The Impact of Ageing on International Capital Flows in a Heterogeneous World with Imperfect Capital Mobility

Henri L.F. de Groot and Paul J.G. Tang[1]

CPB Netherlands Bureau for Economic Policy Analysis
Van Stolkweg 14
P.O. Box 80510
2508 GM The Hague
Email: hlfdg@cpb.nl or tang@cpb.nl

Abstract
This paper develops and calibrates a simple neoclassical model of economic growth to analyse the impact of ageing on international capital markets. Savings depend on the age structure of the population, but also on the growth rate and the per capita income level. Capital immobility results in real interest rate differentials that depend on the Net Foreign Asset Position of countries. In such a world, the impact of ageing on international capital markets depends on a range of mechanisms, partly offsetting each other. The main mehanisms that are presents in the model are that ageing reduces labour supply and thus reduces investment demand, while at the same time it reduces savings. The effect on the Net Foreign Asset Position, the user cost of capital and the world interest rate is therefore ambiguous. Within the context of such a model, the main questions that we address are how important demographic changes are for international capital flows and how capital mobility affects the allocation of investment funds in economies that are ageing at different speeds. We will initially restrict the attention to the developed countries. Subsequently, we address the implications of ageing for capital flows between developed and developing regions.

Keywords: ageing, capital immobility, net foreign asset positions
JEL codes: E20, F12, F21, F41, J10

[1] We are grateful to Leon Bettendorf, Willem Heeringa, and participants to the CPB/ENEPRI workshop on Ageing and International Capital Flows for useful comments on an earlier version of this paper. Research assistance and extensive comments by Nico van Leeuwen, Arjan Lejour, Guido van Steen and Gerard Verweij are also gratefully acknowledged. Henri de Groot would like to thank NWO for financial support.

1 Introduction

The world is rapidly ageing. In the USA, the share of people aged 65 and above in the population has increased from about 8% in 1950 to 13% to date. It is expected to increase further to 21% in 2050 (UN, 2000). All countries tend to follow similar patterns in this respect, albeit starting in different periods. Less developed countries typically start later with their process of ageing reflecting that fertility and life expectancies are strongly related to per capita income levels. The macroeconomic impacts of these changes are far-reaching. Participation rates are expected to decline. Aggregate savings are be expected to decline as well (Bayoumi and Masson, 1996, Carroll and Weil, 1994, Miles, 1999, etc.). Spending on, for example, health is however likely to increase.

Ageing may also lead to imbalances between national savings and investment, unleashing potentially significant international capital flows. Developed and developing countries differ importantly in the predicted pattern of ageing. A common idea is that developed countries will invest (rapidly) developing countries to finance old-age pensions for baby-boom generations. However, with the group of rich countries the degree and pace of ageing . In the United States the population will not age as much and as fast as in Japan or Southern Europe. This could also provide a potential for international trade in capital. This paper tries to gauge the impact of ageing, and international difference therein, on capital flows between North and South and within North. Besides, it assesses to what extent international trade in capital helps ageing countries to finance old-age pensions or, more generally, how large the benefits of international trade in capital are.

The rather complex problem of ageing and capital flows has been approached in at least two different ways. First, Higgins (1998) has estimated reduced-form equations for savings, investments and the current account balance for a large panel of countries. The demographic structure has an effect on all three variables. An important finding is that relatively young cohorts (up to 30 years) have a negative effect on the current account and relatively old cohorts have positive effect. Second, applied general-equilibrium models have been developed that incorporate life-cycle savings decisions of households (Börsch-Supan, Ludwig and Winter, 2001; INGENUE, 2001) . These models show ageing may induce sizeable capital flows if capital mobility is perfect.

Both approaches have their merits. The first, reduced-form approach has a firm empirical base, whereas the second, structural approach allows an analysis of policy changes, for example moving from a pay-as-you-go to a funded system. However, in both approaches investment demand and (imperfect) capital mobility is given scant attention. This is understandable but limits the results. The estimated reduced-form equation are not derived from an explicit model for investment demand. Higgins does not attempt to discriminate between the number of workers and heterogeneity among these workers (age-specific productivity) or to include terms-of-trade effects. Omitted variables could easily bias the results. In the AGE models more or less similar problems arises. When construction these model much attention is given to savings but less to investments. This is likely to affect the model results. Besides, in both approaches, measures for capital mobility are either poor or lacking. For example, with the AGE models a situation of financial autarky is often compared to a situation of perfect capital mobility. Of course, this does not realistically show the interaction among countries through the international capital market.

In this paper both approaches are combined. We develop a Solow-like, general-equilibrium model of economic growth. Savings in the model are exogenous. Their projections are determined on the basis of a macroeconometric estimation incorporating the effects of ageing and growth. The model thus focusses more on investments than on savings. This approach does not substitute but rather complements the two other approaches. It has allows us to focus on two important factors that have largely been ignored thus far: imperfect capital mobility and terms-of-trade effects on investment demand.

In the model capital mobility is imperfect. Depending on the foreign debt or wealth position, countries pay a risk premium resulting in interest rate differentials. The relation between interest rates and net foreign debt or asset positions is estimated. This gives a empirical indication to what extent incipient imbalances on local capital markets induces international capital flows and/or changes in the local interest rate.

Building on Acemoglu and Ventura (2001), the model allows for terms-of-trade effects of capital investment. Acemoglu and Ventura shows that countries with high per-capita growth experience terms-of-trade losses. This may put a constraint on international capital flows. A country that attracts foreign capital and expands production, will see its terms-of-trade deteriorate. This reduce the incentive to accumulate further. In other words, terms-of-trade losses imply decreasing returns to capital.

We proceed as follows. Section 2 discusses the key ingredients of the model. A twelve-region version of this model is calibrated in Section 3. For this, we use estimated relationships between savings, growth and age structure of the population on the one hand, and between real interest rates and net foreign asset positions. The former equation is estimated to include the effect of ageing on savings in a well-founded manner into the model, whereas the latter equation is estimated to get a good indication for the degree of capital immobility. Section 4 focuses on the future effect of ageing the capital flows between North and South and with North. Section 5 gauges the effect of more or less capital mobility on the allocation of investment funds across the globe. Section 6 concludes and discusses roads for further research.

2 A simple model

In this section we develop a simple neoclassical model of economic growth. Its basic aim is to characterise the demand for investment funds in different regions of the world. The starting point is the standard Solow model of economic growth, characterised by decreasing returns to capital (Solow, 1956, Swan, 1956). In order to study the international dynamics of ageing, the basic Solow model is extended into three directions:

– Capital mobility - Different demographic developments in the world give rise to opportunities for intertemporal trade. Countries with a relatively young population experience higher labour force growth than countries with a relatively old population. The consequence is that returns on investment and real interest rates will differ and capital will flow between these countries. However, the mobility of capital is far from perfect and real interest rate differentials are fairly persistent (e.g., Gordon and Bovenberg, 1994). Typically, countries with net foreign debt have a real interest rate than countries with net foreign assets (see Lane and Milissi, 2001). Estimating the relationship between real interest rates and net foreign asset positions provides a measure for the degree of capital mobility. We return to this in Section 3.
– Terms of trade - Countries with good growth prospects (i.e. fast technical progress) may initially have a high real interest rate and want to accumulate additional capital. Decreasing returns to capital and accumulation imply that the real interest rate falls and that the incentive for additional capital accumulation peters out. Acemoglu and Ventura (2001) provide a second reason why, apart from decreasing returns to capital, the demand for capital in fast-growing countries is limited. They provide evidence that countries with high growth experience terms-of-trade losses. To explain this, they build a model that in its simplest form incorporates the Armington assumption: goods from different origin are imperfect substitutes. The consequence of this assumption is that countries with fast technical change can only gain market share in other countries through lower production prices. The gains of fast growth are hence partly dissipated through terms-of-trade losses. These losses reduce the incentive for extra capital accumulation and limit the demand for capital.
– Technological differences - Across countries, there are huge differences in productivity and growth of productivity. The Solow model in its pure form assumes that these differences are absent technology is global public good.[1] We therefore allow for differences in the level of technology and growth therein. Whether a country is rich or poor depends mainly on the level of technology and less on the capital stock. Factors that might account for these

[1] Islam (1995) empirically assesses country-specific technology levels by estimating the neoclassical growth model using a pooled cross section analysis. This analysis reveals that indeed cross-country differences of the measure of total factor productivity distinguished in the neoclassical growth theory differ substantially.

differences include, among others, public infrastructure and education, but are exogenous in our simple model. In our calibration model, we will allow for differences in initial technology (see Section 3). It is, of course, conceivable and consistent with modern theories of economic growth that differences in the state of technology give poor countries the potential to catch up with rich countries (e.g., Gerschenkron, 1952, Abramovitz, 1986, and Barro and Sala-i-Martin, 1995). Poor countries may learn and adapt new technologies from rich countries where technology is state of the art. Not every country is necessarily able to realise the potential for technological catching-up, however. It depends on factors such as technological congruence and social capability that can be seen as preconditions for exploiting the advantages of backwardness.

