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A SIMULATION MODEL OF GLOBAL PENSION INVESTMENT

by

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RÉSUMÉ

Une intégration financière poussée au niveau mondial peut-elle aider les pays de l'OCDE en vieillissement rapide à tirer parti de la maturation démographique moins avancée des autres pays ? Si oui, comment et dans quelle proportion ? Ces questions deviennent de plus en plus pressantes dans un contexte où l'on prend lentement conscience que les systèmes de retraite — même entièrement capitalisés — n'échapperont pas aux contraintes démographiques en l'absence de transferts de capitaux considérables entre la zone de l'OCDE et les pays plus jeunes.

Un modèle de simulation néoclassique « économie-démographie » portant sur deux régions met en évidence deux conclusions fondamentales pour les décideurs. D'une part, les flux de capitaux depuis les pays à vieillissement rapide (principalement la zone de l'OCDE) vers les pays plus jeunes (surtout des pays en développement) ne peuvent qu'atténuer légèrement — sans les annuler — les effets du vieillissement sur la baisse des rendements du capital. D'autre part, l'interaction entre le vieillissement de la population et l'intégration financière pourrait bien avoir des conséquences importantes en matière de répartition. En effet, elle risque de profiter aux personnes âgées qui ont épargné leur vie durant, mais d'empirer la situation de ceux qui n'ont pu le faire. La mise en œuvre de politiques encourageant ou contraignant les ménages pauvres à épargner pourrait bien devenir une priorité.

SUMMARY

How and to what extent can a high degree of global financial integration help the fast-ageing OECD benefit from the delayed ageing process in the non-OECD area? The question is being raised with increasing urgency as it is slowly understood that even fully funded pension schemes will not escape demographic pressures in the absence of considerable capital flows between the ageing OECD and the younger part of the world.

A simulation with a two-region neo-classical economic-demographic model reaches two basic conclusions of importance to policy makers. First, capital flows from fast-ageing, mostly OECD countries to slowly ageing, mostly developing countries can only slightly attenuate, but not reverse, the consequences of an ageing population on falling returns to capital. Second, significant distributional effects are likely to arise from the interaction of population ageing and financial integration. Global financial integration benefits elderly lifetime savers, but hurts elderly lifetime non-savers, hence increasing the urgency of implementing policies which encourage or force poor households to save.

PREFACE

Maintaining prosperity in an ageing society is a rapidly growing concern in almost all OECD countries and was one of the topics discussed in depth at the 1998 Meeting of the OECD Council at Ministerial level.

The ageing of populations, and policy reactions to it, will have important implications for the financial interdependence between the OECD area and the developing world as OECD region savers seek to maximise their returns outside OECD countries. The authors of this study, Landis MacKellar of the International Institute for Applied Systems Analysis (IIASA) and Helmut Reisen of the OECD Development Centre, have developed an economic-demographic model to simulate the nature of these implications for the 21st century. Their model complements the OECD Minilink model created to examine the macroeconomic implications of ageing by adding policy-relevant demographic, sectoral and distributional detail.

The results of the simulations point out how, and to what extent, international financial integration could assist in softening the impacts of population ageing. The authors conclude that the investment of pension assets into emerging markets can attenuate, but not reverse, the decline in capital returns that will result from population ageing. Moreover, the study shows that significant distributional effects will arise from the interaction of financial globalisation and population ageing: while globalisation is likely to benefit funded pensions, it might reduce pensions from unfunded schemes.

This study was carried out within the framework of the Development Centre's research programme on Macroeconomic Interdependence and Capital Flows and was also included as a contribution to a larger, OECD-wide report, *Maintaining Prosperity in an Ageing Society* (1998). The findings will be of particular interest to policy makers in finance, social affairs and development ministries as well as people in the financial industry and researchers carrying out applied economic research.

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INTRODUCTION

"Once freed, money may well flow disproportionately to developing countries. For this is the surest way to beat demography", wrote *The Economist* on 20 June 1992. This paper aims at quantifying and testing that proposition via simulation analysis with a two-region neo-classical economic-demographic growth model. The two regions considered are "Fast-Ageing Countries" (FACs) and "Slowly Ageing Countries" (SACs), corresponding fairly closely to the traditional "industrial/less developed" and "OECD/non-OECD" aggregates. The paper will discuss two different scenarios with respect to international capital mobility, comparing a baseline *Autarky Scenario* with a scenario of rapid financial integration between the two regions, the *Globalisation Scenario*. While the Autarky Scenario corresponds to a continuation of home-asset preference currently observed among portfolio managers, the Globalisation Scenario is meant to reflect exploitation of the global diversification benefits proclaimed by modern portfolio theory.

Aggregate macroeconomic results — in terms of impacts of population ageing and financial globalisation on output and income, savings, capital flows, and net foreign assets — are similar to those obtained from simulation analysis with more advanced models (such as the OECD's Minilink model, OECD, 1998). What is gained from economic simplicity is added demographic, sectoral, and distributional detail.

How can we summarise the relationship between global demographic dynamics and financial globalisation? It is widely understood that unfunded Pay As You Go (PAYG) pension schemes are locked into the ageing economy. Less widely appreciated, however, is the fact that even fully funded pension schemes are exposed to demographic pressures so long as their assets remain invested in ageing countries alone. When the baby-boom generation starts to draw on funded pension schemes (around 2010), the impact of that decumulation on asset prices, and thus on pension benefits, might be decidedly negative (Reisen, 1998).

The diversification of FAC retirement savings into SACs via investment in emerging stock markets provides the prospect of higher expected return for a given level of risk or, put differently, lower risk (as systemic volatility is reduced) for given expected return. The correlation between returns on established and emerging stock markets is likely to remain low as financial globalisation advances[1]. This suggests that the benefits of diversification will persist far into the future. The benefits of global portfolio diversification also apply to emerging-economy financial managers, who could reduce some of the risks stemming from high exposure to shocks in their own countries by allocating a portion of their asset portfolios to established financial markets (Reisen, 1997).

Table 1 documents the strong growth in OECD and non-OECD pension assets, the most important institutional vehicle for portfolio investments (equities and bonds). The table also shows that these are heavily invested in home assets

(defined as assets held in the home country of the investor only) though the home bias in OECD assets has been reduced during the 1990s, including through investment into emerging markets. The World Bank (1997) estimated that in 1995 around $70 billion were held by OECD pension funds in the emerging markets.

Table 1. **The Home-Asset Preference in Funded Pension Assets**

	1990	1995[e]
Total Pension Assets, bn $		
- OECD	4 813	7 865
- non-OECD	109	311
Home-Asset Share, % of Assets (a)		
– OECD Pension Assets	92.8	88.9
– non-OECD Pension Assets (b)	100.0	99.3

Notes: (a) Home assets share refers only to the share of assets invested in the home country of the investor.
(b) excludes Hong Kong where the foreign asset share is 60 per cent.
(e) Estimate.
Source: InterSec Research Company.

The first section of the paper will highlight some salient aspects of global demographic trends, which are likely to intensify the financial interdependence between the two regions. The second section will present a simple two-region simulation model (details of which are contained in Annexes 1 and 2). The third section will present and discuss the results of several model runs, underlying assumptions for which are described in Annex 3. We derive conclusions regarding macroeconomic benefits from financial integration, quantify the volume of capital flows involved, and identify distributional impacts on the working-age and retirement-age populations. In closing, we discuss the basic policy implications of our analysis of the interaction between population ageing and financial globalisation.

I. DEMOGRAPHIC TRENDS AND THEIR IMPLICATIONS

"Global population ageing" is a shorthand phrase used to describe a complicated set of regionally distinct changes in population age composition (see Table 1). Going hand in hand with changes in population age distribution are trends in aggregate population growth, namely, continued very slow rates of demographic increase in the North and rapidly decelerating population growth in the South.

If "population ageing" is defined as an increase in the average age of the population, all populations are ageing. However, when "population ageing" is (as is more conventional) defined as transition from a high support ratio (population aged 15-59 divided by population aged 60+) to a low support ratio, then the populations of the world fall into two groups. In the first, consisting of populations in Europe, the European regions of the Former Soviet Union, North America, Japan, Australia and New Zealand, the support ratio is declining rapidly from an already low base. In the second, consisting of populations in Africa, Asia, and Latin America, the support ratio is also declining, but it will not reach levels currently seen in the first group of countries until the middle of the next century. Thus, in this paper we divide the world into two regions based on the support ratio: Fast-Ageing Countries (FACs) and Slowly Ageing Countries (SACs)[2].

Despite the uncertainties in forecasting demographic trends over the next 50 or so years, uncertainties which are mostly due to the difficulty of projecting fertility rates, some demographic trends can be predicted with a high degree of confidence. Two salient aspects deserve to be highlighted because of their great importance for future economic interdependence (see Table 2):

- FAC populations will age from the 'middle' of the age pyramid as the large baby-boom cohort becomes elderly in roughly 2010. SAC populations, by contrast, are ageing from the 'bottom', meaning that, as today's young persons move into the working years, they are being replaced by a much smaller cohort of children (due to fertility decline). Therefore, the prospective demographic changes imply divergent trends in labour force growth across the two regions. Assuming that age- and sex-specific labour force participation rates remain unchanged, labour force growth rates will rapidly decline in the FAC area and turn negative after 2010. In strong contrast, age-distribution changes are increasing the labour force in the SAC area; the proportion of the population in the working-age bracket (15-59) will remain roughly constant, despite rapid increase in the elderly population.

- Changes in the age composition of the population will have consequences for the rate of net financial asset accumulation and on the rate of return of financial assets. An important aspect of prospective age-structure changes is that these will shift the balance between the age groups that may be characterised as prime borrowers and prime savers. The United States, for example, features relatively high household savings in the high-income age cohorts (40-59), whereas net savings in the other age cohorts is low or negative (Attanasio, 1994). As the baby boom generation filters

through the peak asset accumulation years, the share of the adult population in the prime saving years (population aged 40-59 divided by population aged 15+) will rise until roughly 2010 in FACs and then commence an extended decline (see Table 2). In SACs, as well, this ratio will rise until 2010; by contrast, however, it will remain fixed at approximately 0.3 throughout the rest of the century.

In a closed economy, the neo-classical response to slowing labour force growth is to substitute capital for labour, leading to an increase in the capital-output ratio and a corresponding reduction in the rate of return to capital. *Pari passu*, the rate of return to saving declines, leading households to consume rather than save, so the economy's reduced demand for investment expenditure is matched by reduced supply of savings. In long-run equilibrium, the result of population ageing (independent of changes in the rate of growth of total population) is reduced *per capita* output and consumption.

In an open economy, the situation is complicated, because households have the option of purchasing assets installed abroad, where the rate of return to capital may be higher. A number of studies (Cutler *et al.*, 1990; Börsch-Supan, 1996; Masson and Tryon, 1990; OECD, 1998; Higgins, 1997; Yoo, 1994) have concluded that global demographic divergences should stimulate capital flows from the most rapidly ageing regions (especially Europe and Japan) to less rapidly ageing regions (especially North America and the less developed countries), where the capital-output ratio is lower and the rate of return to capital is higher. With a significant proportion of FAC savings being invested in SACs, capital returns and saving rates, as well as *per capita* output and consumption, would be higher in the FACs *vis-à-vis* the autarky case.

However, simulations with the OECD Minilink model, based on a modified version of the Blanchard consumption model, led the authors to caution that any benefits from investment abroad are likely to be small. As the authors wrote (OECD, 1998, p. 28):

– the accumulation of the net foreign assets by an OECD country, particularly a small country which faces ageing soon, might provide a small but significant contribution to living standards through future net investment income. However, given the potentially adverse effects on domestic productivity of shifting investment away from domestic sources, such effects are likely to be very limited in offsetting the effects of ageing.

– the scope for many/most OECD countries to obtain such beneficial effects are likely to be even more limited, given that increased investment in the non-OECD will progressively lower the return on such investments.

Our simulation confirms these results, despite our using a simple accounting model. We extend previous studies by incorporating detailed demographic trends and by providing more fine-grained results for sectoral and distributional outcomes.

