts and Nevis Saint Lucia
Saint Vincent and the Grenadines San Marino Solomon Islands The former Yugoslav Republic of Macedonia
Tonga Trinidad and Tobago Tuvalu Vanuatu Western Samoa Yugoslavia

3. CHINA

China Hong Kong Taiwan

4. JAPAN

5. EAST ASIA

Korea Malaysia Philippines Singapore Thailand Vietnam

6. INDONESIA

7. INDIA

8. OTHER SOUTH ASIA (OS_ASIA)

Bangladesh Bhutan Maldives Nepal Pakistan Sri Lanka

9. NORTH AMERICA (NAM)

American Samoa Canada Guam Mexico Northern Mariana Islands
United States of America

10. SOUTH AMERICA (SAM)

Argentina Bolivia Brazil Chile Colombia Ecuador Peru
Venezuela Uruguay

11. WESTERN EUROPE (WEU)

Belgium Denmark Finland France French Guiana Germany Greece
Iceland Ireland Italy Leichtenstein Luxembourg Martinique Netherlands
Norway Portugal Reunion Spain Sweden Switzerland
United Kingdom

12. CENTRAL EUROPE & FORMER USSR (CEU_FSU)

Armenia Azerbaijan Belarus Bulgaria Czech Republic Estonia Georgia Hungary Kazakhstan
Kyrgyzstan Latvia Lithuania Poland Republic of Moldova Romania
Russian Federation Slovakia Slovenia Tajikistan Turkmenistan Ukraine Uzbekistan

13. MIDDLE EAST & NORTH AFRICA (ME_NA)

Algeria Bahrain Egypt Iraq Islamic Republic of Iran Israel Jordan Kuwait
Lebanon Libyan Arab Jamahiriya Morocco Oman Qatar Saudi Arabia Syrian Arab Republic
Tunisia Turkey United Arab Emirates Yemen

14. SUB-SAHARAN AFRICA (SSAFR)

Angola Benin Botswana Burkina Faso Burundi Cameroon Cape Verde Central African
Republic Chad Comoros Congo Cote d'Ivoire Djibouti Equatorial Guinea Eritrea
Ethiopia Gabon Gambia Ghana Guinea Guinea-Bissau Kenya
Lesotho Liberia Madagascar Mali Malawi Mauritania Mauritius Mayotte Mozambique
Namibia Niger Nigeria Rwanda Sao Tome and Principe Senegal Seychelles
Sierra Leone Somalia Sudan South Africa Swaziland Tanzania Togo Uganda
Zaire Zambia Zimbabwe

Table 2: Life Expectancy at 60

Years	Male		Female	
	Initial	**2020**	**Initial**	**2020**
Australia	17	20	21	25
North America	19	21	23	24
Western Europe	19	21	23	25
Central Europe, FSU	15	15	20	20
Japan	22	26	26	31
China	16	17	18	20
Indonesia	14	14	15	15
Other East Asia	17	17	19	19
India	15	16	18	19
Other South Asia	15	16	15	17
South America	17	19	20	20
Mid East Nth Africa	16	17	18	18
Sub-Saharan Africa	10	10	13	13
Rest of World	18	21	23	27

a Aggregation is by population weighted average. Projections of these parameters to 2020 assume convergence on target rates observed in comparatively "advanced" countries, as explained in the text. Only the end point values are shown here but the model uses values that change with time along the path to convergence.
Source: Aggregated from United Nations (2000b).

Table 3: Projected Population Structure:

	Population, millions		**% Female**		**% 60+**	
	Initial	**2020**	**Initial**	**2020**	**Initial**	**2020**
Australia	19	22	50.2	50.7	16.1	22.1
North America	403	491	50.8	50.6	13.9	20.0
Western Europe	421	410	51.2	51.1	21.2	27.0
Central Europe	388	345	52.3	52.1	16.3	22.6
Japan	126	120	51.0	51.0	21.9	31.6
China	1272	1379	48.5	48.9	9.7	18.4
Indonesia	201	257	50.2	50.2	7.2	13.0
Other East Asia	282	358	50.2	50.0	7.6	14.7
India	955	1310	48.2	48.8	6.9	12.6
Other South Asia	372	570	48.8	48.6	5.7	10.3
South America	335	448	50.4	50.2	8.0	14.7
Mid East Nth Afr	331	488	49.1	49.1	6.1	11.7
Sub-Saharan Africa	586	950	50.4	50.8	4.6	6.5
Rest of World	215	287	50.0	50.0	8.2	15.4

Source: Projection using the model described in the text.