Whereas the demand for investment funds is given careful attention, the supply of these funds, i.e. savings, is only rudimentary modelled. Consumption and savings do not follow from life-cycle decisions from households (see, for example, Aglietta et al., 2001, for such an approach). Instead, we have adopted an empirically driven approach. Consumption and savings are simply a fraction of income. We estimate an equation for savings rates and use this equation to project the savings rate into the future. According to this equation the savings rate depends, among other things, on the expected growth rate and demographic structure.

2.1 Savings and asset accumulation

Each country uses part of its income Y for consumption C and part for accumulation of capital goods K. Savings S is simply a fraction of current income Y,

$$S_i = s_i Y_i \tag{1}$$

where s is the savings rate. This savings rate is semi-exogenous. It does not follow from intertemporal optimization, but is does depend on growth, per capita income, and the demographic composition of the population. The first two factors are endogenous in the model, whereas demographic factors are exogenous (but changing over time). In the next period the capital stock is the sum of savings and the capital stock, net of depreciation, in the current period

$$K_{i,t+1} = \frac{S_{i,t}}{p_{Z,i}} + (1-\delta) K_{i,t} \tag{2}$$

where p_Z is the price of local final goods (investment and consumption goods) and δ the depreciation rate.

2.2 Trade in capital goods

Countries face different interest rates against which they can borrow or loan investment funds. Structural differences in interest rates are assumed to reflect transaction costs. Even though these structural differences remain, opportunities for arbitrage – taking into account the transaction costs that are involved – are fully exploited. In this sense the international capital market is perfect, but capital mobility is not. This view on capital market and capital mobility is strongly advocated by Stigler (1963): “A misallocation of capital is created, not eliminated, if interest rates are reduced to borrowers without a commensurate reduction in the costs of transactions. The situation is exactly comparable to the elimination of geographical differences in the price of a commodity: if prices at two points differ by less than the transportation costs. The movement of goods is uneconomic.” Here, we pursue the analogy between transaction costs in the capital markets and the transportation costs in goods markets.

The capital stock can be employed either in domestic or in foreign production. However, international trade in capital goods is costly. More specifically, exporting and importing capital are subject to iceberg transport costs. Only a fraction π_i that exporter *i* ships from its country to the global market of capital goods arrives at that market. Similarly, only fraction π_j that importer *j* ships from the market to its country arrives. The price for internationally traded capital goods p_K ensures that the global market is in equilibrium:

$$\sum_i \pi_i K_{F,i} = 0 , \tag{3}$$

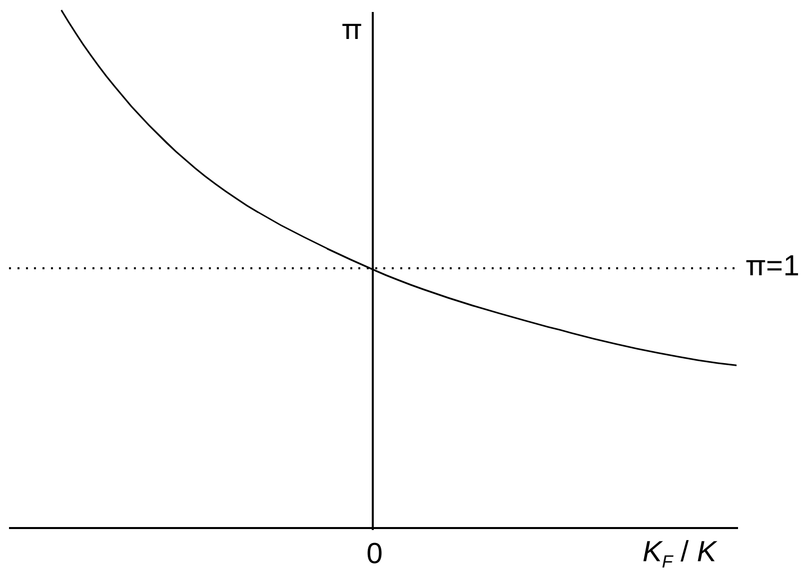
where K_F represents exports of capital goods. The exports are positive for an exporting country, $K_F > 0$, and negative for an importing country, $K_F < 0$. An exporter *i* receives $p_K \pi_i K_{F,i}$ and an importer *j* pays for *M* capital goods on the global market $p_K M = -p_K \pi_j K_{F,j}$.

The transportation or transaction costs are assumed to depend on the volume of trade. The more capital a country exports, the lower π_i is, and the more capital a country imports, the higher π_i is. More technically, π is a negative function of K_F,

$\pi(K_F/K) > 0 , \quad \pi'(K_F/K) < 0 , \quad \pi(0) = 1 .$

Figure 1 illustrates the relation between the transaction costs and the net capital flow. Since the aggregate volume of trade matters, households do not take into account the effect of the trade volume on transaction costs.

Figure 2.1 Transactions costs and net capital flows



For convenience we assume that households own the capital stock and rent it to domestic and -- through the international market of capital goods -- foreign producers. The rental rate for domestic producers is the price of final goods times the sum of the real domestic interest rate *r* (in terms of the final good) and the depreciation rate δ. It is equal to the global price of capital goods net of transport cost (see the technical Appendix)

$$(r_i + \delta) p_{Z,i} = \pi_i p_K \tag{4}$$

Capital mobility is limited and countries face different real interest rates. A country with positive foreign assets will have a lower π and lower real interest rate *r* than a country with net foreign debt. More specifically, the real interest rate differential between country *i* and *j* depends on the net foreign asset positions of these countries and on the relative price of final (investment) goods

$$\frac{r_i - r_j}{r_j + \delta} \simeq \log(\pi_i/\pi_j) - \log(p_{Z,i}/p_{Z,j}) \tag{5}$$

Higher capital mobility implies the benefit of lower transaction costs. Besides, the interest differentials become smaller, improving the allocation of investment funds across countries.

2.3 Production and income

Domestic production of consumption and investment goods *X* depend on the allocation of the capital stock according to

$$X_i = (K_i - K_{F,i})^{\alpha_i} (A_i L_i)^{1-\alpha_i} \tag{6}$$

where *A* represents the state of technology and *L* the active labour force. Both *A* and *L* are exogenous.

Producers maximize profits and employ capital such that the marginal productivity of capital equals its rental rate,

$$p_{X,i} \alpha_i (K_i - K_{F,i})^{\alpha_i - 1} (A_i L_i)^{1-\alpha_i} = (r_i + \delta) p_{Z,i} \tag{7}$$

where $p_{X,i}$ is the price of domestic goods. The final good is homogeneous and traded so that the price of domestic goods must equal the price of final goods at the world market, $p_{X,i} = p_{Z,i} = p_Z$. In fact, the world market price of final goods is a constant. The difference between the price of domestically produced goods and the price of final goods may seem redundant but is only introduced to extend the model later on. Therefore, we continue to make the distinction between prices.

Income derives from production and trade in capital goods,

$$Y_i = p_{X,i} X_i + p_K \pi_i K_{F,i} . \tag{8}$$

2.4 Solving the model

To save on notation we introduce two transformed variables . The first is the capital stock per efficiency unit of labour $k = K/AL$, and the second is the ratio of ex- or imported capital to total capital, $f = K_F/K$.

The model can be reduced to two equations for *k* and *f*. Using the consumption function (1), the definition of income (8) and the production function (6) in the accumulation equation for (transformed) capital (2) gives

$$g_{k_{i,t+1}} = \frac{k_{i,t+1} - k_{i,t}}{k_{i,t}} = s_{i,t} \left[\frac{p_{X,i}}{p_{Z,i}} k_{i,t}^{\alpha_i - 1} (1 - f_{i,t})^{\alpha_i} + \frac{p_{K,t}}{p_{Z,i}} \pi_{i,t} f_{i,t} \right] - \left(\delta + g_{A_{i,t+1}} + g_{L_{i,t+1}} \right) \tag{9}$$

This dynamic equation governing the law of motion of the capital stock in efficiency units of labour looks familiar. At the heart of the Solow-model of economic growth (for a closed economy) is a similar equation. If *k* suddenly increases -- for example as a result of a negative technology shock --, *k* will subsequently start to decline (and return to its equilibrium value). The main difference with the standard model is the assumption of imperfect capital mobility. If *k* suddenly increases, the marginal productivity of capital in domestic production will fall and renting the capital goods to foreign producers becomes more attractive. This is revealed by the first-order condition (equation (7)). Substituting the expression for the rental rate in the first-order condition gives,

$$\frac{p_{X,i}}{p_{Z,i}}\alpha_i\left[k_{i,t}(1-f_{i,t})\right]^{\alpha_i-1} = \frac{p_{K,t}}{p_{Z,i}}\pi_{i,t} \qquad \textbf{(10)}$$

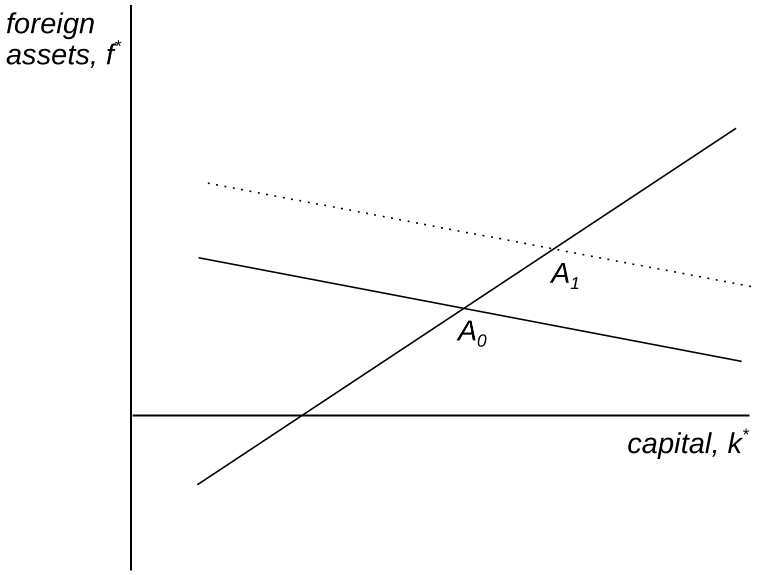
The degree to which capital goods reallocate between domestic and foreign production depends on how strongly the transport costs react to the volume of trade in capital goods.