Table 2. **Population, by age group**

	1995	2010	2020	2030	2040	2050	2100
Fast-ageing countries							
Total population (million)	1 251	1 315	1 339	1 350	1 344	1 317	1 212
Avg. annual per cent change		0.3	0.2	0.1	0.0	-0.2	-0.2
Age 0-14	256	226	218	207	200	196	197
Avg. annual per cent change		-0.8	-0.3	-0.5	-0.3	-0.2	0.0
Age 15-59	774	812	784	750	716	678	613
Avg. annual per cent change		0.3	-0.3	-0.4	-0.5	-0.5	-0.2
Age 60+	221	278	336	392	428	443	402
Avg. annual per cent change		1.5	1.9	1.6	0.9	0.4	-0.2
Age structure (per cent)							
Age 0-14	20.5	17.2	16.3	15.3	14.9	14.9	16.3
Age 15-59	61.9	61.7	58.6	55.6	53.3	51.5	50.6
Age 60+	17.7	21.1	25.1	29.0	31.8	33.6	33.2
Support ratio (population 15-59 : population 60+)	3.5	2.9	2.3	1.9	1.7	1.5	1.5
Prime savers ratio (population 40-59 : population 15+)	0.31	0.34	0.33	0.31	0.30	0.28	0.27
Slowly ageing countries							
Total population (million)	4 451	5 696	6 539	7 321	7 995	8 593	9 188
Avg. annual per cent change		1.7	1.4	1.1	0.9	0.7	0.1
Age 0-14	1 534	1 765	1 902	1 965	1 973	1 997	1 583
Avg. annual per cent change		0.9	0.7	0.3	0.0	0.1	-0.5
Age 15-59	2 595	3 430	3 934	4 375	4 783	5 069	5 187
Avg. annual per cent change		1.9	1.4	1.1	0.9	0.6	0.0
Age 60+	322	501	703	981	1 239	1 527	2 418
Avg. annual per cent change		3.0	3.4	3.4	2.4	2.1	0.9
Age structure (per cent)							
Age 0-14	34.5	31.0	29.1	26.8	24.7	23.2	17.2
Age 15-59	58.3	60.2	60.2	59.8	59.8	59.0	56.5
Age 60+	7.2	8.8	10.8	13.4	15.5	17.8	26.3
Support ratio (population 15-59 : population 60+)	8.1	6.8	5.6	4.5	3.9	3.3	2.1
Prime savers ratio (population 40-59 : population 15+)	0.25	0.29	0.30	0.30	0.30	0.30	0.31

Source: Lutz, 1996.

II. A SIMULATION MODEL

Based on work originally presented by Blanchet and Kessler (1992), we have developed a simple neo-classical two-region, two-factor economic-demographic model, which is described in Annexes 1 and 2.

Age-specific saving and labour force participation rates are exogenous; thus, the IIASA model in its present form is essentially an accounting model. For a given population size, age structure has three effects on *per capita* income: first, through the labour force as it affects the number of workers relative to non-workers; second, through capital formation, as it affects the number of savers relative to dissavers; third, and also through capital formation, as it affects the wage rate and rate of return to capital, which in turn determine the income streams which give rise to saving. In concentrating on relatively detailed age-structure effects, our work complements other analyses (e.g. Börsch-Supan, 1996; Cutler *et al.,* 1990) in which the impact of population ageing is mediated through the life cycle hypothesis (LCH) of household consumption. Closely related to these are linked international macroeconomic model-based analyses (e.g. Masson and Tryon, 1990 and OECD, 1998), in which the impact of ageing is mediated through the major macroeconomic functions, particularly the aggregate consumption/saving function. Given theoretical ambiguities, a simple accounting model with ample demographic detail provides a useful benchmark for work with more economically sophisticated, but demographically sparse, models.

Savings are allocated to investment projects at home and abroad by means of exogenous capital-flow coefficients, and investment in each region is equal to domestic, plus foreign, savings. A rise in foreign savings is assumed to be mirrored by a corresponding rise in domestic capital formation: the possibility that additional foreign savings might merely inflate asset prices or fuel consumption is not allowed for and the current account is assumed to adjust passively to changes in capital inflows[3]. The exchange rate plays no explicit role, and all economic variables are expressed in 1995 US dollars.

As illustrated in Table 3, the model tracks receipts and disbursements — and thus net savings — by institutional sector (households, firms, government)[4]. Capital consists of residential capital, capital operated by private unincorporated enterprises (PUEs), and capital operated by firms (i.e. corporate enterprises). The first two types of capital are installed exclusively in the home region. Imputed rents (in the case of residential capital) and the profits of PUEs accrue directly to households. Capital operated by firms is installed both at home and abroad; these firms earn profits, pay taxes and distribute dividends to holders of claims[5]. Direct taxation follows the principle of taxation at the source, meaning that capital returns are taxed only once, when and where they are earned[6].

Table 3. **Sources of Savings, Region 1**

HOUSEHOLDS

1. Population aged 15-59

Receipts
- Compensation of employees
- Entrepreneurial income (net of depr. and indirect tax)
- Imputed housing services (net of depr. and indirect tax)
- Transfers incl. bequests (from pop. aged 60+)

Disbursements
- Direct tax
- Workers' social security contributions
- Employers' social security contributions
- Workers' contributions to private pension plans
- Employers' contributions to private pension plans
- Consumption
  - From after-tax compensation of employees
  - From after-tax entrepreneurial income
  - Imputed housing services
  - From transfers incl. bequests

2. Population aged 60+

Receipts
- Compensation of employees
- Annuity payments from PPS and OIs
- Social security benefits

Disbursements
- Direct tax
- Workers' social security contributions
- Employers' social security contributions
- Workers' contributions to private pension plans
- Employers' contributions to private pension plans
- Consumption
  - From after-tax compensation of employees
  - From annuity income
  - From social security benefits
- Transfers incl. bequests (to pop. aged 15-59)

3. Private Pension System (PPS)

Receipts
- Dividends distributed from profits on capital installed in Region 1
- Dividends distributed from profits on capital installed in Region 2 (portfolio claims only)
- Workers' contributions to PPS
- Employers' contributions to PPS

Disbursements
- Annuity payments to population aged 60+

4. Other Institutions (OI)

Receipts
- Dividends distributed from profits on capital installed in Region 1
- Dividends distributed from profits on capital installed in Region 2 (portfolio claims only)
- Dividends distributed from repatriated profits on FDI abroad
- Capital returns to residential capital and capital operated by PUEs (portion owned by 60+ population only)

Disbursements
- Annuity payments to population aged 60+
  - Capital operated by firms
  - Residential capital and capital operated by PUEs

Sum of receipts minus disbursements over 1-4 equals net savings of households

FIRMS

Receipts
- Profits on capital installed in Region 1 (net of depr. and indirect tax; excl. profits on FDI from abroad)
- Profits on capital installed in Region 2 (FDI only, net of depr. and indirect tax)

Disbursements
- Direct tax to government in Region 1 (on first line under "Receipts")
- Direct tax to government in Region 2 (on second line under "Receipts")
- Dividends distributed to domestic holders of claims on capital installed in Region 1
- Dividends distributed to foreign holders of claims on capital installed in Region 1 (portfolio claims only)
- Dividends distributed from repatriated profits on FDI abroad

Net savings of firms
- Reinvested profits on foreign direct investment
- Net saving apart from reinvested profits on foreign direct investment

GOVERNMENT

Receipts
- Direct taxes
- Indirect taxes
- Employers' contributions to social security
- Workers' contributions to social security

Disbursements
- Government consumption
- Social security benefits

Net savings of government

These claims are held on behalf of households by two financial intermediaries: the private pension system (PPS) and other institutions (OIs). When receipts and expenditures are summed across households aged 15-59, households aged 60+, the PPS, and OIs, cancellations bring us to the net household savings accounting concept which is familiar from the OECD national accounts.

The PPS represents fully funded, defined-contribution pension plans; the model does not specify a private PAYG, defined-benefit component. The rationale for not including a private PAYG component is two-fold. First, the role of private PAYG pension funds is shrinking rapidly, as few new workers are being offered such arrangements. Second, the obligations of this component of the pension system are essentially underwritten by public authorities (for example, by the Pension Benefits Guarantee Corporation in the United States), as a result, the line between the private and public PAYG systems is blurred. Implicitly, the private PAYG pension system is subsumed under the public PAYG pension system in our model.

OIs are a residual sector in our model, covering banks, insurance companies, mutual funds, and other financial intermediaries apart from pension funds. Implicitly, OIs also include individual households to the extent that the latter hold financial claims directly.

The distinction between portfolio investment and foreign direct investment (FDI) is a significant one[7]. As a number of observers have pointed out, investors who purchase shares of a domestically-based multinational are effectively acquiring an international asset to the extent that the firm operates globally. FDI, consisting mainly of the acquisition of fully-owned foreign subsidiaries by multinational firms, is one of the principal corporate globalisation strategies.

In our model, we recognise that firms in both regions earn profits both at home and abroad. Firms in Region 1 are credited with profits earned on that portion of Region 1's capital stock which is owned by foreign portfolio investors, and are debited with taxes and dividends paid out of these profits (to the government of Region 1 in the first case, to the PPS and OIs of Region 2, in the second case). On the other hand, profits on that portion of Region 1's capital stock which represents FDI from Region 2 are credited to firms in Region 2. Taxes paid out of these profits are debited to firms in Region 2 and credited to the government of Region 1. Firms in Region 2 choose to reinvest a given share of these profits in Region 1; the remainder they repatriate to Region 2, where dividends are paid out to claimants.

Who are these claimants? Historically, PPS portfolio managers have engaged almost exclusively in portfolio investment. Almost all FDI has originated with firms, largely in the form of the acquisition of fully-owned foreign subsidiaries. Since firms in our model only operate, but do not own, capital, we make the simplifying assumption that FDI is undertaken by corporate holding companies who are implicitly subsumed under OIs, and the share of OI foreign assets consisting of FDI is an exogenous variable. Dividends paid out of repatriated profits on FDI from Region 2 in Region 1 are credited to OIs in Region 2. Symmetrically, profits on FDI from Region 1 in Region 2 are credited to firms in Region 1, and dividends paid out of repatriated earnings are credited to OIs in Region 1.

Flows of income from capital must ultimately be allocated to households. The capital stock as a whole is divided into portions owned by the working-age (15-59) and retirement-age (60+) population. The shares used to apportion the capital stock between the working- and retirement- age populations are functions of the age distribution of the population, the rate of economic growth, and the rate of return to capital (see Annex 2). Simulations indicate that the first of these is by far the most important variable, suggesting that, in simulations where the age structure of the population is identical in the baseline and alternative scenarios, simulation results are robust to specification of the share variables.

The most important feature of the articulation of savings is that the model is able to track the downward pressure on household saving and capital accumulation which is expected as the baby boomers begin to retire (Schieber and Shoven, 1994).

People aged 15-59 do not consume out the dividends which are distributed from earnings on the capital they own (or, more accurately, the PPS and OIs which hold claims on behalf of 15-59 year olds do not pass them along to the claimants). Persons over 60, whether they are still in the labour force or not, are assumed to annuitise their portion of the capital stock, meaning that they receive (from the PPS and OIs) an annuity which is based on the current rate of return to capital, the amount of capital they own, and life expectancy at age sixty. In the case of capital operated by firms, the PPS and OIs receive dividends on and pay out the annuity value of, the retirement-age population's assets. In the case of assets consisting of residential capital and capital operated by PUEs, it is similarly assumed the OIs play the intermediary role[8].

People in the 15-59 year-old age bracket earn wages, out of which they and their employers make pension and social security contributions; they also earn profits on PUEs and receive imputed services from their share of the stock of owner-occupied housing. Persons in the retirement age bracket, in addition to receiving wages (if they work), receive annuity income from the PPS and OIs based on their assets, and receive social security benefits. Persons over 60 transfer unspent income from all sources to the population aged 15-59; in this way, the model "annualises" bequests.

The public social security system is assumed to be a balanced PAYG system, meaning that social security contributions collected from workers are spread over the elderly population[9]. Pressures on the social security system in this model are reflected in declining levels of benefit per member of the elderly population, rather than in higher government budget deficits or higher social security taxes. This assumption can easily be changed in model simulations; in the current political environment, however, the assumption that replacement rates will be permitted to erode is more attractive than the competing assumptions.

Particularly in less-developed countries, intrafamily transfers from children to parents may be an important part of old-age support. In our model, these are implicitly included under the public PAYG pension system.

III. SIMULATION RESULTS

The parameters of the model and scenario assumptions are presented in Annex 3. The simulation period is effectively 1995-2050; however, we solved the model out to 2100 and will occasionally refer to ultra long-term results. These obviously must be taken with caution, and we will tend, therefore, to focus on the period 1995-2050.

Shifting Asset Allocation Shares

The key to the simulation is changes in assumptions on the share of annual asset acquisition that consists of capital installed in the foreign region. We estimate that, in 1995, 1 per cent of all purchases of assets by FAC pension fund managers consisted of claims on capital installed in the SACs[10]. For OIs, the corresponding figure was 10 per cent, the higher number being largely due to the role of FDI.

In the baseline scenario, which corresponds roughly to a situation of autarky, the foreign-investment share of the PPS is assumed to rise gradually to 10 per cent between 1995 and 2005, then to remain constant through 2100. The foreign-investment share of OIs is assumed simply to remain constant at 10 per cent. The share of OI foreign assets consisting of FDI claims is assumed to remain constant at 50 per cent, and the proportion of FDI earnings reinvested is kept constant at 20 per cent.