Table 4: Projected Labour Force Structure:

	Labour force[a]		% Female		% 40+	
	Initial	**2020**	**Initial**	**2020**	**Initial**	**2020**
Australia	8	9	37	39	42	48
North America	182	232	40	41	42	46
Western Europe	184	174	40	43	47	54
Central Europe	181	161	47	46	44	51
Japan	61	57	37	37	58	63
China	570	613	37	36	34	44
Indonesia	87	121	38	38	40	51
Other East Asia	127	168	41	40	37	49
India	356	531	27	28	36	45
Other South Asia	134	226	28	28	32	42
South America	123	174	38	39	33	45
Mid East Nth Afr	103	155	24	23	30	40
Sub-Saharan Afr	150	283	28	29	29	35
Rest of World	79	120	36	35	38	46

a Measured in full time equivalent workers.
Source: Projection using the model described in the text.

Table 5: Non-Working Aged Dependency Ratio

	Non-working aged/working	
	Initial	**2020**
Australia	0.35	0.49
North America	0.24	0.34
Western Europe	0.42	0.56
Central Europe	0.29	0.39
Japan	0.32	0.44
China	0.19	0.37
Indonesia	0.09	0.14
Other East Asia	0.09	0.19
India	0.12	0.20
Other South Asia	0.09	0.16
South America	0.16	0.26
Mid East Nth Afr	0.15	0.28
Sub-Saharan Afr	0.13	0.15
Rest of World	0.15	0.24

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

Table 6: Effects in 2020 of Accelerating Growth in Target Life Expectancies at 60 by 2% per year

per cent change	Population		Labour force		Non-working aged dependency ratio
	Total	**60+**	**Total**	**60+**	**Aged NW**
Australia	2.9	13.1	0.7	13.6	12.2
North America	2.5	12.7	1.1	13.0	11.4
Western Europe	3.7	13.7	1.1	14.0	12.3
Central Europe	3.7	16.6	1.6	17.1	14.5
Japan	3.6	11.4	2.6	11.7	8.4
China	2.7	14.6	0.7	15.5	13.8
Indonesia	2.2	16.7	2.3	16.9	14.0
Other East Asia	2.0	13.8	1.7	14.0	11.8
India	1.8	14.5	1.6	15.0	12.5
Other South Asia	1.5	14.7	1.5	14.8	12.9
South America	1.9	13.2	1.6	13.4	11.4
Mid East Nth Africa	1.6	13.8	1.2	14.1	12.4
Sub-Saharan Africa	1.3	19.5	1.4	20.6	17.3
Rest of World	1.7	11.1	1.5	11.6	9.1

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

Table 7: 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 8: 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 9: Elasticities of Per Capita Consumption Expenditure to Per Capita Personal Disposable Income by Age-Gender Group

	0-14		15-39		40-59		60+	
	Male	Female	Male	Female	Male	Female	Male	Female
Australia	1.0	1.0	0.3	0.3	0.5	0.5	0.4	0.4
North America	1.0	1.0	0.5	0.5	0.7	0.7	0.4	0.4
Western Europe	1.0	1.0	0.7	0.7	0.3	0.3	0.6	0.6
Central Europe, FSU	1.0	1.0	0.7	0.7	0.3	0.3	0.7	0.7
Japan	1.0	1.0	0.8	0.8	0.8	0.8	1.1	1.1
China	1.0	1.0	0.8	0.8	0.8	0.8	1.1	1.1
Indonesia	1.0	1.0	0.7	0.7	0.3	0.3	0.7	0.7
Other East Asia	1.0	1.0	0.8	0.8	0.8	0.8	1.1	1.1
India	1.0	1.0	0.7	0.7	0.3	0.3	0.7	0.7
Other South Asia	1.0	1.0	0.7	0.7	0.3	0.3	0.7	0.7
South America	1.0	1.0	0.6	0.6	0.7	0.7	1.2	1.2
Mid East Nth Africa	1.0	1.0	0.7	0.7	0.3	0.3	0.7	0.7
Sub-Saharan Africa	1.0	1.0	0.7	0.7	0.3	0.3	0.7	0.7
Rest of World	1.0	1.0	0.3	0.3	0.5	0.5	0.4	0.4

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); UK: Attanasio and Banks (1998).