The condition for equilibrium on the global capital market (3), macro-economic budget constraint (9) and the first-order condition (10) define the equilibrium. Given the capital stocks the allocation across domestic and foreign production is determined in the current period. The results for this period then determine the capital stocks in the next period.

Long-run equilibrium

Constructing a balanced-growth path helps to clarify the properties of the model. Along such a path capital *K*, technology *A*, labour *L* grow at a common rate (in the world economy). Furthermore, both the capital stock per efficiency unit of labour and the ratio of foreign to total capital attain constant equilibrium values, k^* and f^*. From equations (9) and (10) these values are straightforwardly derived. The first-order condition defines a positive relation between k^* and f^*. A higher k^* leads to a lower marginal productivity of capital in domestic production. To maintain the first-order condition f^* must rise. This directly increases the marginal productivity and lowers the rental rate. From the macroeconomic budget constraint follows that a higher k^* requires more investment and thus more savings. This is brought about by less foreign assets (debt), since this implies less transaction costs and a higher (lower) interest payments. Figure 2.2 illustrates both relations for a country with net foreign assets.

Figure 2.2 Long-run eqilibrium



An increase in the savings rate *s* shift the negatively sloped macro-economic budget constraint upward, and the new equilibrium is represented by A_1 rather than A_0. Both k^* and f^* are higher in the new than in the old equilibrium. A lower rental rate (π falls) also implies a higher capital stock in domestic production, $k^*(1\text{-}f^*)$.

Other comparative static results are easy to derive. Table 1 gives an overview of these results. If capital mobility increases, net lenders will increase their foreign assets and net borrowers their foreign debt (relative to their total financial wealth). The real interest rates converge towards each other. The falling transport costs for capital leads to a higher income for both net lenders and net borrowers, to more savings and thus more capital per worker (in efficiency units).

Table 2.1 Comparative statics along a balanced growth path: Marginal effects of exogenous variables and parameters

	savings	depreciation and growth	capital share[a]	capital mobility
	s	$\delta+g_A+g_L$	α	$\pi^{/}$
net foreign assets - f^*	+	−	−	+ f[b]
capital stock - k^*	+	−	−	+

[a] This ignores the effects of changing exponents but considers the direct effect on the marginal capital productivity.

[b] The effect is positive for net lenders and negative for net borrowers.

2.5 Extending the model: trade patterns and capital mobility

Deteriorating terms of trade is often the 'price to be paid' for fast development and high growth rates. This will reduce the incentive to invest and constrain the demand for investment Trade in capital is linked to trade in goods. To clarify the relation between capital and goods markets we adapt the Dixit-Stiglitz model of monopolistic competition between firms that supply different varieties (Dixit and Stiglitz, 1977).

The production of final goods Y requires different varieties of traded, intermediate goods. In each country firms are identical, since they face similar conditions on output and input markets. Using symmetry across firms within a country, the production function for final goods is,

$$Z_j = N^{\phi}\left[N^{-1}\sum_i e_{ij}^{\frac{1}{\epsilon}} N_i x_{ij}^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}}, \quad \sum_i e_{ij} \equiv 1, \quad \sum_i N_i \equiv N, \quad \epsilon > 1 \tag{11}$$

where N_i is the number of varieties from country i, x_{ij} represents intermediate deliveries from a representative firm in country i to country j and the parameters e_{ij} reflect the 'taste' for a product from country i.[2] This function deviates from the standard formulation in two respects. First, it allows for exogenous taste differences across countries, which is relevant from an empirical point of view. Second, it distinguishes between the returns on variety ϕ and the elasticity of substitution ϵ (see, e.g., Broer and Heijdra, 1996, Benassy, 1996, and De Groot and Nahuis, 1998 and 2002). In the remainder the possibilities of returns to scale is ignored and $\varphi = 1$.

Standard profit maximization yields the demand for each variety as (given that $\varphi = 1$)

$$x_{ij} = e_{ij}\left(\frac{p_{X,ij}}{p_{Z,j}}\right)^{-\epsilon} \frac{Z_j}{N p_{Z,i}} \tag{12}$$

where p_X is the price of intermediate goods and p_Z is the ideal price index for final goods. The latter depends on prices of intermediate goods that are employed in the production of final goods,

$$p_{Z,j} = \left[\sum_i n_i e_{ij} p_{X,ij}^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}} \tag{13}$$

[2] Note that we assume the intermediate deliveries obtained from one specific country to be symmetric.

where the share of country i in the total supply of varieties is denoted n_i. Transport costs and other trade barriers are ignored, so the price of variety i is the same on each market, $p_{X,ij} = p_{X,i}$.

In the current configuration the final good is not traded. Instead, intermediate goods are traded and capital goods are rented to or from foreigners. Export of capital goods amounts to a trade deficit, i.e. imports of intermediate goods exceed exports. Since the final good is not traded, the demand for final goods in each country is equal to income of that country, $p_{Z,i}Z_i = Y_i$, where the definition of income (equation 8) is unchanged. Aggregating exports of a country then gives the price of domestically produced intermediate goods (i.e. the price of exports) in terms of the final good,

$$n_i \left(\frac{p_{X,i}}{p_{Z,i}} \right)^{1-\epsilon} = \frac{p_{X,i} X_i}{\sum_j e_{ij} (p_{Z,i}/p_{Z,j})^{1-\epsilon} Y_j} \tag{14}$$

To understand this equation, consider a more *simple configuration* in which the production functions for final goods are similar across countries: $e_{ij} = e_i$ and thus $p_{Z,i} = p_{Z,j} = 1 \ \forall i,j$. Equation (14) then becomes,

$$n_i e_i \left(\frac{p_{X,i}}{p_{Z,i}} \right)^{1-\epsilon} = \frac{p_{X,i} X_i}{\sum_j p_{X,j} X_j} = q_i \tag{15}$$

Given n_i, the price of domestically produced intermediate goods in terms of final goods falls when the share of country in the world economy q_i increases. This effect lowers the incentive to expand. Terms-of-trade losses imply a lower marginal productivity of capital (see equation 10) and also reduce income and thus the accumulation of capital goods (see equation 9). In other words, terms-of-trade losses limit the demand for foreign capital from rapidly growing countries to finance their expansion.

To understand the implications of equation (14) or (15), it helps to realise that the macroeconomic budget constraint (9) and the first-order condition (10) still characterise equilibrium along a balance growth path. Rather than f^* and k^* and, they determine f^* and $p_X^* k^{*(\alpha-1)}$. If the price of exports falls, as the result of temporary extra growth or an adverse changes in preference for the country's exports, the capital stock per efficiency unit of labour will also have to fall.

When the number of varieties is constant for each country, international trade is characterized by the common Armington formulation that goods from different origin are imperfect substitutes. However, this formulation is not entirely satisfactory. Acemoglu and

Ventura show that faster growth *per sé* does not imply worsening terms of trade. Only countries that catch up to other, richer countries, suffer from terms-of trade losses. The potential to catch up is present in countries that start with obsolete technologies and learn to apply better, already existing technologies from other countries and/or in countries for which capital is initially scarce and that can accumulate capital at fast pace. Besides , Hummels and Klenow study export to the United States and find that countries with more workers export in more categories and larger quantities within categories at similar unit prices than countries with fewer workers. This seems to favour Krugman-style models of international trade over Armington-type models.

The Armington formulation for international trade links terms of trade to growth but does not differentiate between the source of growth: is growth the result of more capital and better technology or does it originate from the growth in the labour force? In the latter case the number of varieties should show growth as well, and the terms of trade does not deteriorate.