In the alternative scenario, designed to illustrate the impacts of financial globalisation, the allocation of FAC investment is shifted to reflect the share of SACs in global stock market capitalisation (estimated as total capital stocks minus residential capital stocks minus capital operated by PUEs) and output[11]. In the case of pension fund managers, the share of annual investment expenditure allocated to SACs is set equal to that region's share in global stock market capitalisation, approximately 15 per cent in 1995 rising to over 40 per cent in 2050 and over 60 per cent in 2100[12]. In the case of OIs, the foreign investment share was taken as a weighted average of the SACs' shares in global stock market capitalisation and in world GDP, the weights reflecting the portfolio-FDI split in foreign assets held by OIs. The FDI share was assumed to rise linearly from 50 per cent in 1995 to 66.7 per cent in 2100, while the share of FDI earnings reinvested was set equal to Region 2's share in world GDP. The rationale behind these assumptions is that, in a totally integrated world market, the rigidities which lead international investors to prefer portfolio claims to FDI should diminish, as should the disincentives to reinvesting earnings in the host country. The impact is to raise the share of OI investment allocated to SACs from 10 per cent to 17 per cent in the immediate term, rising to 50 per cent in 2050 and 66 per cent in 2100.

Aggregate GDP growth in SACs is likely to be more rapid than in FACs, *per capita* income levels in SACs are likely to rise substantially, and age-distribution

trends in SACs are favourable for savings. On all three counts, aggregate savings in SACs are likely to play a growing role in the world economy, and assumptions made regarding the behaviour of SAC portfolio managers are an important aspect of scenario design.

In the Autarky Scenario, the domestic investment share of SAC pension fund managers is assumed to decline gradually from 99 per cent in 1995 to 90 per cent in 2005, after which it remains fixed. The domestic investment share of OIs is assumed to remain constant at 90 per cent throughout the simulation period. These assumptions precisely mirror those made for the FACs.

An alternative scenario in which FAC portfolio managers diversify while SAC portfolio managers continue to invest virtually all of their capital domestically would give rise to a lopsided global picture over the very long term. Under such a scenario, net foreign assets of the FACs would grow explosively, as would net factor payments from SACs to FACs, giving rise to unreasonable gaps between gross national product (GNP) and GDP in both regions. Moreover, recent experience indicates that, when capital controls are lifted, portfolio managers in emerging economies have been eager to diversify into more mature financial markets.

Therefore, we assume in the Globalisation Scenario that SAC portfolio managers also begin to diversify internationally, although less aggressively than their FAC counterparts. Whereas FAC portfolio managers are assumed to rationalise their investment allocation decisions instantly, SAC managers are assumed to do so slowly over the course of the simulation period. The domestic investment share of the PPS, after reaching 90 per cent in 2005, is assumed to decline linearly by half a percentage point per year until it equals the SAC region's share in global stock market capitalisation. This occurs at a domestic investment share of approximately 55 per cent in the year 2075. After this point, the PPS domestic investment share is assumed to move in line with the SAC region's share in global capitalisation, rising to 60 per cent at the end of the century. Exactly the same assumption was made regarding the domestic investment share of OIs in the SACs, the only difference being that the target share reflected both share in stock market capitalisation and in world GDP. This target was reached at a domestic market share of 58 per cent in 2070, after which the domestic investment share rose gradually to 66 per cent in 2100. The share of FDI in OI foreign assets was assumed to rise linearly from 50 per cent to 66.7 per cent over the simulation period and the share of FDI earnings reinvested in Region 1 was set equal to Region 1's share in world GDP. These assumptions are identical to those made in the case of FACs.

Simulation results are shown in Tables 4 to 8 and in Figures 1 to 3.

Table 4. **Macroeconomic Aggregates**

	1995	2010	2020	2030	2040	2050	2100
GDP (1995 $ per capita)							
Fast-ageing countries							
Autarky	24 939	32 316	37 099	42 340	48 462	55 762	119 845
Globalisation	24 939	32 005	36 474	41 383	47 210	54 333	121 337
Difference (per cent)	0.0	-1.0	-1.7	-2.3	-2.6	-2.6	1.2
Slowly ageing countries							
Autarky	1 554	2 488	3 381	4 581	6 237	8 398	37 950
Globalisation	1 554	2 579	3 547	4 817	6 532	8 726	37 751
Difference (per cent)	0.0	3.7	4.9	5.2	4.7	3.8	-0.5
World							
Autarky	6 685	8 083	9 112	10 458	12 313	14 695	47 494
Globalisation	6 685	8 099	9 144	10 508	12 385	14 788	47 493
Difference (per cent)	0.0	0.2	0.4	0.5	0.6	0.6	0.0
GNP (1995 $ per capita)							
Fast-ageing countries							
Autarky	25 013	32 610	37 551	42 934	49 179	56 568	119 595
Globalisation	25 013	32 594	37 568	43 079	49 615	57 535	128 669
Difference (per cent)	0.0	0.0	0.0	0.3	0.9	1.7	7.6
Slowly ageing countries							
Autarky	1 533	2 420	3 288	4 472	6 117	8 275	29 052
Globalisation	1 533	2 443	3 324	4 505	6 128	8 235	29 413
Difference (per cent)	0.0	1.0	1.1	0.7	0.2	-0.5	1.2
Capital-output ratio							
Fast-ageing countries							
Autarky	3.14	3.37	3.62	3.85	4.05	4.23	4.60
Globalisation	3.14	3.30	3.50	3.68	3.84	4.02	4.72
Difference	0.00	-0.07	-0.12	-0.17	-0.21	-0.22	0.12
Slowly ageing countries							
Autarky	2.50	2.46	2.50	2.54	2.58	2.64	2.94
Globalisation	2.50	2.64	2.75	2.82	2.84	2.85	2.91
Difference	0.00	0.19	0.26	0.27	0.25	0.21	-0.03
Net saving rate (per cent)							
Fast-ageing countries							
Autarky	8.3	8.7	8.1	7.5	7.0	6.6	6.2
Globalisation	8.3	8.8	8.3	7.8	7.5	7.3	7.0
Difference	0.0	0.1	0.2	0.3	0.5	0.7	0.9
Slowly ageing countries							
Autarky	9.0	10.6	10.8	10.7	10.6	10.3	9.1
Globalisation	9.0	10.2	10.0	9.8	9.7	9.5	8.8
Difference	0.0	-0.5	-0.7	-0.8	-0.8	-0.8	-0.3
Rate of return to capital							
Fast-ageing countries							
Autarky	0.081	0.076	0.070	0.066	0.063	0.060	0.055
Globalisation	0.081	0.077	0.073	0.069	0.066	0.063	0.054
Difference	0.000	0.001	0.002	0.003	0.003	0.003	-0.001
Slowly ageing countries							
Autarky	0.092	0.094	0.092	0.090	0.089	0.087	0.078
Globalisation	0.092	0.087	0.084	0.082	0.081	0.081	0.079
Difference	0.000	-0.007	-0.009	-0.009	-0.008	-0.007	0.001

Table 5. **International Capital Flows**

	1995	2010	2020	2030	2040	2050	2100
Net capital flows, fast- to slowly ageing countries (bill. 1995 $)							
Private pension system							
Autarky	9	102	134	160	177	182	-187
Globalisation	9	320	492	669	831	957	607
Difference (per cent)	0	217	358	508	654	775	794
Other institutions							
Autarky	163	248	281	282	233	126	-1 969
Globalisation	163	653	949	1 227	1 431	1 483	310
Difference (per cent)	0	405	668	945	1 198	1 358	2 279
Total							
Autarky	172	350	415	442	410	308	-2 156
Globalisation	172	972	1 441	1 896	2 262	2 440	917
Difference (per cent)	0	623	1 026	1 454	1 851	2 132	3 072
Net capital flows, fast- to slowly ageing countries (per cent of fast-ageing country GDP)							
Private pension system							
Autarky	0.0	0.2	0.3	0.3	0.3	0.2	-0.1
Globalisation	0.0	0.8	1.0	1.2	1.3	136	0.4
Difference	0.0	0.5	0.7	0.9	1.0	1.1	0.5
Other institutions							
Autarky	0.5	0.6	0.6	0.5	0.4	0.2	-1.4
Globalisation	0.5	1.6	1.9	2.2	2.3	2.1	0.2
Difference	0.0	1.0	1.4	1.7	1.9	1.9	1.6
Total							
Autarky	0.6	0.8	0.8	0.8	0.6	0.4	-1.5
Globalisation	0.6	2.3	3.0	3.4	3.6	3.4	0.6
Difference	0.0	1.5	2.1	2.6	2.9	3.0	2.1
Net foreign assets : GDP (per cent)							
Fast-ageing countries							
Autarky	2.6	7.7	9.9	10.8	10.3	8.4	-19.2
Globalisation	2.6	17.3	28.3	38.1	45.1	48.1	-2.8
Difference	0.0	9.6	18.4	27.3	34.8	39.7	16.4
Slowly ageing countries							
Autarky	-11.7	-23.0	-22.2	-18.3	-13.4	-8.6	8.0
Globalisation	-11.7	-49.4	-59.7	-60.3	-54.8	-45.9	1.2
Difference	0.0	-26.4	-37.4	-41.9	-41.3	-37.3	-6.8
Foreign portfolio share (foreign assets as per cent of total assets)							
Fast-ageing countries							
Private pension system							
Autarky	0.9	4.7	6.4	7.4	8.0	8.4	9.4
Globalisation	0.9	12.5	18.3	23.1	27.3	31.1	45.5
Difference	0.0	7.8	11.9	15.7	19.4	22.8	36.2
Other institutions							
Autarky	3.5	6.8	7.9	8.7	9.2	9.6	10.9
Globalisation	3.5	12.2	17.5	22.5	27.3	32.2	55.8
Difference	0.0	5.4	9.6	13.8	18.1	22.6	44.9
Slowly ageing countries							
Private pension system							
Autarky	0.3	6.8	8.4	9.1	9.5	9.7	9.9
Globalisation	0.3	7.4	11.6	15.4	19.4	23.3	39.1
Difference	0.0	0.6	3.1	6.3	9.9	13.7	29.2
Other institutions							
Autarky	3.4	6.2	7.9	8.8	9.3	9.6	10.0
Globalisation	3.4	7.0	11.3	15.6	20.0	24.3	36.4
Difference	0.0	0.9	3.4	6.8	10.7	14.7	26.3
Share in global market capitalisation (per cent)							
Fast-ageing countries							
Autarky	85.0	77.6	73.2	68.7	64.1	59.5	39.9
Globalisation	85.0	72.7	66.0	60.3	55.5	51.5	41.3
Difference	0.0	-4.9	-7.1	-8.4	-8.6	-7.9	1.5
Slowly ageing countries							
Autarky	15.0	22.4	26.8	31.3	35.9	40.5	60.2
Globalisation	15.0	27.3	34.0	39.7	44.5	48.5	58.7
Difference	0.0	4.9	7.1	8.4	8.6	7.9	-1.5

Table 6. **Savings, by sector**

	1995	2010	2020	2030	2040	2050	2100
Fast-ageing countries							
Total savings (per cent of GDP)							
Autarky	8.3	8.7	8.1	7.5	7.0	6.6	6.2
Globalisation	8.3	8.8	8.3	7.8	7.5	7.3	7.0
Difference	0.0	0.1	0.2	0.3	0.3	0.5	0.7
Households							
Autarky	5.4	5.2	4.6	4.3	4.0	3.9	4.0
Globalisation	5.4	5.2	4.6	4.2	4.0	3.9	4.0
Difference	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Firms							
Autarky	3.1	3.9	4.0	4.0	3.9	3.8	3.5
Globalisation	3.1	3.9	4.2	4.2	4.3	4.3	4.4
Difference	0.0	0.0	0.1	0.2	0.4	0.6	0.9
Government							
Autarky	-0.2	-0.4	-0-6	-0-8	-0-9	-1.1	-1.3
Globalisation	-0.2	-0.3	-0.5	-0.7	-0.8	-0.9	-1.4
Difference	0.0	0.0	0.1	0.1	0.1	0.1	-0.1
Slowly ageing countries							
Total savings (per cent of GDP)							
Autarky	9.0	10.6	10.8	10.7	10.6	10.3	9.1
Globalisation	9.0	10.2	10.0	9.8	9.7	9.5	8.8
Difference	0.0	-0.5	-0.7	-0.8	-0.8	-0.8	-0.3
Households							
Autarky	5.0	5.2	4.9	4.6	4.5	4.3	3.8
Globalisation	5.0	5.0	4.8	4.5	4.4	4.1	3.6
Difference	0.0	-0.1	-0.2	-0.1	-0.1	-0.1	-0.2
Firms							
Autarky	2.3	3.8	4.2	4.4	4.5	4.5	4.0
Globalisation	2.3	3.6	3.8	3.9	4.0	4.0	3.9
Difference	0.0	-0.2	-0.4	-0.5	-0.5	-0.5	-0.1
Government							
Autarky	1.6	1.7	1.6	1.6	1.5	1.5	1.3
Globalisation	1.6	1.5	1.4	1.4	1.4	1.3	1.3
Difference	0.0	-0.1	-0.2	-0.2	-0.2	-0.1	0.0