Table 10: Private Expenditure Shares by Age-Gender Group

		0-14		15-39		40-59		60+	
		Male	Female	Male	Female	Male	Female	Male	Female
Australia	Food	0.15	0.15	0.12	0.12	0.12	0.12	0.13	0.13
	Manufactures	0.08	0.08	0.15	0.15	0.21	0.21	0.12	0.12
	Services	0.77	0.77	0.73	0.73	0.66	0.66	0.75	0.75
North America	Food	0.09	0.09	0.07	0.07	0.07	0.07	0.08	0.08
	Manufactures	0.08	0.08	0.14	0.14	0.20	0.20	0.11	0.11
	Services	0.84	0.84	0.79	0.79	0.73	0.73	0.81	0.81
Western Europe	Food	0.15	0.15	0.11	0.11	0.12	0.12	0.13	0.13
	Manufactures	0.13	0.13	0.23	0.23	0.31	0.31	0.18	0.18
	Services	0.72	0.72	0.65	0.65	0.57	0.57	0.68	0.68
Central Europe, FSU	Food	0.38	0.38	0.29	0.29	0.29	0.29	0.33	0.33
	Manufactures	0.12	0.12	0.22	0.22	0.29	0.29	0.17	0.17
	Services	0.51	0.51	0.49	0.49	0.42	0.42	0.50	0.50
Japan	Food	0.15	0.15	0.11	0.11	0.12	0.12	0.13	0.13
	Manufactures	0.07	0.07	0.14	0.14	0.19	0.19	0.11	0.11
	Services	0.78	0.78	0.75	0.75	0.69	0.69	0.77	0.77
China	Food	0.37	0.37	0.31	0.31	0.31	0.31	0.34	0.34
	Manufactures	0.10	0.10	0.35	0.35	0.34	0.34	0.25	0.25
	Services	0.53	0.53	0.34	0.34	0.35	0.35	0.41	0.41
Indonesia	Food	0.36	0.36	0.34	0.34	0.34	0.34	0.36	0.36
	Manufactures	0.06	0.06	0.25	0.25	0.25	0.25	0.17	0.17
	Services	0.57	0.57	0.41	0.41	0.41	0.41	0.47	0.47
Other East Asia	Food	0.24	0.24	0.20	0.20	0.20	0.20	0.22	0.22
	Manufactures	0.09	0.09	0.34	0.34	0.34	0.34	0.24	0.24
	Services	0.67	0.67	0.45	0.45	0.46	0.46	0.53	0.53
India	Food	0.48	0.48	0.41	0.41	0.41	0.41	0.45	0.45
	Manufactures	0.08	0.08	0.29	0.29	0.29	0.29	0.20	0.20
	Services	0.44	0.44	0.29	0.29	0.30	0.30	0.34	0.34
Other South Asia	Food	0.45	0.45	0.41	0.41	0.41	0.41	0.44	0.44
	Manufactures	0.07	0.07	0.26	0.26	0.26	0.26	0.18	0.18
	Services	0.48	0.48	0.33	0.33	0.33	0.33	0.38	0.38
South America	Food	0.28	0.28	0.24	0.24	0.24	0.24	0.27	0.27
	Manufactures	0.09	0.09	0.34	0.34	0.33	0.33	0.24	0.24
	Services	0.63	0.63	0.42	0.42	0.42	0.42	0.49	0.49
Mid East Nth Africa	Food	0.37	0.31	0.24	0.27	0.24	0.31	0.42	0.45
	Manufactures	0.02	0.04	0.30	0.28	0.30	0.26	0.06	0.02
	Services	0.61	0.66	0.46	0.45	0.46	0.44	0.52	0.54
Sub-Saharan Africa	Food	0.45	0.36	0.29	0.32	0.28	0.36	0.50	0.53
	Manufactures	0.02	0.01	0.32	0.30	0.33	0.27	0.07	0.02
	Services	0.53	0.63	0.39	0.38	0.39	0.37	0.44	0.45
Rest of World	Food	0.31	0.31	0.23	0.23	0.23	0.23	0.27	0.27
	Manufactures	0.12	0.12	0.23	0.23	0.31	0.31	0.18	0.18
	Services	0.57	0.57	0.54	0.54	0.46	0.46	0.55	0.55