To distinguish between sources of growth, the number of varieties are derived from a zero-profit condition. The production of intermediate goods involves a fixed cost in terms of labour *F*, which is the same for each country. The price of intermediate goods is a constant mark-up over unit costs, and the profits just cover the fixed cost. One can easily show that number of varieties depends on the labour supply,

$$N_i = \frac{L_i}{1 + (1-\alpha_i)(\epsilon-1)F} \,. \qquad (16)$$

In the *general configuration* (with $e_{ij} \neq e_i$) the terms-of-trade not only depends on the share in the world economy. The taste parameters are chosen such that the model reproduces current bilateral trade patterns. These parameters thus reflect not only taste but also trading and transport costs. This implies at two things. First, a country with relatively strong home bias is relatively closed and less prone to terms-of-trade losses. Second, a country that intensively trade with slower growing countries can expect a terms-of-trade loss, even if growth in that country is equal to the world average. International trade patterns are relevant for understanding international capital flows.

3 Calibration

In this section, we discuss the procedure that we have used to calibrate the model. Section 3.1 starts with a description of the process of ageing in the regions that we distinguish in the model. It presents the evolution of projected labour supply in the first half of the 21st century as well as the changes in the demographic composition. Next, we turn to two key-aspects of the model, namely the estimation of the savings rate s_i and the estimation of the degree of capital mobility. These are discussed in Section 3.2 and 3.3, respectively. Other information used for the calibration is discussed in Section 3.4.

3.1 Demographic development and labour supply

In our model, we distinguish 12 regions, namely Canada, China and Hong Kong, Germany, France, United Kingdom, Japan, Australia and New Zealand, Rest of Asia, Rest of West Europe, Southern Europe, United States and the Rest of the World. Table 3.1 describes the demographic development of these regions in terms of the share in the total population of the young (younger than 15) and the old (older than 65) for the individual regions as well as for the OECD on average. The data clearly reveal the high share of the young in China, Rest of Asia and the Rest of the World. Compared to the OECD, also Australia and New Zealand, and the USA have a relatively high share of young, in sharp contrast with Germany, Japan and Southern Europe. The share of the old reveals an almost opposite pattern of distribution around the world. In terms of evolution over time, the high speed of ageing in China is striking, largely due to the adopted one-child policy. Also the rest of Asia and the rest of the world experience ageing, but more due to declining birth rates. In most other regions, there is a stabilization of the share of the young in the population towards 2050 and an increased process of ageing due to longer lifetimes and retirement of the baby-boom generation.

The changes in the demographic composition have several implications for labour supply. Acknowledging the fact that participation rates are age-specific, it is evident that changes in the demographic composition will affect labour supply. Furthermore, birth rates depend on the degree of development of regions. The population and participation projections that we use are derived from the UN and result in a prediction of labour supply.[1] These projections are given in Table 3.2. All regions are characterized by slowing down of labour supply growth due to both lower participation rates and lower population growth. The strongests delines occur in China and Hong Kong, Rest of Asia and Southern Europe. In the OECD, Canada and the US still experience increases in labour supply over the entire first half of the 21st century, due to relatively high population growth that compensates for the declining participation rates. World population growth is clearly concentrated in the Rest of the World.

3.2 Savings and age composition

For the estimation of the relationship between savings and the demographic composition of economies, we have used the methodology developed in Fair and Dominguez (1991). We estimate the following equation:

$$S_{it}=\beta_{0,i}+\beta_1 g_{it}+\beta_2 1/\log(gdpcap_{it})+\sum_{j=1}^{17}\alpha_j C_{j,it}+\varepsilon_{it}, \qquad (0)$$

[1] Labour force participation rates are from the ILO and were used to construct the labour force by multiplying population with participation rates. For the period 2000-2050, projections for participation and population growth developed by the CPB (...) and the UN, respectively, were used.

where S_{it} is the average savings rate of country *i* over the time period *t,...t*+5, β_{0i} is a series of country-specific fixed effects, g_{it} is the growth rate of GDP per capita of country *i* over the time period *t,...t*+5, *gdpcap* is GDP per capita at time *t*, and $C_{j,it}$ is the fraction of cohort *j* of the total population in country *i* at time *t*. In total, we have seventeen 5-year cohorts, namely 0-5, 5-10, 10-15, ..., 75-80 and 80 and above. Multi-collinearity among the cohort-size variables complicates the estimation of this equation. We therefore follow Fair and Dominguez in putting more structure on the estimated effects sizes α_j. The polynomial constraint that we impose is

$$\alpha_j=\gamma_0+\gamma_1 j+\gamma_2 j^2 \tag{1}$$

Furthermore, we impose the restriction that

$$\sum_{j=1}^{17}\alpha_j=0 \tag{2}$$

We can then derive that

$$\gamma_0 = -\frac{\gamma_1}{17}\sum_{j=1}^{17} j - \frac{\gamma_2}{17}\sum_{j=1}^{17} j^2 \tag{3}$$

The age variables thus enter into the regression equation in the following way:

$$\sum_{j=1}^{17}\alpha_j C_{j,it}=\gamma_1 Z_{1,it}+\gamma_2 Z_{2,it} \tag{4}$$

where

$$Z_{1,it} = \sum_{j=1}^{17} jC_{j,it} - \frac{\sum_{j=1}^{17} j\cdot\sum_{j=1}^{17} C_{j,it}}{17} \quad \text{and} \quad Z_{2,it} = \sum_{j=1}^{17} j^2 C_{j,it} - \frac{\sum_{j=1}^{17} j^2\cdot\sum_{j=1}^{17} C_{j,it}}{17} \tag{5}$$

Our estimation yields estimates for the country specific fixed effects, β_0, β_1, β_2, β_1, and γ_2. Using equation (20), we obtain the value of γ_0. Finally, using γ_0, γ_1, γ_2, and equation (18), the cohort-specific effects on savings are derived.

The contribution of ageing to variation in savings can then simply be determined as

$$S^{ageing} = \sum_{j=1}^{17}\alpha_j C_{j,it} = \sum_{j=1}^{17}(\gamma_0+\gamma_1 j+\gamma_2 j^2)C_{j,it} \tag{6}$$

Our data are derived from a variety of sources (see the Data Appendix for details). Information on the age composition of economies is taken from the United Nations.[2] Data on GDP per capita are taken from the World Bank (World Development Indicators, 2000). The growth rate was constructed as an average annual growth rate of GDP per capita in PPP's. GDP per capita is in constant dollars of .. where conversion is again based on purchasing power parities. Our measure for savings is average Gross Domestic Savings for the five-year periods distinguished in the analysis and is taken from the World Development Indicators. Their data have been aggregated to five-year cohorts, neglecting the distinction between males and females.

The regression results for several specifications are reported in Table 3.1. Our preferred regression equation that we use in the simulation exercises in Section 4 is equation 3.The other equations are added to indicate the sensitivity of the regression results for model specification and sampling.

[2] More detailed information is needed: version of UN and scenario used.

Table 3.1 Dependent variable is average domestic savings, pooled cross-section analysis with 5-year periods from 1963-1998

	Spec. 1 (ALL)	Spec. 2 (OECD)	Spec. 3 (ALL)	Spec. 4 (OECD)
g_{gdpcap}	0.44**	0.76***	0.46**	0.77***
	(2.30)	(4.31)	(2.39)	(4.00)
1/log($gdpcap_{ini}$)	-5.45***	-7.06***	-5.39***	-4.94***
	(-6.47)	(-3.66)	(-6.35)	(-2.89)
$C_{0\text{-}15}$	-0.12	0.03		
	(-0.41)	(0.19)		
$C_{15\text{-}35}$	-0.06	-0.32**		
	(-0.26)	(-1.99)		
$C_{50\text{-}65}$	+0.31	-0.27		
	(1.11)	(-1.26)		
$C_{65\text{-}up}$	-1.09**	-1.48***		
	(-2.45)	(-3.96)		
Z_1			0.0789	-0.0278
			(0.87)	(-0.50)
Z_2			-0.0072	-0.0021
			(-1.27)	(-0.55)
R^2	0.84	0.79	0.83	0.76
N	638	155	638	105

Note: all equations are estimated using country-specific fixed effects. White heteroskedasticity consistent *t*-statistics have been reported in parentheses. *, ** and *** means significance at, respectively, 10, 5 and 1%.

From this equation, γ_0 is straightforwardly derived as 0.0418. This results in a pattern of α's as depicted in Figure 1. Details on sensitivity analyses performed to check for the robustness of the estimated relationship are available upon request from the authors.