Table 7. **Income, Population 15-59**

	1995	2010	2020	2030	2040	2050	2100
Fast-ageing countries							
Total income (1995 $ per capita)							
Autarky	29 723	37 525	44 460	52 594	62 035	73 089	157 374
Globalisation	29 723	37 311	43 991	51 824	60 973	71 825	158 769
Difference (per cent)	0.0	-0.6	-1.1	-1.5	-1.7	-1.7	0.9
Compensation of employees							
Autarky	26 516	34 302	41 251	49 317	58 633	69 537	152 168
Globalisation	26 516	33 972	40 556	48 203	57 118	67 755	154 063
Difference (per cent)	0.0	-1.0	-1.7	-2.3	-2.6	-2.6	1.2
Entrepreneurial income							
Autarky	1 566	1 531	1 478	1 468	1 487	1 517	2 119
Globalisation	1 566	1 585	1 582	1 625	1 691	1 750	1 886
Difference (per cent)	0.0	3.5	7.0	10.7	13.8	15.4	-11.0
Imputed housing services							
Autarky	1 542	1 569	1 550	1 569	1 616	1 672	2 453
Globalisation	1 542	1 624	1 659	1 737	1 838	1 929	2 179
Difference (per cent)	0.0	3.5	7.0	10.7	13.8	15.4	-11.2
Transfers incl. bequests							
Autarky	99	124	180	239	300	363	634
Globalisation	99	131	193	260	326	391	641
Difference (per cent)	0.0	5.3	7.4	8.5	8.7	7.8	1.1
Slowly ageing countries							
Total income (1995 $ per capita)							
Autarky	1 932	2 912	3 902	5 260	7 099	9 616	44 176
Globalisation	1 932	2 984	4 039	5 458	7 344	9 888	43 904
Difference (per cent)	0.0	2.5	3.5	3.8	3.5	2.8	-0.6
Compensation of employees							
Autarky	1 757	2 715	3 678	4 988	6 753	9 171	42 402
Globalisation	1 757	2 815	3 859	5 245	7 072	9 528	42 180
Difference (per cent)	0.0	3.7	4.9	5.2	4.7	3.9	-0.5
Entrepreneurial income							
Autarky	85	92	101	119	146	183	677
Globalisation	85	79	81	92	114	146	655
Difference (per cent)	0.0	-14.4	-20.1	-22.3	-22.1	-20.2	-3.2
Imputed housing services							
Autarky	84	97	112	135	172	219	839
Globalisation	84	83	89	105	134	175	812
Difference (per cent)	0.0	-14.3	-20.1	-22.4	-22.2	-20.3	-3.2
Transfers incl. bequests							
Autarky	6	7	11	19	28	43	258
Globalisation	6	6	10	16	24	39	257
Difference (per cent)	0.0	-13.2	-13.8	-12.9	-11.2	-9.2	-0.5

Table 8. **Income, Population 60+**

	1995	2010	2020	2030	2040	2050	2100
Fast-ageing countries							
Total income (1995 $ per capita)							
Autarky	16 451	17 942	18 366	18 930	20 313	22 466	46 500
Globalisation	16 451	17 999	18 439	18 998	20 352	22 463	47 065
Difference (per cent)	0.0	0.3	0.4	0.4	0.2	0.0	1.2
Compensation of employees							
Autarky	1 768	2 287	2 750	3 288	3 909	4 636	10 145
Globalisation	1 768	2 265	2 704	3 214	3 808	4 517	10 271
Difference (per cent)	0.0	-1.0	-1.7	-2.3	-2.6	-2.6	1.2
Annuity income							
Autarky	2 858	2 837	3 237	3 437	3 654	3 941	6 127
Globalisation	2 858	3 039	3 566	3 854	4 124	4 413	6 190
Difference (per cent)	0.0	7.1	10.1	12.1	12.9	12.0	1.0
Social security benefits incl. intrafamily transfers							
Autarky	11 825	12 818	12 378	12 206	12 750	13 889	30 228
Globalisation	11 825	12 695	12 170	11 930	12 420	13 533	30 605
Difference (per cent)	0.0	-1.0	-1.7	-2.3	-2.6	-2.6	1.2
Per capita income population aged 60+ : per capita income population aged 15-59							
Autarky	0.553	0.478	0.413	0.360	0.327	0.307	0.295
Globalisation	0.553	0.482	0.419	0.367	0.334	0.311	0.296
Difference	0.000	0.004	0.006	0.007	0.006	0.004	0.001
Slowly ageing countries							
Total income (1995 $ per capita)							
Autarky	986	1 175	1 444	1 780	2 254	2 931	11 210
Globalisation	986	1 135	1 396	1 723	2 192	2 858	11 152
Difference (per cent)	0.0	-3.4	-3.3	-3.2	-2.8	-2.5	-0.5
Compensation of employees							
Autarky	234	362	490	665	900	1 223	5 654
Globalisation	234	375	514	699	943	1 270	5 624
Difference (per cent)	0.0	3.7	4.9	5.2	4.7	3.9	-0.5
Annuity income							
Autarky	392	340	427	543	679	917	3 142
Globalisation	392	269	329	422	543	765	3 125
Difference (per cent)	0.0	-20.8	-22.9	-22.3	-20.1	-16.6	-0.5
Social security benefits incl. intrafamily transfers							
Autarky	360	474	527	572	674	792	2 415
Globalisation	360	491	553	602	706	823	2 403
Difference (per cent)	0.0	3.7	4.9	5.2	4.7	3.9	-0.5
Per capita income population aged 60+ : per capita income population aged 15-59							
Autarky	0.510	0.404	0.370	0.338	0.318	0.305	0.255
Globalisation	0.510	0.380	0.346	0.316	0.298	0.289	0.259
Difference (per cent)	0.000	-0.023	-0.024	-0.023	-0.019	-0.016	0.004

Figure 1. Net capital flows, fast- to slow-aging countries

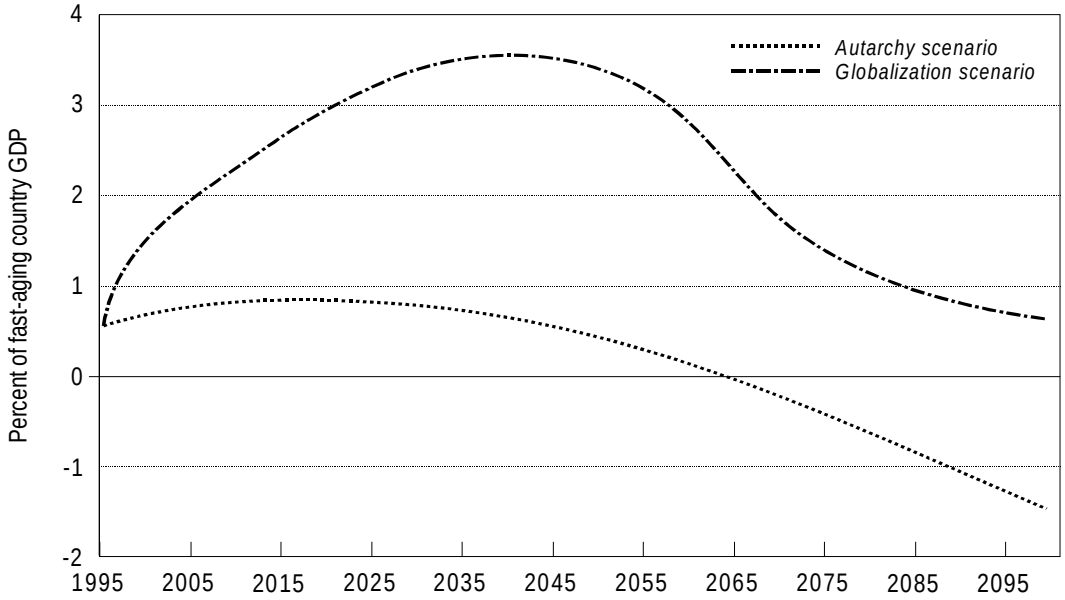


Figure 2. Net foreign assets

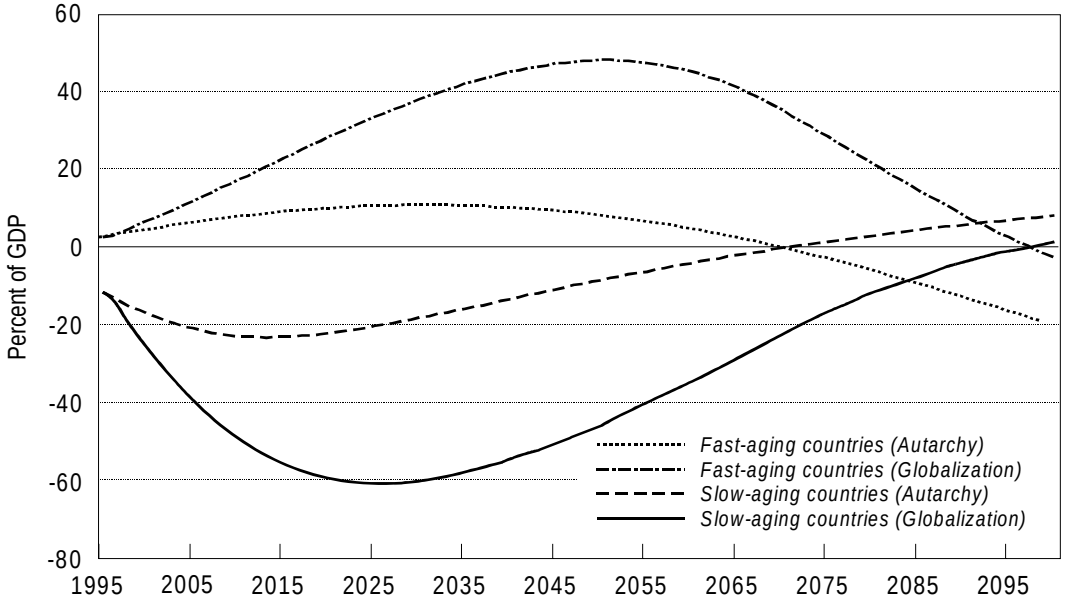
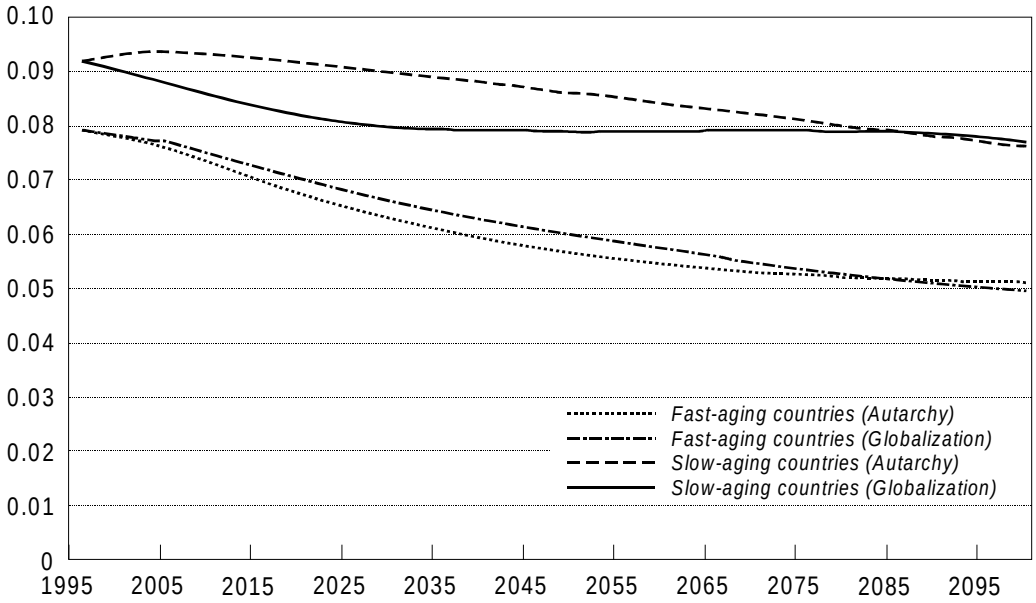


Figure 3. Rate of return to capital



Baseline (Autarky) Scenario

In the baseline Autarky Scenario, as predicted by theory, the capital-output ratio in FACs rises from 3.14 in 1995 to 4.23 in 2050, causing the rate of return to capital to decline from 8.1 per cent to 6.0 per cent (see Table 4). With age-specific saving rates held constant, and with no account taken of pressure on government to engage in deficit spending in order to avert the decline in social security benefits relative to real wages, the net national saving rate still declines from 8.3 per cent in 1995 to 6.6 per cent in 2050. This can be interpreted as a lower-bound estimate: if the model incorporated a decline in age-specific saving rates as a result of the lower rate of return to saving, an increase in the government deficit as public authorities strove to maintain pension benefit levels, plus the impact of ageing on health care expenditure, the decline in the aggregate net saving rate in FACs would be steeper.

Total net annual capital flows from FACs to SACs rise from 0.6 per cent of FAC GDP in 1995 to 0.8 per cent in 2010-30, then decline and turn negative in the second half of the century (see Table 5 and Figure 1). In level terms, total annual net capital flows from FACs to SACs are projected to double from an estimated $172 billion in 1995 to $350 billion in 2010 and peak at $442 billion in 2030. Net capital flows originating from FAC pension funds peak at $182 billion in mid-century, flows from OIs peak earlier (2030) at $282 billion.