Source: Constructed with guidance from the results presented by: Abdel-Ghany and Sharpe (1997), Blisard (2001), 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 11: Factor Productivity Growth

	Regional average	Sector	Primary factor					Sectoral average
			Land	Prodn labour	Skilled labour	Capital	Nat resources	
Australia	2.28	Food	0.2	2.7	0.5	1.5	0.0	1.80
		Manufactures	0.0	5.0	0.5	0.0	0.0	1.70
		Services	0.0	7.0	2.0	0.5	0.0	2.78
North America	2.19	Food	0.0	0.5	0.0	0.0	0.0	0.17
		Manufactures	0.0	7.0	0.5	1.0	0.5	3.32
		Services	0.0	7.0	0.5	1.0	0.5	1.56
Western Europe	2.01	Food	0.5	2.0	0.5	0.5	0.0	1.16
		Manufactures	0.0	5.0	0.5	1.0	0.0	2.72
		Services	0.0	5.0	0.5	1.0	0.0	1.46
Central Europe, FSU	3.67	Food	1.0	4.0	0.0	2.0	0.0	2.75
		Manufactures	0.0	7.0	1.0	3.0	0.0	4.05
		Services	0.0	5.0	0.5	1.0	0.0	3.65
Japan	1.76	Food	0.5	1.0	0.5	0.0	0.0	0.52
		Manufactures	0.0	3.0	0.5	1.0	0.0	1.65
		Services	0.0	3.0	0.5	1.0	0.0	2.01
China	4.01	Food	0.5	5.0	0.5	1.0	0.0	3.02
		Manufactures	0.0	7.0	2.0	3.0	0.0	4.48
		Services	0.0	7.0	2.0	3.0	0.0	3.79
Indonesia	2.52	Food	0.5	5.0	0.5	0.0	0.0	1.89
		Manufactures	0.0	5.0	0.5	3.0	0.0	2.93
		Services	0.0	5.0	0.5	3.0	0.0	2.10
Other East Asia	3.58	Food	0.5	6.0	0.5	1.0	0.0	2.75
		Manufactures	0.0	6.0	0.5	3.0	0.0	3.71
		Services	0.0	6.0	0.5	3.0	0.0	3.62
India	3.43	Food	1.0	6.0	0.5	1.0	0.0	2.87
		Manufactures	0.0	6.0	1.0	3.0	0.0	3.76
		Services	0.0	6.0	1.0	3.0	0.0	3.35
Other South Asia	3.16	Food	0.5	6.0	0.5	1.0	0.0	2.57
		Manufactures	0.0	5.0	0.5	3.0	0.0	3.29
		Services	0.0	5.0	0.5	3.0	0.0	3.45
South America	1.77	Food	1.0	1.0	0.5	0.0	0.0	0.49
		Manufactures	0.0	4.0	0.5	2.0	0.0	2.55
		Services	0.0	4.0	0.5	2.0	0.0	1.21
Mid East Nth Africa	1.73	Food	0.5	1.0	0.5	0.5	0.0	0.75
		Manufactures	0.0	5.0	0.5	2.0	0.0	2.40
		Services	0.0	5.0	0.5	2.0	0.0	1.21
Sub-Saharan Africa	2.05	Food	0.5	2.0	0.5	1.0	0.0	1.51
		Manufactures	0.0	5.0	0.5	2.0	0.0	2.64
		Services	0.0	5.0	0.5	2.0	0.0	1.66
Rest of World	2.21	Food	0.5	3.0	0.5	0.0	0.0	1.30
		Manufactures	0.0	5.0	0.5	2.0	0.0	2.65
		Services	0.0	5.0	0.5	2.0	0.0	2.03

Source: Constructed with guidance from the results presented by: Bernard and Jones (1996), DEFRA(2003), Fu (2004), Huffman and Evenson (2003), Ianchovichina et al. (2001), Pack (2003), Productivity Commission (1999) and Stiroh (2001).