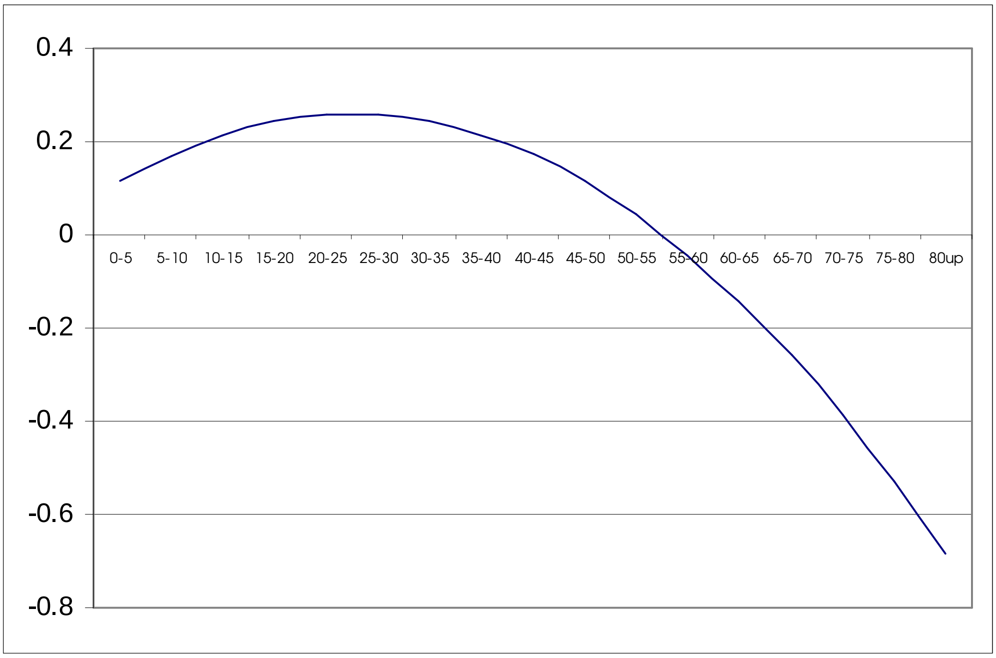


Figure 1. Cohort specific effects on savings.

The implications for the development of savings over time due to demographic changes for the US is decribed in Figure 2 (information for other countries is available upon request). The results for the US are fairly representative for other industrialized countries. << CHECK >> The Figure reveals that due to ageing of the population of the US, the savings rate is gradually declining. Over the period 1960-2050, the US is projected to experience a drop in savings of approximately 10% points.

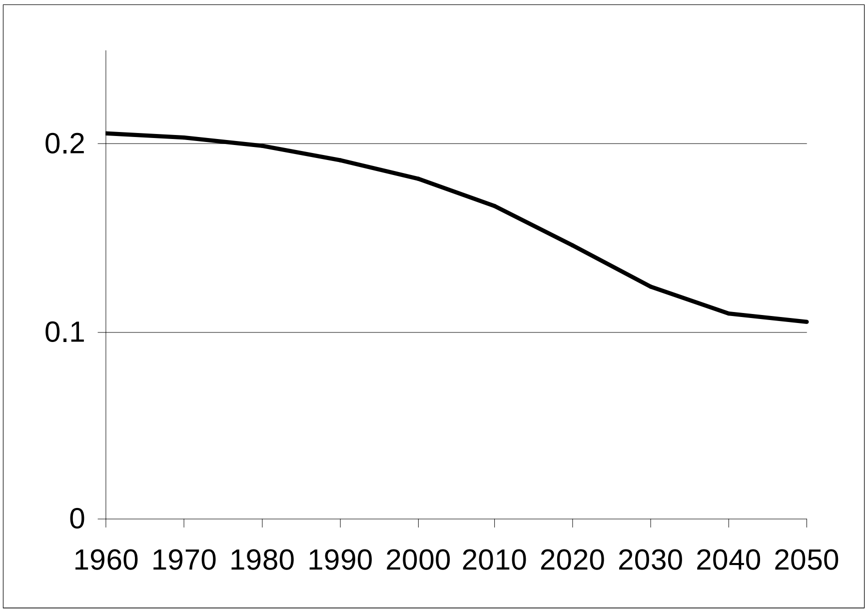


Figure 2. Development of savings due to changes in demographic composition of the US economy over the period 1960-2050

Figure 3 projects the savings rate for the US for the period 2000-2050. Information for other countries is available upon request. The Figure reveals the effects of growth and changes in per capita income due to growth as well as the effects of changes in the demographic composition. For the former effect, we have assumed a 2% growth rate of GDP per capita over the period 2000-2050. This Figure reveals that the decline of savings due to ageing will partly be ameliorated by the positive effect of growth on savings and the increasing income per capita. For the period 2000-2050, this effect is estimated to be slightly less than 5% points.

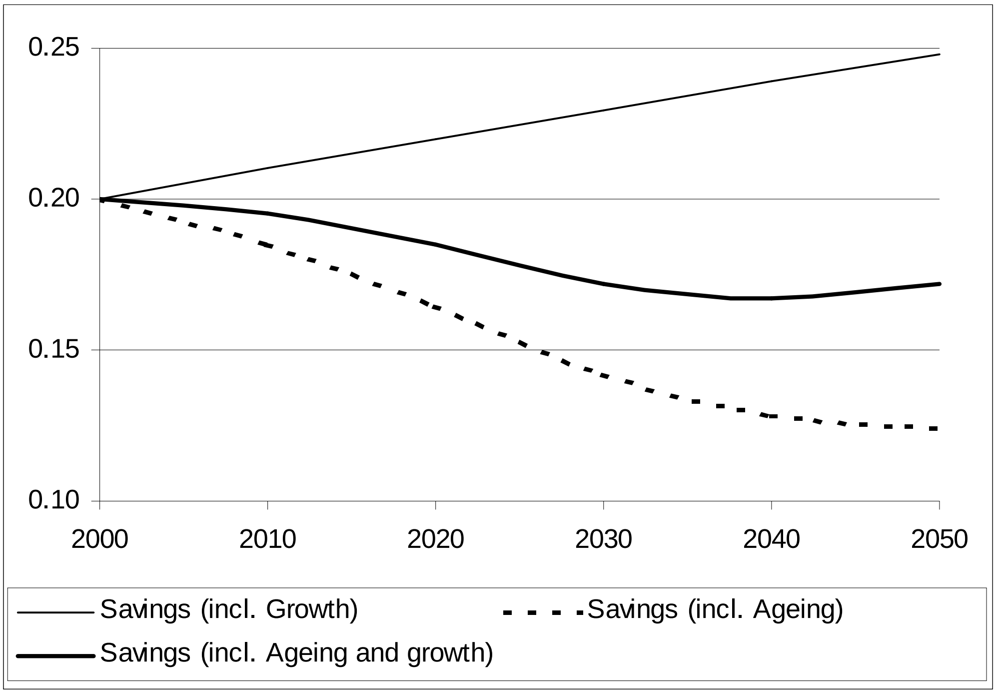


Figure 3. Effects of demographic factors, growth and GDP per capita on projected savings for the US over the period 2000-2050

Finally, in Table .., we describe the development of the savings rate in the baseline of our model for the different regions. Note that these developments are the resultant of both changes in the demographic composition of the population and changes in GDP per capita and the growth rate that depend on the scenario that we develop. We return to a discussion of the latter in more detail in Section 4, but in order to give insight into the development of the (semi-) exogenous variables in the model, we present the development of the savings rate for the realistic scenario at this stage. Except for China and the Rest of Asia, all regions experience a decline in the savings rate. The increase in China and the Rest of Asia is caused by the relatively slow process of ageing resulting in high-saving cohorts initially dominating the population and, more importantly, the high growth rate resulting in strongly increasing GDP per capita with the associated upward effect on the savings rate. The decline in the savings rate is particularly strong in the fast ageing regions Japan and Southern Europe. The other regions take intermediate positions in terms of the development of the savings rate.

3.3 Degree of capital mobility

For the estimation of the degree of capital mobility, we have used data and the methodology developed by Lane and Milesi-Ferretti (2001). Our basic regression equation explains the real interest rate as a function of the Net Foreign Asset Position as a ratio of GDP, the openess of a country as measured by the export share, and a set of country and time-specific fixed effects. The latter are included to control for period-specific global imbalances on the world capital market. We estimate the following equation:[3]

$$r_{it} = \beta_{0,i,t} + \beta_1 \frac{CUMCA_{i,t}}{2+CUMCA_{i,t}} + \beta_2 EXP_{i,t} + \beta_3 DEBT_{i,t} + \varepsilon_{i,t} \qquad (7)$$

where r is the real interest rate, CUMCA the Cumulative Current Account as a fraction of GDP, EXP the openness measure (exports as fraction of GDP), and DEBT the government debt (see Appendix for sources of the data used for the estimation). The latter two variables are merely included to avoid biases on the estimate of β_1 which is our measure of capital market mobility. We expect government debt to have a positive effect on the real interest rate and the degree of openness as measures by the export share to have a negative impact. The latter is driven by the notion that countries that export much have - ceteris paribus - a relatively large capacity to repay debt.

Our basic regression results are reported in Table 2. The results reveal the strength of the omitted bias resulting when omitting government debt. In our simulation model, we will use the last regression equation. To give a feeling for the size of the effects, we take the Cumulated Current Accounts of the USA and Japan. These are -0.18 and .40, respectively. Ceteris paribus, the regression equation predicts that because of this difference, the USA will face a 3.45% points higher real interest rate than Japan.