Net foreign assets of FACs peak at 10.8 per cent of GDP in 2030 and turn negative in roughly 2070 (see Table 5 and Figure 2). In the Autarky Scenario, the share of SAC assets in the portfolio of FAC-based private pension funds rises from 0.9 per cent in 1995 to 8.4 per cent in 2050 and 9.4 per cent at the end of the century. The share of SAC assets in the portfolio of OIs rises from 3.5 per cent to 9.6 per cent in 2050 and 10.9 per cent in 2100. These apparently substantial increases must be viewed in context, however. The share of SACs in global market capitalisation is projected to rise from 15 per cent in 1995 to 40.5 per cent in 2050 and 60.2 per cent in 2100. The share of the SACs in global output is projected to increase from 18.1 per cent in 1995 to 49.6 per cent in 2050 and 70.6 per cent in 2100. Thus, by either metric, the Autarky Scenario actually implies *dis*integration of global financial markets over the next century.

The pressures of population ageing on public pension systems must be apportioned between lower replacement rates, higher public sector budget deficits, and higher wage-based payroll taxes. In constructing the baseline scenario, we have kept direct and indirect tax rates, as well as social security contribution rates, constant. As a result (see Table 8), social security income per person aged 60+ stagnates between 1995 and 2050 (average annual growth of 0.3 per cent per year, outright decline during the period 2010-30), a period over which real wage rate grows at a rate of 1.8 per cent per year. As a result the ratio of total income per person aged 60+ and total income per person aged 15-59 declines from 0.55 in 1995 to 0.31 in 2050, after which it remains constant (see Table 8). In SACs, the income ratio declines from 0.51 in 1995 to 0.30 in 2050 and 0.25 in 2100. In both FACs and SACs, total income *per capita* of the 60+ population grows in level terms (albeit very slowly) over the entire simulation period, and it is only relative to the working-age population that the elderly lose ground.

Alternative (Globalisation) Scenario

Neo-classical theory suggests that the greater international integration of capital markets in the Globalisation Scenario should lead, on a baseline *versus* alternative scenario basis, to *i)* lower spreads between rates of return to capital and *ii)* a more efficient allocation of productive resources, leading to convergence of *per capita* output between the two regions. World GDP *per capita* should rise, as capital is reallocated to the region characterised by higher marginal product. GDP *per capita* should fall in FACs and rise in SACs as a result of the transfer of capital. GNP *per capita* should rise in FACs as a result of globalisation, as capital returns are higher abroad than at home. As long as the marginal product of capital invested from abroad exceeds the capital returns accruing to foreign investors, GNP should rise in SACs as well.

Implications for Net Capital Flows

In the Globalisation Scenario, as shown in Table 5, roughly one-third of FAC investment portfolios is projected to consist of SAC assets in 2050 (31.1 per cent for the PPS and 32.2 per cent for the OIs). This share is estimated to rise to about one-half by the end of the next century (45.5 per cent in the case of the PPS and 55.8 per cent in case of the OIs). The share of the SACs in global market capitalisation is estimated to be 48.5 per cent in 2050 and 58.7 per cent in 2100; their share in world GDP for the same years is projected to be 51.2 per cent and 70.2 per cent. Thus, even our Globalisation Scenario falls somewhat short of the degree of financial integration which would be attained if financial managers fully subscribed to the tenets of modern portfolio theory.

In SACs, 23.3 per cent of the PPS investment portfolio and 24.3 per cent of the OI investment portfolio are projected to consist of FAC assets in 2050 (i.e. domestic shares of 76.6 and 75.7 per cent, respectively). In 2100, the domestic shares are projected to decline to 58.7 per cent for the PPS and 41.3 per cent for OIs.

Under the Globalisation Scenario, net annual capital flows from FACs to SACs rise steadily from 0.6 per cent of GDP in 1995 to 3.6 per cent in 2040, then recede to 3.4 per cent in 2050 and 0.6 per cent at the end of the century (see Table 5 and Figure 1). Sustained capital flows of this magnitude are not unprecedented and can be reconciled with the observed weakening of the Feldstein-Horioka observation of a historically strong association between domestic savings and investment (Taylor, 1997). Net PPS capital flows, estimated to have been $9 billion in 1995, rise to $957 billion in 2050 and diminish in the second half of the century. Net annual capital flows from OIs increase from $163 billion in 1995 to a peak of $1 483 billion in 2050 and then decline.

Output and assets grow more rapidly in SACs than in FACs, therefore the long-run evolution of net foreign assets is sensitive to the investment allocation

behaviour of SAC portfolio managers. Under the assumptions of the Autarky Scenario, net foreign assets of FACs are projected to peak at 10.8 per cent of FAC GDP in 2030 before diminishing (see Table 5 and Figure 2); under the Globalisation Scenario they peak at roughly 50 per cent of GDP in 2050. Under the Autarky Scenario, the FACs switch from being a net creditor region to a net debtor region in approximately 2070, under the Globalisation Scenario, the switch is delayed until the very end of the century.

Per Capita Output and Income

Model simulation results conform to the basic predictions of neo-classical theory (see Table 4). *Per capita* GDP in the FACs is reduced by 1.0 per cent (*vis-à-vis* the Autarky Scenario) in 2010, with the impact rising steadily to 2.6 per cent by 2040-50. *Per capita* GDP in SACs increases by 3.7 per cent in 2010, with the impact rising to 5.2 per cent in 2030 and then narrowing to 3.8 per cent in 2050. By the very end of the simulation periods, the impacts have been reversed; *per capita* GDP is marginally higher in FACs and lower in SACs as a result of globalisation. Not much significance should be read into the ultra-long term results, which depend crucially on the assumptions made regarding the allocation of SAC savings. Improved allocation of capital under the Globalisation Scenario is estimated to increase GDP *per capita* for the world as a whole (versus the Autarky case) by 0.2 per cent in 2010, the impact rising to 0.6 per cent in 2050 and then disappearing entirely by 2100.

Globalisation has no impact on *per capita* GNP in FACs until 2030, when it is estimated to lead to a 0.3 per cent increase *vis-à-vis* the Autarky Scenario. Unlike the case of GDP, the impact steadily rises, to 0.9 per cent in 2040, 1.7 per cent in 2050, and 7.6 per cent in 2100. The explanation for the growing impact lies in the fact that net factor payments reflect cumulative capital flows. Globalisation increases *per capita* GNP in SACs by roughly 1.0 per cent in 2010-20, after which the impact diminishes. By mid-century, GNP *per capita* is estimated to be marginally lower in the Globalisation Scenario than in the Autarky Scenario, but this has reversed itself by the end of the simulation period. Once again, results for the end of the simulation period should be taken with caution.

Rates of Return to Capital

As expected, increased investment abroad under the Globalisation Scenario causes the rate of return to capital in FACs to rise *vis-à-vis* the Autarky Scenario (see Table 4 and Figure 3). However, the magnitude of this increase (10 basis points in 2010, rising to 30 basis points in 2030-50) is virtually insignificant. This attenuates only one-seventh of the ageing-induced decline in the rate of return to capital envisioned in the Autarky Scenario (210 basis points between 1995 and 2050).

So trivial a gain would not appear to compensate FAC savers for the risks implied by heavy exposure to SAC financial markets[13]. On the other hand, when the question is posed in terms of the *ex post* gain to retirement savers, the risk-return

picture is more reasonable. Under the Globalisation Scenario, annuity income *per capita* of the 60+ year-old population is increased by 7.1 per cent (as compared to the Autarky Scenario) in 2010, rising to 12.9 per cent in 2040 before starting to decline (see Table 8).

Both absolutely and proportionally speaking, the decline in SAC rates of return to capital attributable to globalisation (70 basis points in 2010, 90 basis points in 2020-30, returning to 70 basis points in 2050) is much more significant. This is because the capital transfer implied by globalisation is greater relative to the SAC capital stock than it is relative to the FAC capital stock. Even under conditions of globalisation, the rate of return to capital in SACs is projected to stay well above that in FACs throughout the simulation period. On the other hand, the convergence of rates of return attributable to globalisation, on the order of 100-120 basis points in 2020-50, is significant.

Net Saving Rates

Globalisation is estimated to augment the net saving rate in FACs by one-tenth of a percentage point in 2010, rising steadily to 0.7 percentage point by 2050 and continuing to rise into the very long term (see Table 4). Analysis of the components of saving reveals that this increase in aggregate savings is entirely attributable to increases in corporate retentions (see Table 6). Some of this represents higher profit margins on domestic capital, while some represents reinvested earnings on that portion of investment abroad that consists of FDI. The failure of household savings to rise in the face of globalisation largely reflects lower levels of real wages. However, simulation results do not reflect the possible impact of enhanced rates of return on household saving rates. In SACs, globalisation acts to depress savings, mostly through downward pressure on profits.

Distributional Impacts

The distributional impacts of globalisation are much discussed, but the generational dimension is under-appreciated (see Tables 7 and 8). The impact of increased capital mobility on the aged population is theoretically ambiguous, despite the simplicity of the model. Elderly persons' income depends on past earnings, which determine savings, the rate of return earned by these savings, and current receipts of the PAYG pension system. Greater investment of FAC pension funds in SACs should reduce the capital-labour ratio, thus reducing the wages of FAC workers, and hence their savings. On the other hand, those pension savings that are invested domestically earn a higher rate of return and those pension savings that are invested in the SACs reap a premium to the extent that the interregional rate-of-return gap persists. PAYG pension system receipts will, in theory, be depressed by the reduced wage bill. The story in reverse applies to pensioners in the SACs: higher wages will permit greater saving, but lower rates of return to capital will retard accumulation; higher wages will increase PAYG pension system receipts and benefits (as well as enhance the working-age population's ability to transfer money

to parents). However, higher elderly labour force participation rates in SACs enhance the importance of wage income for the older population.

Model simulation results suggest that, on average, greater capital mobility benefits the FAC retirement-age population. However, for the first group, the total impact is slight: annuity income is higher under the Globalisation Scenario, but income derived from social security benefits is lower because of the reduced wage bill. Total *per capita* income of the retirement-age FAC population is estimated to be increased by only 0.3 per cent (*vis-à-vis* the Autarky Scenario) in 2010, 0.4 per cent in 2020-40 (estimated to be the years of greatest stress on public pension systems); by 2050, any gain has disappeared.

On the other hand, the apparently marginal impact of globalisation on the elderly population as a whole may hide considerable disparities within the age group. So long as upper-income retirees continue to depend disproportionately on income derived from assets and lower-income retirees to depend almost entirely on public social security system benefits, globalisation is likely to widen income disparity among aged households.

The working-age FAC population, which derives no income from annuities and earns lower real wages as a result of reduced capital per worker, sees a decline in its income relative to the Autarky Scenario: 0.6 per cent in 2010, rising to a peak of 1.7 per cent in 2040-50.

In SACs, the distributional tilt is reversed: capital inflows help the working-age population but hurt those in the retirement age bracket; in both cases, the impact is relatively more significant than in FACs. Total income *per capita* for the population aged 15-59 is increased (in the Globalisation Scenario relative to the Autarky Scenario) by 2.5 per cent in 2010, rising to 3.8 per cent in 2030 and then diminishing. Total income *per capita* for the population aged 60+ is reduced (*vis-à-vis* the baseline scenario) by 3.4 per cent in 2010, with the impact gradually diminishing but still amounting to 2.5 per cent in 2050. The effect on the working-age population is straightforward: more capital per worker translates into higher wage income. The impact on persons over 60, however, is subject to one qualification: it seems likely that, as workers' wages benefited substantially, and as elderly persons' income derived from capital was squeezed by lower rates of return, intrafamily transfers would be set in motion. However, the basic insights of the model simulation, i.e. that globalisation tends disproportionately to benefit the working-age population in SACs, and that distributional impacts in the South are likely to be more significant than in the North, would appear to be sound.

IV. CONCLUSION

What difference would a high degree of financial integration between the fast-ageing and slowly ageing regions of the world make for the macroeconomic impact of population ageing? Our simulation with a two-region neo-classical economic-demographic model reaches two basic conclusions of importance to policy makers:

First, capital flows from fast-ageing, mostly industrialised countries to slowly ageing, mostly developing countries can slightly attenuate, but not reverse, the consequences of an ageing population. Population ageing will lead to a falling rate of return on capital despite declining net saving rates. We estimate that the rate of return to capital in FACs will decline by roughly 200 basis points between 1995 and 2050 regardless of the degree of global financial integration. The net saving rate in FACs is estimated to decline from 8.3 per cent in 1995 to 7.3 per cent in 2050 even under the Globalisation Scenario, as opposed to 6.6 per cent under the Autarky Scenario. The benefits of higher income (as measured by GNP *per capita*) resulting from more efficient allocation of investment are insignificant in the near term and, even by 2050, amount to only 1.7 per cent.

Second, our simulation finds that significant distributional effects are likely to arise from the interaction of population ageing and financial integration. While increased mobility of capital will hurt the working-age population in FACs, it will benefit the working-age population in SACs much more significantly. Within the elderly population, impacts are likely to differ according to income group. While increased capital mobility will benefit those retirement-age households in FACs who have access to funded pensions (including personal retirement savings outside the pension system), it will hurt households which are still dependent on unfunded, payroll-tax financed PAYG pension systems. In other words, globalisation benefits elderly lifetime-savers, consisting disproportionately of the well-to-do, but hurts elderly lifetime non-savers, consisting disproportionately of the poor. One interpretation of this is that globalisation increases the urgency of implementing policies which encourage or force poor households to save. Such neo-classical results admittedly ignore dynamic efficiency gains from integration, as well as the risk-reduction that results from a more widely diversified portfolio. However, they point to a new dimension of the globalisation debate, namely the age dimension.

In closing, nothing in our analysis suggests that capital mobility can “beat demography”. International financial integration is only one of the broad range of policies affecting pensions, retirement, and health care that will be necessary to reduce the impacts of population ageing.

NOTES

1. Country-specific shocks take very different forms in the two regions, there is little harmonisation of economic policies, and economic and demographic structures will remain broadly divergent for many decades to come.

2. To confuse matters, the rate of growth of the elderly population in the SACs is actually much more rapid than the corresponding rate of growth in FACs, because the SACs are starting from a small base. The appelations “Fast-Ageing” and “Slowly Ageing” make sense only with respect to the level of the support ratio.

3. On the other hand, to the extent that foreign capital inflows depress the rate of return to capital and thus the rate of profit on existing capital, the model incorporates a second-round offset in the form of lower domestic savings. This is in line with empirical evidence which suggests that only about half of a given increment to foreign savings translates into added investment.

4. Following the convention of the OECD national income accounts, net savings in each sector of the economy are defined as gross receipts, minus depreciation (concerning which see the next footnote), minus expenditure. The sum of net savings across sectors is equal to net saving for the economy as a whole (national disposable income, minus private consumption, minus government consumption), which is in turn equal to change in total capital assets (installed both at home and abroad).

5. Depreciation (and indirect taxes) are deducted from profits at the level of the firm or, in the case of residential capital and capital operated by PUEs, at the level of the household. Thus, in Table 3, income derived from profits is already net of depreciation and indirect taxes, and there is no need for separate expenditure lines to cover these outlays. The only complication is that depreciation and indirect taxes must subsequently be accounted for in the calculation of GNP and national disposable income (see Annex 1).

6. Thus, neither the PPS nor OIs pay taxes on dividends received, taxes have already been paid by firms when profits were earned. Nor do elderly persons, who receive annuity income from the PPS and OIs, pay direct taxes on this income. Profits on capital owned by foreign investors, whether portfolio investors or foreign direct investors, are taxed in the region in which the capital is installed, i.e. where the profits were earned.

7. FDI is defined as the acquisition of 20 per cent or more of the outstanding equity in a foreign corporation, acquisition of less than 20 per cent of the outstanding equity of a foreign firm being referred to as portfolio investment.

8. Implicitly, the retired population signs over its stock of residential and PUE capital to OIs in return for an annuity; OIs in turn rent this capital out.

9. In order to simplify accounting, persons over 60 are assumed to begin receiving social security income whether they are still in the labour force or not.

10. Explicit claims, not counting implicit ones in the form of investment in domestic multinationals.

11. The two scenarios with respect to international capital mobility can be thought of as implying different degrees of sovereign risk aversion.

12. There is simultaneity, which the model captures, between capital-flow coefficients and regional market shares.

13. Rates of return implicitly incorporate sovereign and other risk premia. Global financial markets have been characterised by inconsistent pricing of sovereign risk, as the yield spread (over US treasury bill rates) on sovereign dollar bonds issues by non-OECD governments has fluctuated wildly. In one panel estimate including both OECD and non-OECD sovereign dollar bonds, the yield spread has been found to be significantly linked to net foreign debt as a percentage of GDP. It was estimated that each percentage point rise in net foreign debt raises the dollar bond yield spread by 0.5 basis points (Larraín, Reisen and von Maltzan, 1997). Should the model incorporate a risk premium in SAC rates of return, which would rise in line with net foreign liabilities, the story would change accordingly.

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ANNEX 1: THE IIASA MULTIREGIONAL ECONOMIC-DEMOGRAPHIC MODEL

Though the model can be generalised to fit the multi-region case, we present it in terms of two regions, Region 1 corresponding to Fast-Ageing Countries (FACs) and Region 2 corresponding to Slowly Ageing Countries (SACs). Since model structures in Region 1 and 2 are symmetrical, we present only Region 1. Save where necessary for clarity, the time argument is suppressed. The sub-scripts 11,12 and 21 are used to index flows from 1 to 1, from 1 to 2, and from 2 to 1, respectively. The asterisk operator is used to denote summation over regions (for example 1* denotes from 1 to 1 plus from 1 to 2). The asterisk is also used to denote summation over population age groups, types of capital, and so on.

Population, Labour Force, Employment and Households

Population is divided into three age groups, 0-14, 15-59, and 60+, corresponding roughly to children, the working-age population, and the retirement-age population:

$$Pop_1^{*} = Pop_1^{0-14} + Pop_1^{15-59} + Pop_1^{60+}$$

Age-specific labour force participation rates are exogenous assumptions

$$LabForce_1^{*} = LabForce_1^{15-59} + LabForce_1^{60+}$$
$$LabForce_1^{15-59} = Pop_1^{15-59}\ LabForcePartRate_1^{15-59}$$
$$LabForce_1^{60+} = Pop_1^{60+}\ LabForcePartRate_1^{60+}$$

as are age-specific unemployment rates:

$$Emp_1^{*} = Emp_1^{15-59} + Emp_1^{60+}$$
$$Emp_1^{15-59} = LabForce_1^{15-59}\left(1 - UnEmpRate_1^{15-59}\right)$$
$$Emp_1^{60+} = LabForce_1^{60+}\left(1 - UnEmpRate_1^{60+}\right)$$

Output and Rates of Return to Factors

Gross Domestic Product (GDP) is given by a Cobb-Douglas production function and rates of return to factors are neoclassical:

$$GDP_1 = \alpha_1 (1+g_1)^t\ K_{*1}^{\beta_1} EMP_1^{*(1-\beta_1)}$$
$$R_1 = \beta_1 \left(GDP_1 / K_{*1}\right)$$
$$W_1 = (1-\beta_1)\left(GDP_1 / EMP_1^{*}\right)$$

where g is the rate of total factor productivity growth; R is the gross profit rate,

including depreciation and indirect taxes net of subsidies; and *W* is the rate of employee compensation, including social insurance contributions (workers' and employers' contributions to public and private pension schemes). The double subscript on capital refers to the fact that claims on the capital installed in Region 1 are held both in Region 1 and in Region 2.

In order to net depreciation and indirect taxes out of the rate of return to capital, we define

$$r_1 = R_1 - \frac{\left[(IndTaxRate_1)(GDP_1)\right]}{K_{*1}} - \delta_1$$

where IndTaxRate is defined with respect to GDP and δ_1 is the depreciation rate. The advantage of netting out depreciation and indirect taxes is that we can ignore them in calculating income, outlay, and net savings. However, we will need to add them back in when calculating net factor payments from abroad and gross national product (GNP).

The Structure of Capital, its Location and the Nature of Claims

Capital is either residential (Res) or non-residential (NonRes); the latter is further subdivided into capital operated by private unincorporated enterprises (PUEs) and capital operated by firms, i.e. corporate enterprises. Residential capital and capital operated by PUEs are installed entirely in the home region and are held by households directly. Capital operated by corporate enterprises is installed either at home or abroad. Financial claims on this capital are held on behalf of households by institutions which collect dividends and pay out annuities.

These institutions are subdivided into those which comprise the private pension system (PPS) and other institutions (OI) such as banks and mutual funds. As discussed in the main body of the text, the PPS includes only the fully-funded, defined-contribution component of the private pension system; Pay As You Go (PAYG) corporate pension funds being implicitly included under the public PAYG system.

Firms in our model operate capital, either distributing or reinvesting earnings which accrue, they do not own shares in other firms. Therefore, included among OIs are corporate holding companies that engage in foreign direct investment (FDI) on behalf of domestic firms. Also implicitly included among OIs are households themselves to the extent that they individually hold claims on corporate assets[1]. No distinction is made between equity and debt claims on corporations, nor does government debt play a role.

In summary,

$$K_{*1} = K\,\mathrm{Re}\,s_1 + KPUE_1 + KPPS_{*1} + KOI_{*1}$$
$$K_{1*} = K\,\mathrm{Re}\,s_1 + KPUE_1 + KPPS_{1*} + KOI_{1*}$$

where

$$KPPS_{*1} = KPPS_{11} + KPPS_{21}$$
$$KOI_{*1} = KOI_{11} + KOI_{21}$$
$$KPPS_{1*} = KPPS_{11} + KPPS_{12}$$
$$KOI_{1*} = KOI_{11} + KOI_{12}$$

Since only capital operated by firms can be located abroad, all international claims are held entirely by the PPS and OIs:

$$K_{12} = KPPS_{12} + KOI_{12}$$

We assume that all foreign assets held by the PPS consist of portfolio investment, and only the foreign assets of OIs contain an FDI component, which is determined by an exogenous share coefficient:

$$KOI_{12} = KOIFDI_{12} + KOIPort_{12}$$
$$KOIFDI_{12} = KOIFDI_{12}Share \;\; KOI_{12}$$
$$KOIPort_{12} = \left(1 - KOIFDI_{12}Share\right) \; KOI_{12}$$

The distinction between portfolio investment and FDI has important consequences for national saving. Earnings (and net savings therefrom), which accrue to capital claimed by foreign portfolio investors are credited to the firm which operates the capital (i.e. to the region in which the capital is installed). Earnings, and net savings therefrom, which accrue to capital claimed by foreign direct investors are credited to the parent firm, and therefore to the region of the claimant.

The Age Structure of Capital Ownership

Ideally, each cohort should be tracked as it accumulates capital during its working life and draws it down during retirement. An expedient measure (particularly for model applications in which the age structure of populations is invariant between the baseline and alternative scenarios) is to share down the aggregate capital stock by age of owner. The assumption is made that the age structure of all forms of capital (residential and non-residential; operated by firms and PUEs, installed at home or abroad, held by the PPS and OIs) is identical. Assuming that persons under 15 do not own capital, this leaves us with:

$$K\,\mathrm{Re}\,s_1^{15-59} = K\,\mathrm{Re}\,s_1^{*} \; KShare_{1*}^{15-59}$$
$$K\,\mathrm{Re}\,s_1^{60+} = K\,\mathrm{Re}\,s_1^{*} \; (1 - KShare_{1*}^{15-59})$$

$$KPUE_1^{15-59} = KPUE_1^{*} \; KShare_{1*}^{15-59}$$
$$KPUE_1^{60+} = KPUE_1^{*} \; (1 - KShare_{1*}^{15-59})$$

$$KPPS_{12}^{15-59} = KPPS_{12}^{*} \;\; KShare_{1*}^{15-59}$$
$$KPPS_{12}^{60+} = KPPS_{12}^{*} \;\; (1 - KShare_{1*}^{15-59})$$

$$KOIFDI_{12}^{15-59} = KOIFDI_{12}^{*} \; KShare_{1*}^{15-59}$$
$$KOIFDI_{12}^{60+} = KOIFDI_{12}^{*} \; (1 - KShare_{1*}^{15-59})$$
$$KOIPort_{12}^{15-59} = KOIPort_{12}^{*} \; KShare_{1*}^{15-59}$$
$$KOIPort_{12}^{60+} = KOIPort_{12}^{*} \; (1 - KShare_{1*}^{15-59})$$

This leaves us with the problem of estimating the share variable. In Annex 2, we present a model from demography which results in the following expression:

$$KShare_{1*}^{15-59}(t) = \frac{Pop_1^{15-59}(t)}{POP_1^{15-59}(t) + 0.25\frac{(1+r(t))^{(60-A_W)}}{(1+g(t))^{(A_R-A_W)}} POP_1^{60+}(t)}$$

where A_R is the average age of the population aged over 60 and A_W is the average age of the population 15-59.

Income, Outlay and Net Saving of Households

In the System of National Accounts (SNA), national income and saving are assigned to households, firms, and government. In order to highlight the role of age structure, the income and outlay of households is split into payments and receipts of households proper and the income and outlay of the PPS and OIs, which hold financial claims on behalf of households. Examples of such receipts and payments would be receipt of stock dividends from firms and payment of annuities to the retirement-age population.

We do not articulate households' deposits to the banking system (and purchases of mutual fund shares) as a debit to households and a credit to OIs; in this sense, income minus outlay of the OIs gives a misleading picture of the flow of funds. However, the sum of income minus outlay across the population aged 15-59, the population aged 60+, the PPS, and OIs gives us the household net saving concept familiar from the SNA (see Table 3 in the main body of this paper).