[3] The choice for our measure for net foreign asset position is driven by the notion that

$$f_i = \frac{z_i}{z_i + \frac{\alpha_i}{\tilde{r}+\delta}}$$

where we assume the second term in the denominator to equal 2. This is based on the assumptions that are roughly in line with the data in our model, namely α=0.3, $\tilde{r}$=0.07 and δ=0.08 implying $\alpha/(\tilde{r}+\delta) \approx 2$ Sensitivity analyses for the latter assumption have been performed and do not substantially affect the results. Data for net foreign assets as a fraction of GDP (z_i) are available from Lane and Milesi Ferretti. The ratio of foreign to total capital f_i can be derived from this fraction:

$$z_i = \pi_i \frac{K_{F,i}}{p_{X,i} X_i} = \frac{\alpha_i}{p_K} \frac{K_{F,i}}{K - K_{F,i}}$$

Table 3.2 Dependent variable: Real interest rate

CUMCA_C_GDP?/(2+CUMC)	-0.05152**	-0.04668**	-0.091672**	-0.12997***
	-2.24999	-1.98574	-2.152336	-3.15745
EXP_SH?/100		-0.05857		-0.36999***
		-1.34416		-3.84058
GOV_DEBT?/100			0.007788	0.028874*
			0.506266	1.959857
R-squared	0.639484	0.641163	0.649220	0.672482
N	463	463	463	463

Note: all equations are estimated using country- and period-specific fixed effects. White heteroskedasticity consistent *t*-statistics have been reported in parentheses. *, ** and *** means significance at, respectively, 10, 5 and 1%. Included countries in the analysis are Australia, Belgium, Canada, Switserland, Germany, Denmark, Spain, Finland, France, Great Britain, Greece, Ireland, Iceland, Italy, Japan, Netherlands, Norway, New Zealand, Portugal, Sweden, USA

3.4 Other calibration issues

In our callibration, we target on GDP per capita in 1997. Data are taken from GTAP 4. The capital stock capital stock and labour augmenting technology (level) are determined as follows. Given the net-foreign asset positions, we determine the relative real interest rates among countries that are conistent with the relative NFA-positions (according to equation 5). Next, we determine the world interest rate that is consistent with the assumption that the world is in its steady state. Finally, capital stocks and technology levels of inidvidual countries are determined using the definition of the marginal product of capital being equal to the real interest rate and the production function of the individual countries. Labour augmenting technological progress is modelled as scenario input. In the realistic scenario, we allow for catching up (except for the Rest of the World), implying that as countries converge in terms of per capita income, they also converge in labour augmenting technological progress.[4]

[4] The Solow-model of economic growth also predicts convergence between rich and poor countries. Rich countries with a high capital stock will grow slower than poor countries with a low capital stock. Mankiw, Romer and Weil (1992) have demonstrated that with a capital share of one-third, convergence is more rapid than observed in reality. With capital mobility, albeit imperfect, convergence will occur at an even more rapid pace (see, for example, Blanchard and Fischer, 1989 and Barro, Sala-i-Martin and Romer, 1995). In our extended version of the Solow model differences in the initial capital stock and in the pace of capital accumulation cannot satisfactorily explain convergence (let alone divergence). However, contrary to Romer, Mankiw and Weil we allow for differences in technology. Given the different levels of technology, convergence occurs (too) rapidly. Convergence to similar levels of technology is a different matter. Technological catching-up is likely to be slow process. Countries differ in savings rates, capital shares and technology. They share a common growth rate for labour and technology.

4 Ageing and capital mobility in developed countries

4.1 Introduction

The model in section 2 highlights several factors that are important for the allocation of capital funds across the globe and for a country's net foreign asset position: the capital intensity of production; substitution between different varieties; the pace of technical progress; the growth rate of labour supply; the degree of capital mobility; and the savings rates. Underlying two of these factors, labour supply and savings, is demography. Section 3 discusses data and evidence for these factors, where special attention was given to the degree of capital mobility and savings rates. By combining model and empirical information, we can study how the allocation of capital funds across the globe, net foreign asset positions and interest rates develop over time.

Let us briefly recapitulate the development of the essential exogenous variables in the model. A common trend to which all currently rich countries are exposed is ageing. In these countries, the growth rate of labour supply falls from 2000 onwards and turns substantially negative (on average) in the period 2021-2040. This is shown in Table 4.1 The macroeconomic savings rates declines as well, reflecting the fact that the fraction of the population that is older than 65 years will increase (see Section 3).[1] The demographic changes will thus reduce both the demand for and supply of investment funds. The implication of these changes for the world interest rate is a priori unclear: it can increase as well as decrease. Our model simulation shows that over time changes of the interest rate in both directions occur.[2] The average user cost of capital steadily increases from 11% in the starting period to 11.7% in the period 2021-2030. Afterwards, the average user cost of capital starts to decline. It is important to emphasise that this result has to be interpreted with some caution. Experience with our model as well as insights from previous studies reveals that projections of the world interest rates are highly sensitive for initial conditions. If in the starting period the world interest rate is high and the capital stock per efficiency unit of labour is low, the world interest rate tends to fall, and vice versa. This is a typical feature of the Solow model. Direct observations for the level of technology and for the capital stock are either poor or completely lacking. This is resolved by choosing a

[1] Also in these countries, there is an offsetting effect related to the increases in GDP per capita that exert an upward pressure on the savings rate. This effect is, however, dominated by the effect related to the share of old people in the population and the declining growth rate of GDP per capita that these countries experience.

[2] To reiterate, these simulations assume that capital mobility between developed and developing countries is limited.

particular calibration strategy, where different options are available.[3] Given that the uncertainty about the initial conditions is hard to resolve, we provide a sensitivity analysis at the end of the paper. We will include this sensitivity analysis at a later stage.

Table 4.1 Labour supply, age structure and savings in the OECD

	2000	2020	2040
labour supply (average growth rate in 20 years period)	-	-0.0	-0.5
population older than 65 (% of total population)	15	20	26
savings (% of national income)	21	17	14

Given these demographic developments and their implications for labour supply and savings, we will address three fundamental questions in the remainder of this section. The first starts from the common expectation that differences among developed countries and between developed and developing countries will induce capital flows at an unprecedented scale. We consider the question how important future demographic changes are for international capital flows. The answer to this question is is not self-evident. What holds for the group of developed countries, also holds for individual countries: ageing will reduce both the demand for and the supply of investment funds. In section 4.2, we will therefore study the effect of (differences in) ageing on capital flows within the group of developed countries.

Our second question is to what extent international capital mobility can help countries that experience rapid aging. More specifically, it addresses the issue to what extent financial imbalances that result from ageing can be absorbed in the world economy given the asymmetric patterns of ageing. This question is of particular relevance for countries that save now to pay for old-age pensions later: if the absorption capacity is limited, they will face the problem that the returns on their savings are low and that paying for old-age pensioners will require a huge distribution from the young to the old. Investing the savings abroad rather than at home could avoid this danger to materialize. Subsection 4.3 will study this idea. Irrespective of the factors behind international capital flows - that could be differences in the process of ageing but also difference in (inter-temporal) preferences - it will demonstrate the effect of more or less capital mobility on real income and on the distribution of income between capital owners and workers.

[3] An alternative for this calibration procedure would ne to take observed real interest rate (for example from the World Development Indicators) as a starting point and determine the capital stocks and technology levels that are consistent with the marginal productivity rule and the production function. A final alternative would be to determine the interest rates that are consistent with the assumption that - for current values of the exogenous variables - countries are in their steady state.

In this subsection will also illustrate the interaction between trade in goods and trade in capital. This interaction is most often ignored in the literature, but turns out to be important.

Throughout the assumption is that capital mobility between developed and developing countries is more limited than among developed countries (see also section 3). Nevertheless, capital flows between developed and developing countries are not negligible in the simulations. The reason is that China and other Asian countries are projected to grow rapidly, so that at the end of the simulation period, in 2050, their share in the world economy is significant. Section 4 will study capital flows between developed countries on the one hand and developing countries on the other hand. In this section attention is confined to capital flows among the developed countries.

4.2 How important are demographic changes for international capital flows?

Developed countries are characterized by substantial differences in timing and degree of demographic changes. Potentially, international trade in capital can exploit these differences. For example, capital markets could channel investment funds from 'old' countries, in which the growth in labour supply has become negligible or even negative, to 'young' countries. The net foreign asset position of a country would then reflect its phase of demographic developments. However, the future demographic developments will affect not only the demand for capital but also the supply. Less labour supply implies less investment and more pensioners imply less macroeconomic savings. The net effect on the foreign asset position is unclear.

To determine the net effect of ageing on foreign asset positions and real interest rates, we compare two cases. The first case can best be described as a realistic baseline. It is the point of reference for all subsequent analyses. It incorporates all relevant empirical phenomena that we discussed earlier: i.e., income dependent savings, moderate capital mobility (that is relatively large among OECD countries), and ageing and declining participation rates affecting labour supply. This case will be compared to a case in which demographic developments are assumed to be equal in all developed regions; i.e., the demographics of all developed regions behaves according of the average of these regions. This comparison thus enables us to analyse the consequences of a-symmetric processes of ageing within the OECD countries.

Table 4.1 presents for four countries or regions the differences between the two cases in terms of the relevant exogenous variables, namely labour supply, savings rates, and the user cost of capital. The world interest rate is almost identical in the two cases. Changes in the user cost of capital thus reflect changes in the net foreign asset position. If foreign debt increases, the user cost increases as well, and vice versa.

Table 4.2	Comparing different and similar demographic changes within the OECD for 2031-2040[a]			
	United States	Japan	Germany	Southern Europe
labour supply - L	19.9	-24.8	-19.0	-42.7
savings - s (% of national income)	2.0	-3.0	-1.4	-5.9
users costs of capital - $(r+\delta)p_Z$ (%)	-0.5	+0.0	-0.1	-0.3

[a] For labour supply the relative difference is presented, whereas for other two variables the absolute difference is given.

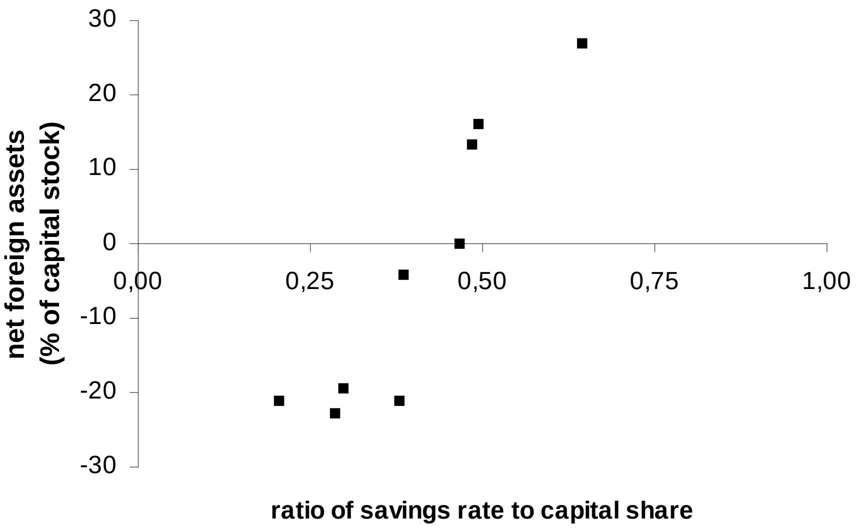
Before turning to a discussion of the effects for the individual regions, it is important to realize that throughout the entire period, the United States and Southern Europe are net debtors, whereas Japan and Germany are net creditors. The results in the Table reveal that ageing in the United States is projected to be less than in the OECD as a whole. When comparing the cases of different and similar demographic changes, this shows up in the positive effect on labour supply and the savings rate. In the other three countries or regions ageing is more serious. They will experience a more than average decline in the labour supply (growth) and the savings rate.

The main effect of less than average ageing in the United States is a decrease in its foreign debt and a decline in the user cost of capital. The positive effect of aging on supply of investment funds dominates the negative effect on the demand for investment funds (through labour supply), resulting in excess savings, an improvement in the Net Foreign Asset Position and a lower user cost of capital. For Germany and Southern Europe the picture is different. There, the negative effect on savings is more than compensated by a reduction in labour supply. Also in those countries, the Net Foreign Asset Position improves and the user cost of capital declines. Finally, Japan is hardly affected at all in terms of its user cost of capital and Net Foreign Asset Position.

So although there is some effect of differences in the pattern of ageing in the OECD on individual region's Net Foreign Asset Positions and user costs of capital, the overall effect on the world interest rate is virtually absent. Furthermore, heterogeneity in patterns of ageing only forms a minor part of the explanation of changes in Net Foreign Asset Positions. In the realistic baseline scenario, the difference in users costs of capital (which is attributable to differences in Net Foreign Asset positions) between the United States and Japan is 4.5 percentage points (on average in the period 2031-2040). Differences in the pattern of ageing between these two countries can only explain 0.5 percentage point of this difference. The reason is clear. Ageing decreases both the demand for investment funds as well as the supply of investment funds. The net effect is modest.

Differences in ageing within the OECD is not an crucially important factor behind the differences in net foreign asset positions(and real interest rates). This then raises the question to what factors differences in net foreign asset positions can be attributed. The pace of technical progress is not likely candidate. Within the OECD per capita growth rates are more or less similar. However, the developed countries show important differences in capital income shares and in savings rates (unexplained by among other things demography). Figure 4.1 plots the net foreign positions against the ratios of savings rate to capital income share. A clearly positive relation emerges.

Figure 4.1 **Net foreign assets, savings rates and capital income share in the OECD, 2021-2030**



4.3 Capital mobility and the allocation of investment funds

Capital mobility allows countries to exploit differences among them. Important differences concern the capital intensity of production, demography, the pace of technical progress, and savings rates (as far as they are unexplained by the phase of economic and demographic development). The question arises how important capital mobility is for the net debtors and the net creditors. To assess the economic consequences of capital mobility requires to compare two fictitious situations: one with low and one with high capital mobility. Important is not only the effect on total income but also on the distribution of income. For workers and capital owners and for young and old generations the effects will not be the same.

Usually, autarky and free trade are compared. However, this overestimates the consequences of capital mobility (severely). Having derived and estimated a measure for capital mobility (the β in section 2), there is no need to resort to the hypothetical constructs of autarky and free trade. From the statistical analysis derives a confidence interval for the degree of capital mobility. We simulate the model with a value for β which is two standard deviations higher (less capital mobility), and lower (more capital mobility), respectively, than the point estimate that was used in the realistic scenario. The two boundary values of capital mobility and the projections with plausible interest rate differentials, allow us to gauge the economic importance of capital mobility. The results are, however, subject to two limitations. First, a statistically reliable measure for capital mobility between developed and developed countries is missing. The simulations are thus confined to capital mobility within the group of developed countries. Second, the simulation model does not describe the consumption-savings decision of households and the effect of interest rates on this decision. With exogenously given savings rates, the simulation models thus shows the economic consequences of changes in the allocation of investment funds (within the group of developed countries).

The simulations show the benefits that are associated with the changes in the allocation of investment funds. With higher capital mobility, the interest rate differentials become smaller and with lower capital mobility larger. Gains or losses not only derive from changes in the allocation. Trading on international capital markets involves costs. Lower mobility implies higher trading costs and higher mobility lower costs.

The results of the simulations are presented in Table 4.3. The United States and Southern Europe are net debtors in period 2031-2040, whereas Japan and Germany are net creditors. With lower capital mobility the United States and Southern Europe will attract less capital and see as a result a fall in their GDP. This will decrease their interest payments, even though the interest rate is higher. The negative effect on real national income is therefore smaller than on GDP. Within the United States and Southern Europe, the loss is not evenly distributed across workers and capital owners. Workers see their wage fall, since less capital is available and labour productivity is lower, whereas capital owners see the return on investment rise. Decreased capital mobility thus goes at the expense of the current generation as compared to future generations. Japan and Germany will invest less abroad and more at home. Lower capital mobility thus implies a higher GDP for these countries. At the same time they see the return on their foreign investments fall. Besides, larger and more capital-intensive production at home leads to terms-of-trade losses. The lower return on foreign investment and terms-of-trade losses add up to a decrease in real gross national income. Each of the four is thus worse off if the international mobility of capital becomes less. In terms of the inter-generational distribution of income, the current generation gains as compared to the future generations in Japan and Germany.

An opposite picture emerges with higher capital mobility. For example, each of the four gains if capital becomes more mobile. The cases of low and high capital mobility give a range of outcome for the various variables. The effect on real national income is modest. The effect on the income distribution is more significant. In Japan the difference in the user costs of capital between both cases is almost 2 percentage points. In Southern Europe the difference in GDP, and therefore in wages, is noticeable.

Table 4.3 Economic consequences of lower and higher capital mobility within the OECD for 2031-2040[a] changes in relation to a path with an average degree of capital mobility

	United States	Japan	Germany	Southern Europe
lower capital mobility				
gross domestic product	-1.8	2.3	1.1	-2.8
real gross national income	-0.5	-0.4	-0.0	-0.7
user costs of capital	0.5	-0.7	-0.4	0.4
higher capital mobility				
gross domestic product	3.4	-3.8	-2.0	6.0
real gross national income	1.1	1.1	0.2	1.8
user costs of capital	-0.9	1.2	0.8	-0.8

[a] For gross domestic product and gross national income the relative difference is presented, whereas for the user costs of capital the absolute difference is given.

Capital mobility also depends on product markets. To demonstrate this, the simulations with low, average and high capital mobility have been rerun with a lower substitution elasticity between varieties (the ε in section 2), 2.5 instead of 5. This comes close the value that Acemoglu and Ventura find when trying to generate a plausible pace of convergence between poor and rich countries.[4] Table 4.4 produces the simulation results with a lower substitution elasticity.