Income, Outlay, and Net Saving of the Population 15-59 Years Old

Persons of working age receive wage income, entrepreneurial income in the form of profits from PUEs, imputed rental services of residential capital, and transfers from persons aged over 60. As we discuss later, the latter implicitly include bequests. Pre-tax income in this age group is thus

$$YPop_1^{15-59} = WageYPop_1^{15-59} + EntrYPop_1^{15-59} + \mathrm{Re}\,ntYPop_1^{15-59} + TransPop_1^{60+,15-59}$$

At the expense of some redundancy, we retain "Pop" in all income acronyms to stress that these variables refer to the income of persons, not the income of households. At a subsequent stage of model development, it is hoped to assign individuals, and the income they receive, to households of various structures, at

which point it will be possible to calculate true household income.

In the following pages, we examine each of these income streams and the associated expenditures.

Income, outlay, and net saving related to wage income. Out of pre-tax wage income, persons aged 15-19 pay direct taxes and social insurance contributions, the latter consisting of contributions to the public PAYG social security system and the PPS.

$$WageYPop_1^{15-59} = W_1\ Emp_1^{15-59}$$
$$DispWageYPop_1^{15-59} = WageYPop_1^{15-59} - DirTaxWageYPop_1^{15-59} - SocInsContrWageYPop_1^{15-59}$$

The direct tax rate is defined with respect to income:

$$DirTaxWageYPop_1^{15-59} = DirTaxRate_1\ W_1\ Emp_1^{15-59}$$

The direct tax rate is assumed to apply equally to all domestic factor incomes. Social insurance contributions consist of contributions to the public PAYG defined benefit public pension system and the PPS:

$$SocInsContWageYPop_1^{15-59} = SocSecContWageYPop_1^{15-59} + PPSContWageYPop_1^{15-59}$$

Social security system and PPS contributions are taken out of gross compensation of employees. The contribution rate is assumed to be the same for both age groups; therefore, it is not indexed by age. It is also assumed to be the same for both wage income and entrepreneurial income:

$$SocSecContWageYPop_1^{15-59} = SocSecContRate_1\ WageYPop_1^{15-19}$$
$$PPSContWageYPop_1^{15-59} = PPSContRate_1\ WageYPop_1^{15-19}$$

Consumption of disposable wage income is calculated by means of an exogenous age-specific share:

$$ConsWageYPop_1^{15-59} = ConsShareWageYPop_1^{15-59}\ DispWageYPop_1^{15-59}$$

and what is left over is net saving:

$$NetSvngWageYPop_1^{15-59} = DispWageYPop_1^{15-59} - ConsWageYPop_1^{15-59}$$

Income, outlay, and net saving related to $KPUE^{15-59}$. The treatment of entrepreneurial income derived from PUEs is identical:

$$EntrYPop_1^{15-59} = r_1\ KPUE_1^{15-59}$$
$$DispEntrYPop_1^{15-59} = EntrYPop_1^{15-59} - DirTaxEntrYPop_1^{15-59} - SocInsContrEntrYPop_1^{15-59}$$
$$DirTaxEntrYPop_1^{15-59} = DirTaxRate_1\ EntrYPop_1^{15-59}$$

$$SocInsContEntrYPop_1^{15-59} = SocSecContEntrYPop_1^{15-59} + PPSContEntrYPop_1^{15-19}$$
$$SocSecContEntrYPop_1^{15-59} = SocSecContRate_1 \; EntrYPop_1^{15-19}$$
$$PPSContEntrYPop_1^{15-59} = PPSContRate_1 \; EntrYPop_1^{15-19}$$

Consumption is again calculated by means of an exogenous age-specific share, and the residual is net saving:

$$ConsEntrYPop_1^{15-59} = ConsShareEntrYPop_1^{15-59} \; DispEntrYPop_1^{15-59}$$
$$NetSvngEntrYPop_1^{15-59} = DispEntrYPop_1^{15-59} - ConsEntrYPop_1^{15-59}$$

Recall that depreciation and indirect taxes have already been netted out of income accruing to capital.

Income, outlay, and net saving related to KRes$^{15-59}$. Imputed rents to residential housing are taxed like any other form of income; the residual is consumed, so there is no net saving out of this income stream:

$$\mathrm{Re}\,ntYPop_1^{15-59} = r_1 \; K\,\mathrm{Re}\,s_1^{15-59}$$
$$Disp\,\mathrm{Re}\,ntYPop_1^{15-59} = \mathrm{Re}\,ntYPop_1^{15-59} - DirTax\,\mathrm{Re}\,ntYPop_1^{15-59}$$
$$DirTax\,\mathrm{Re}\,ntYPop_1^{15-59} = DirTaxRate_1\,\mathrm{Re}\,ntYPop_1^{15-59}$$
$$Cons\,\mathrm{Re}\,ntYPop_1^{15-59} = Disp\,\mathrm{Re}\,ntYPop_1^{15-59}$$

As in the case of entrepreneurial income, depreciation and indirect taxes have already been netted out.

Income, outlay, and net saving related to transfers / bequests. All income not consumed by persons aged 60+ is transferred to 15-59 year olds. This includes the annuity value of the wealth of the 60+ population; in this way, bequests are "annualised":

$$ConsTransPop_1^{60+,15-59} = ConsShareTrans_1^{60+,15-59} \; TransPop_1^{60+,15-59}$$
$$NetSvngTransPop_1^{60+,15-59} = TransPop_1^{60+,15-59} - ConsTransPop_1^{60+,15-59}$$

***Total net saving*.** Total net saving is then the sum over saving from the various income streams:

$$NetSvngPop_1^{15-59} = NetSvngWageYPop_1^{15-59} + NetSvngEntrYPop_1^{15-59} + NetSvngTransPop_1^{60+,15-59}$$

Recall that net saving out of rental income was assumed to be zero.

Income, 0utlay, and Net Saving of the Population aged 60+

Persons above retirement age receive wage income if they are still employed, annuity income derived from their capital assets, and benefits from the public Pay As You Go social security system.

The level of social security benefits is dictated by current revenues flowing into the system (i.e. we assume that no surplus is accumulated and there is no deficit financed from general revenue). As discussed in the main body of the paper, this means that the pressures of population ageing are translated into lower levels of benefit, rather than higher payroll taxes or deeper fiscal deficits. In order to simplify accounting, persons are assumed to start receiving social security benefits at 60 regardless of labour force status.

For the same reason, annuitisation of assets is assumed to commence at 60 whether the individual is retired or not. The 60+ population's claims on all forms of capital is translated into annuity income based on the prevailing rate of return to capital and life expectancy at 60.

Total pre-tax income in this age group is

$$YPop_1^{60+} = WageYPop_1^{60+} + AnnYPop_1^{60+} + SocSecBen_1$$

We proceed to look at each of these components, and expenditures out of each income stream:

Income, outlay, and net saving related to wage income. Wage and entrepreneurial income of 60+ year olds is treated no differently than in the case of younger persons:

$$WageYPop_1^{60+} = W_1\ Emp_1^{60+}$$
$$DispWageY_1^{60+} = WageYPop_1^{60+} - DirTaxWageY_1^{60+} - SocInsContrWageY_1^{60+}$$
$$DirTaxWageYPop_1^{60+} = DirTaxRate_1\ WageYPop_1^{60+}$$

$$SocInsContWageYPop_1^{60+} = SocSecContWageYPop_1^{60+} + PPSContWageYPop_1^{60+}$$
$$SocSecContWageYPop_1^{60+} = SocSecContRate_1\ WageYPop_1^{60+}$$
$$PPSContWageY_1^{60+} = PPSContRate_1\ W_1\ Emp_1^{60+}$$

$$ConsWageY_1^{60+} = ConsShareWageY_1^{60+}\ DispWageY_1^{60+}$$
$$NetSvngWageY_1^{60+} = DispWageY_1^{60+} - ConsWageY_1^{60+}$$

Income, outlay, and net saving related to $KPPS^{60+}$, KOI^{60+}, $KPUE^{60+}$, and $KRes^{60+}$. Persons over sixty derive annuity income from the PPS and OIs, who hold financial claims on their behalf, and this annuity income is assumed to be untaxed.

$$DispAnnYPop_1^{60+} = AnnValKPPS_{1*}^{60+} + AnnValKOI_{1*}^{60+} + AnnValKPUE_1^{60+} + AnnValK\,\mathrm{Re}\,s_1^{60+}$$

These annuities are calculated according to the formulae

$$AnnValKPPS_{1*}^{60+} = KPPS_{1*}^{60+}\ \frac{r_1}{1 + r_1 - \left(\frac{1}{1+r_1}\right)^{LifeExp60_1}}$$

$$AnnValKOI_{1^*}^{60+} = KOI_{1^*}^{60+} \frac{r_1}{1 + r_1 - \left(\frac{1}{1+r_1}\right)^{LifeExp60_1}}$$

$$AnnValKPUE_1^{60+} = KPUE_1^{60+} \frac{r_1}{1 + r_1 - \left(\frac{1}{1+r_1}\right)^{LifeExp60_1}}$$

$$AnnValK\,\mathrm{Re}\,s_1^{60+} = K\,\mathrm{Re}\,s_1^{60+} \frac{r_1}{1 + r_1 - \left(\frac{1}{1+r_1}\right)^{LifeExp60_1}}$$

We make the simplifying assumption (in the first two cases) that assets are annuitised in the domestic market regardless of whether they consist of claims on capital installed at home or abroad.

No distinction is made between the propensity to consume out of various annuity streams:

$$ConsAnnYPop_1^{60+} = ConsShareAnnYPop_1^{60+}\ DispAnnYPop_1^{60+}$$
$$NetSvngAnnYPop_1^{60+} = DispAnnYPop_1^{60+} - ConsAnnYPop_1^{60+}$$

Income, outlay, and net saving related to social security benefits. Social security benefits are assumed to be untaxed.

$$ConsSocSecBen_1 = ConsShareSocSecBen_1\ SocSecBen_1$$
$$NetSvngSocSecBen_1 = SocSecBen_1 - ConsSocSecBen_1$$

Transfers / bequests. Transfers / bequests from the population aged 60+ to the population aged 15-59 are calculated as the residual left after consumption has been deducted from disposable income; i.e. as the sum of net saving from all disposable income flows:

$$TransPop_1^{60+,15-59} = NetSvngWageYPop_1^{60+} + NetSvngAnnYPop_1^{60+} + NetSvngSocSecBen_1$$

Net saving. Given the calculation of transfers / bequests, net saving of the population aged 60+ is by definition zero.

Total Private Consumption

Total consumption in each age group is the sum over all consumption streams:

$$Cons_1^{15-59} = ConsWageYPop_1^{15-59} + ConsEntrYPop_1^{15-59} + Cons\,\mathrm{Re}\,ntYPop_1^{15-59} + ConsTransPop_1^{60+,15-59}$$

$$Cons_1^{60+} = ConsWageYPop_1^{60+} + ConsAnnYPop_1^{60+} + ConsSocSecBen_1$$

and total private consumption in the economy is

$$\mathrm{Pr}\,ivCons_1^* = Cons_1^{15-59} + Cons_1^{60+}$$

Income, Outlay, and Net Saving of the PPS and OIs

The PPS and OI are dummy sectors in that they merely hold assets on behalf of households. The PPS receives workers' and employers' contributions and dividends distributed by firms. Since corporate profits are taxed when (and where) earned, these dividends are assumed to be not taxed. Disposable income of the PPS is thus

$$DispYPPS_1 = PPSContWageY_1^* + PPSContEntrY_1^* + DivDistYFirmsKPPS_{11} + DivDistYFirmsKPPS_{12}$$

In the case of claims corresponding to domestic capital (the first dividend term in the expression above), the dividend is debited to firms in Region 1; in the case of claims consisting of portfolio investment abroad (the second dividend term), the dividend is debited from firms in Region 2.

The PPS pays out annuities to retirees; what is left over comprises net saving of the pension system

$$NetSvngPPS_1 = DispYPPS_1 - AnnValKPPS_{1*}^{60+}$$

OIs receive dividends in the same way as the PPS, in addition to which they receive dividends distributed from repatriated earnings on FDI. Because OIs are assumed to intermediate retirees' annuitisation of their holdings of KPUE and KRes; they are credited with income streams from these assets:

$$DispYOI_1 = DivDistYFirmsKOI_{11} + DivDistYFirmsKOIPort_{12} + DivDist\,\mathrm{Re}\,patErngsKOIFDI_{12} + r_1 KPUE_1^{60+} + r_1 K\,\mathrm{Re}\,s_1^{60+}$$

Like the PPS, OIs pay out annuities, and what is left over comprises net savings:

$$NetSvngOI_1 = DispYOI_1 - AnnValKOI_{1*}^{60+} - AnnValKPUE_1^{60+} - AnnValK\,\mathrm{Re}\,s_1^{60+}$$

Note that, as defined here, net savings of the PPS are quite close to the net flow of funds into the PPS, because inflows to the PPS consist only of dividends and pension contributions. By contrast, net savings of OIs are nowhere close to the net flow of funds into OIs. This is because OIs receive inflows of deposits from other savers, particularly households. It would be possible to make these flows explicit, debiting deposits from other actors and crediting them to the OIs. This would not, however, contribute much to our basic purpose, which is to make explicit the accumulation of assets prior to age 60 and their annuitisation after age 60.