A lower substitution elasticity imply faster decreasing returns to capital. Export of capital raises the return on domestic investment relatively quickly, and import of capital reduces the return relatively quickly. A lower substitution elasticity will thus limit the size of the capital flows and, given saving rates, the corresponding changes in net foreign asset positions. Table 4.4 clearly shows the changes in GDP and user costs of capital are smaller. Interesting is that distribution of the losses or gains across the countries has changed. The effect on real national income in Japan is now almost negligible. The reason for the different distribution is that the reference path with a low substitution elasticity is different from the path with a high elasticity. With a lower substitution elasticity net foreign debt in the United Sates and Southern Europe is higher and net foreign assets in Japan and Germany lower.

[4] This value for the substitution elasticity do not necessarily imply to a more plausible pace of convergence in our model, since it differs from their model of economic growth.

Table 4.4 Economic consequences of lower and higher capital mobility within the OECD for 2031-2040 with a lower elasticity of substitution between varieties [a]changes in relation to a path with an average degree of capital mobility and ε=2.5

	United States	Japan	Germany	Southern Europe
lower capital mobility				
gross domestic product	-1.6	1.7	1.0	-2.4
real gross national income	-0.7	0.1	0.1	-0.9
user costs of capital	0.4	-0.5	-0.3	0.3
higher capital mobility				
gross domestic product	2.9	-2.0	-1.7	4.6
real gross national income	1.3	0.0	-0.2	1.8
user costs of capital	-0.6	1.0	0.7	-0.5

[a] For gross domestic product and gross national income the relative difference is presented, whereas for the user costs of capital the absolute difference is given.

5 Capital flows between developed and developing countries

In fast growing, developing countries opportunities to investment are many. From this perspective the demand for capital in these countries is massive. The counterpart is in developed countries, where labour force growth is considerably lower and the pace of technical progress is slower, the demand for capital is limited. This suggests that capital should flow from North to South, particularly when the effects of ageing are felt in the North.

Growth in labour and technology is only one part of the story. There are at least two reasons why capital flows from North to South are likely to be limited.[1] First, a consistent empirical fact is that the growth rate and the level of per capita income have positive effect on savings rates, so that fast growth in developing countries raises not only the demand for capital but also the supply. Second, Acemoglu and Ventura shows that fast per capita growth induces terms-of-trade losses, which tend to reduce the incentive to invest in fast growing countries.

Simulations can show how important each of these reasons is and what the net effect of fast or slower per capita growth in developing countries is. The assumption is that growth in labour-augmenting technology in Asia becomes one percentage point lower each year. The effect on the user costs of capital are shown in Table 5.1. In the first simulation the savings rates (in Asia) are kept constant, whereas in the second simulation lower growth and income reduces the savings rates. The first simulation have been run with a high and a low elasticity of substitution between product varieties, ε=5 or ε=2.5.

[1] An additional reason is that China will also see its population age. In the period 2020-2050 the labour force in China is projected to decline.

Table 5.1 The effect of lower growth in Asia on user costs of capital in 2021-2030

	technology growth in Asia becomes 1% lower each year		
	United States	Japan	Asia
high substitution elasticity (ε=5)			
constant savings rates	-0.0	-0.0	-0.4
lower savings rates in Asia	0.1	0.1	0.2
low substitution elasticity (ε=2.5)			
constant savings rates	0.0	0.0	-0.1

The first row in Table 5.1 shows that lower technology growth in Asia leads to lower demand for investment funds in this region. Asia will reduce its foreign debt and increase its foreign assets, and the user costs of capital will decline. The lower demand for investment funds in Asia spills over to the international capital market, and worldwide the user costs of capital tend to fall. Since the simulations still assume limited capital mobility between developed and developing countries, the effect on developed countries is modest.

Lower growth and income will reduce savings rates in Asia. The estimation in sections tell how large the negative effect on savings rates is likely to be. The second row in Table 5.1 shows that the net effect of lower growth and income in Asia is not reduce but to push up interest rates, in Asia itself and in the rest of the world.

A lower elasticity of substitution between product varieties does not alter the direction of the capital flows, but reduce the flows themselves. Indeed, the effect on interest rate and user costs of capital is smaller with a low than with a high elasticity, if savings rates are kept constant.

6 Conclusions

This paper has developed a simple neoclassical growth model to analyze the implications of ageing in a world characterized by heterogeneous patterns of ageing. For this aim, we have used a calibrated model, that incorporates empirical evidence on the dependence of savings on the age composition of economies and the relationship between real interest rate differentials and net-foreign asset positions characterizing the degree of capital mobility. We have focussed on three interrelated questions. The first was how differences in the pattern of ageing in developed countries affect Net Foreign Asset Positions and the world real interest rate. It was concluded that these effects are minor. Although there are some differences in the effects on Net Foreign Asset Positions and user costs of capital for individual countries, the effect on the world interest rate is limited. This is basically caused by the fact that ageing affects the demand and supply for capital in similar directions. Our second question was to what extent capital mobility can help in channeling the differences between investments and savings that result from ageing towards the most productive production options. With more limited capital mobility, real interest rate differentials increase, GDP of net debtor countries decline and the GDP of net creditor countries increase. All countries are confronted with a decline in national income. Finally, we have analysed the role of less developed countries. The basic idea here is that less developed countries with their large growth potential can to a large extent absorb the excess savings that are associated with ageing in the early phases of ageing. We have emphasised that these effects are likely to be modest for two reasons. First, as the less developed countries grow rich, their savings rate is likely to increase. This implies that part of the capital need is generated within these regions. Secondly, fast growing countries tend to be faced with terms of trade losses. This implies that the incentive to accumulate capital is reduced. This also puts a break on the capital needs of less developed countries.

7 References

Acemoglu, D. And J. Ventura (2001): The World Income Distribution, NBER Working Paper, no. 8083 Cambridge, MA.

Barro, R.J., X. Sala-i-Martin and Romer (1995)

Blanchard, O. and S. Fischer (1989)

Carroll, C.D. and D.N. Weil (1994): 'Saving and Growth: A Reinterpretation', Carbegie-Rochester Conference Series on Public Policy, 40, pp. 133-192.

Fair, R.C. and K.M. Dominguez (1991): 'Effects of the Changing U.S. Age Distribution on Macroeconomic Equations', American Economic Review, 81, pp. 1276-1294.

Groot, H.L.F. de and R. Nahuis (1998):

Groot, H.L.F. de and R. Nahuis (2002):

Islam. N. (1995):

Lane, P.R. and G.M. Milesi-Ferretti (1999): The External Wealth of Nations, CEPR Discussion Paper, no. 2231, London.

Lane, P.R. and G.M. Milesi-Ferretti (2001): Long-Term Capital Movements, NBER Working Paper, no. 8366, Cambridge, MA.

Lührmann, M. (2001): The Role of Demographic Change in Explaining International Capital Flows, unpublished manuscript, Mannheim University.

Mankiw, Romer and Weil (1992)

Worldbank (2000): World Development Indicators 2000, CDROM, Washington.

8 Technical Appendix

8.1 Determining the number of varieties

The price $p_{X,i}$ is mark-up over unit cost c,

$$p_{X,i} = \frac{\epsilon}{\epsilon - 1} c_i$$

The zero-profit condition is

$$(p_{X,i} - c_i) x_i - w_i F = \frac{1}{\epsilon - 1} c_i x_i - w_i F = 0$$

Labour costs are a constant fraction $1-\alpha_i$ of total cost. Combining this with the resource constraint gives

$$w_i \frac{L_i - N_i F}{N_i} = (1 - \alpha_i) c_i x_i$$

Substituting this expression in the zero-profit condition should equation 16.

8.2 Derivation of equation (4)

Denote the asset price of capital goods v. Renting the capital good to producers implies that the owner foregoes the benefit of consuming this good in this period. In return, the owner receives a payment from the producer (the rent). Besides, it can sell the depreciated capital good in the next period. The required rate of return on the capital good is equal to the nominal rate of interest R. More specifically, the arbitrage condition for arbitrage reads,

$$v_t - F'(.) = \frac{v_{t+1}(1-\delta)}{1+R_t}$$

where $F'(.)$ is the marginal value of capital in period t. Investment is completely reversible and the capital good can either be consumed or employed in production, thus $v = p_Z$. Using this and defining the real interest rate r as the difference between the nominal interest rate and the expected growth rate of final goods prices, gives the following equation,

$$\frac{[r + \delta(1+g_{p_Z})] p_Z}{1+r+g_{p_Z}} = F'(.)$$

Comparing this equation to equation (4), shows that the latter equation has been simplified somewhat. This does not involve severe error as long as the expected inflation rate of final goods prices and the real interest rate are not too large.

9 Data sources

This appendix describes the data that have been used for callibrating the model. Most data are taken from the World Development Indicators 2000 (Worldbank, 2000). They are described in Table 8.1

Abbreviation/ Variable name	Description	Source
C_j	Cohort size of cohort j as share of total population	UN
g	Growth of gdpcap (see below)	WDI
gdpcap	GDP per capita in constant dollars (PPP)	WDI
r	Real interest rate (%): lending rate adjusted for inflation as measured by the GDP deflator	WDI
S	Gross domestic savings (% of GDP): Difference between GDP and total consumption	WDI