Net Saving of Households

Since saving of the population aged 60+ is zero after transfers and bequests have been taken into account, total net saving from household income is

$$NetSvngHH_1 = NetSvngPop_1^{15-59} + NetSvngPPS_1 + NetSvngOI_1$$

Income, Outlay, and Net Saving of Firms

Income and Outlay Related to Capital Installed in Region 1

Firms operate capital installed at home and abroad; they earn profits and pay out direct taxes and dividends. In the case of FDI in Region 2, firms in Region 1 make a two-stage decision: first, what proportion of earnings abroad to repatriate (and, the complementary decision, what proportion to reinvest), and second, what proportion of remitted earnings to pay out as dividends. Earnings on capital owned by foreigners (i.e. $KPPS_{21}$ and KOI_{21} from the standpoint of firms in Region 1) are credited to the firm in Region 1 if the claim represents portfolio investment from Region 2, but to the firm in Region 2 if the claim represents FDI from Region 2. Domestic earnings of firms in Region 1 are:

$$YFirmsKPPS_{11} = r_1\ KPPS_{11}^*$$
$$YFirmsKOI_{11} = r_1\ KOI_{11}^*$$
$$YFirmsKPPS_{21} = r_1\ KPPS_{21}^*$$
$$YFirmsKOIPort_{21} = r_1\ KOIPort_{21}^*$$

Note that all of these flows are net of depreciation and indirect taxes.

Direct taxes are paid to the government of Region 1 on each of the streams that comprise domestic income:

$$DirTaxYFirmsKPPS_{11} = DirTaxRate_1\ YFirmsKPPS_{11}^*$$
$$DirTaxYFirmsKOI_{11} = DirTaxRate_1\ YFirmsKOI_{11}^*$$
$$DirTaxYFirmsKPPS_{21} = DirTaxRate_1\ YFirmsKPPS_{21}^*$$
$$DirTaxYFirmsKOIPort_{21} = DirTaxRate_1\ YFirmsKOIPort_{21}^*$$

and the sum represents total direct taxes paid by firms in Region 1 to the government of Region 1:

$$DirTaxYFirms_{11} = DirTaxFirmsKPPS_{*1} + DirTaxFirmsKOI_{11} + DirTaxFirmsKOIPort_{21}$$

Dividend distributions are made out of pre-tax earnings, and the proportion of earnings distributed is assumed to be independent of the nature of the claim:

$$DivDistYFirmsKPPS_{11} = DivDistRate_1\ YFirmsKPPS^*_{11}$$
$$DivDistYFirmsKOI_{11} = DivDistRate_1\ YFirmsKOI^*_{11}$$
$$DivDistYFirmsKPPS_{21} = DivDistRate_1\ YFirmsKPPS^*_{21}$$
$$DivDistYFirmsKOIPort_{21} = DivDistRate_1\ YFirmsKOIPort^*_{21}$$

These dividends are credited to the PPS in Region 1, OIs in Region 1, the PPS in Region 2, and OIs in Region 2, respectively.

Income and Outlay Related to Earnings on FDI Abroad

Earnings on capital corresponding to FDI from Region 1 in Region 2 is credited to firms located in Region 1:

$$YFirmsKOIFDI_{12} = r_2\ KOIFDI_{12}$$

and are, again, net of depreciation and indirect tax.

Direct taxes on these earnings are paid to the government of Region 2:

$$DirTaxYFirmsKOIFDI_{12} = DirTaxRate_2\ YFirmsKOIFDI_{12}$$

Firms set aside a portion for reinvestment abroad:

$$\mathrm{Re}\,invErngsKOIFDI_{12} = \mathrm{Re}\,InvShareErngsFDI_{12}\ YFirmsKOIFDI_{12}$$

where the reinvestment share is an exogenous assumption and is assumed to be applied to pre-tax earnings. No account is taken of special arrangements for exempting reinvested earnings on FDI from taxation.

The remainder of earnings on FDI is repatriated to Region 1:

$$\mathrm{Re}\ patrErngsKOIFDI_{12} = YFirmsKOIFDI_{12} - DirTaxFirmsKOIFDI_{12} - \mathrm{Re}\,invErngsKOIFDI_{12}$$

where dividends are distributed:

$$DivDist\,\mathrm{Re}\ patrErngsKOIFDI_{12} = DivDistRate_1\ \mathrm{Re}\ patrErngsKOIFDI_{12}$$

and credited to OIs. It is assumed that, having been taxed once in Region 2, repatriated earnings are exempt from taxation in Region 1.

Net Saving of Firms

Net savings of firms are split into two components: savings out of domestic resources (including earnings repatriated from abroad), and savings in the form of reinvested earnings on FDI. The streams which comprise domestic savings of firms in Region 1 are

$$NetSvngYFirmsKPPS_{11} = YFirms\ KPPS_{11} - DirTaxYFirmsKPPS_{11} - DivDistYFirmsKPPS_{11}$$
$$NetSvngYFirmsKOI_{11} = YFirmsKOI_{11} - DirTaxYFirms\ KOI_{11} - DivDistYFirmsKOI_{11}$$
$$NetSvngYFirmsKPPS_{21} = YFirmsKPPS_{21} - DirTaxYFirmsKPPS_{21} - DivDistYFirmsKPPS_{21}$$
$$NetSvngYFirmsKOIPort_{21} = YFirmsKOIPort_{21} - DirTaxYFirmsKOIPort_{21} - DivDistYFirmsKOIPort_{21}$$
$$NetSvng\,\mathrm{Re}\,patErngsKOIFDI_{12} = \mathrm{Re}\,patErngsKOIFDI_{12} - DivDist\,\mathrm{Re}\,patErngsKOIFDI_{21}$$

the sum of which is total net domestic savings of firms in Region 1:

$$NetDomSvngYFirms_1 = NetSvngYFirms\ KPPS_{11} + NetSvngYFirmsKOI_{11} + NetSvngYFirmsKPPS_{21} + NetSvngYFirmsKOIPort_{21} + NetSvng\,\mathrm{Re}\,patErngsKOIFDI_{12}$$

Foreign savings are simply reinvested earnings on FDI:

$$NetForSvngYFirms_1 = \mathrm{Re}\,InvErngsKOIFDI_{12}$$

and total net saving from corporate income in Region 1 is the sum of the two:

$$NetSvngFirms_1 = NetDomSvngYFirms_1 + NetForSvngYFirms_1$$

Income, Outlay, and Net Saving of Government

Government receives direct taxes, indirect taxes, and contributions to the public social security system:

$$YGov_1 = DirTaxWageYPop_1^* + DirTaxEntrYPop_1^{15-59} + DirTax\,\mathrm{Re}\,ntYPop_1^{15-59} + DirTaxYFirms_{11} + DirTaxYFirmsKOIFDI_{21} + IndTax_1 + SocSecContrWageYPop_1^* + SocSecContrEntrYPop_1^*$$

Recall that the 60+ population pays direct taxes (and social insurance contributions) only on wage income. Indirect taxes are calculated as

$$IndTax_1 = IndTaxRate_1\ GDP_1$$

Government expenditure consists of government consumption and social security benefits, and income minus expenditure gives government net savings:

$$NetSvngGov_1 = YGov_1 - GovCons_1 - SocSecBen_1$$

Since the public social security system is assumed to be PAYG, social security outlay is equal to social security revenue:

$$SocSecBen_1 = SocSecContrWageYPop_1^* + SocSecContrEntrYPop_1^*$$

In other words, net saving of the public pension system is assumed to be zero. Government consumption is calculated by means of an exogenous share coefficient:

$$GovCons_1 = GovConsShare_1 GDP_1$$

Sharing out Saving into Investment

A major simplifying assumption is that investment in each region is constrained by the supply of capital, i.e. that investment always equals the amount of savings made available. The approach followed is to share out available savings into different types of investment, some mobile and some immobile, and then share out the former between regions based on exogenous flow coefficients.

Total net savings of Region 1 are

$$NetSvngTot_1 = NetSvngHH_1 + NetDomSvngFirms_1 + NetSvngGov_1 + \mathrm{Re}\, invErngsKOIFDI_{12}$$

of which the domestic component is

$$NetDomSvngTot_1 = NetSvngHH_1 + NetDomSvngFirms_1 + NetSvngGov_1$$

Residential and non-residential investment are calculated from domestic savings by means of an exogenous share coefficient:

$$dK\,\mathrm{Re}\, s_1 = \mathrm{Re}\, sInvShare_1 \;\; NetDomSvngTot_1$$

$$dKNon\,\mathrm{Re}\, s_{1*} = (1 - \mathrm{Re}\, sInvShare_1)\, NetDomSvngTot_1 + \mathrm{Re}\, invErngsKOIFDI_{12}$$

Residential investment takes place exclusively in the home region; non-residential investment, however, can take place either at home or abroad. Investment in PUEs is estimated as a share of non-residential investment (apart from reinvestment of FDI earnings):

$$dKPUE_1 = PUEInvShare_1 \left(dKNon\,\mathrm{Re}\, s_{1*} - \mathrm{Re}\, invErngKOIFDI_{12}\right)$$

Total investment minus residential investment minus investment in PUEs equals investment in capital operated by firms; claims on which are by definition held either by the PPS or by OIs.

We assume that change in capital claimed by the PPS is equal to net savings of this sector, which is sensible since we have more or less enumerated all the sources and uses of funds for this sector. The residual, i.e. investment from all savings not mediated through the PPS, is assigned to OIs:

$$dKPPS_{1*} = NetSvngPPS_1$$
$$dKOI_{1*} = dKNon\,\mathrm{Re}\, s_{1*} - dKPPS_{1*}$$

Regional Share-down

Investment is shared down into location of the project by means of exogenous capital flow coefficients. In the case of the PPS, this is straightforward:

$$dKPPS_{11} = dKPPS_{1*}\,\varphi_{11}^{PPS}$$
$$dKPPS_{12} = dKPPS_{1*}\left(1 - \varphi_{11}^{PPS}\right)$$

In the case of the OIs, the only complication is that we do not wish to share out reinvested earnings on FDI, which are by definition allocated to Region 2:

$$dKOI_{11} = \left(dKOI_{1*} - \mathrm{Re}\,invErngsKOIFDI_{12}\right)\varphi_{11}^{OI}$$
$$dKOI_{12} = \left(dKOI_{1*} - \mathrm{Re}\,invErngsKOIFDI_{12}\right)\left(1 - \varphi_{11}^{OI}\right) + \mathrm{Re}\,invErngsKOIFDI_{12}$$

Calculation of Capital Stocks

Capital stocks are cumulated year by year:

$$K\,\mathrm{Re}\,s_1 = K\,\mathrm{Re}\,s_1(-1) + dK\,\mathrm{Re}\,s_1$$

$$KPUE_1 = KPUE_1(-1) + dKPUE_1$$

$$KPPS_{11} = KPPS_{11}(-1) + dKPPS_{11}$$

$$KPPS_{12} = KPPS_{12}(-1) + dKPPS_{12}$$

$$KOI_{11} = KOFI_{11}(-1) + dKOI_{11}$$

$$KOI_{12} = KOFI_{12}(-1) + dKOI_{12}$$

There is no need to account for depreciation since this has already been netted out in calculating saving.

Domestic capital formation also includes investment from Region 2, calculated along the same lines as above:

$$KPPS_{21} = KPPS_{21}(-1) + dKPPS_{21}$$

$$KOFI_{21} = KOFI_{21}(-1) + dKOFI_{21}$$

Calculation of Gross National Product (GNP) and National Disposable Income

Net (in the sense of receipts minus outlays) factor payments from abroad represent the sum of net dividend payments, net after-tax earnings on FDI (whether remitted or reinvested), net depreciation allowances, and net payments of indirect

tax. Recalling that we now have to adjust for depreciation and indirect taxes, gross factor payments from Region 2 to Region 1 are:

$$GFP_{21} = DivDistYFirmsKPPS_{12} + DivDistYFirmsKOIPort_{12} + YFirmsKOIFDI_{12} - DirTaxYFirmsKOIFDI_{12} + \delta_2 K_{12} + IndTax_{12}$$

where

$$IndTax_{12} = \frac{IndTax_2}{K_{*2}} K_{12}$$

Symmetrically,

$$GFP_{12} = DivDistYFirmsKPPS_{21} + DivDistYFirmsKOIPort_{21} + YFirmsKOIFDI_{21} - DirTaxYFirmsKOIFDI_{21} + \delta_1 K_{21} + IndTax_{21}$$

and

$$NFP_{21} = GFP_{21} - GFP_{12}$$
$$GNP_1 = GDP_1 + NFP_{21}$$

National disposable income is GNP adjusted for depreciation and indirect taxes:

$$NatDispY_1 = GNP_1 - \delta_1 K_{11} - \delta_2 K_{12} + IndTax_{21} - IndTax_{12}$$

National net savings are equal to NatDispY minus consumption:

$$NatNetSvng_1 = NatDispY_1 - \mathrm{Pr}\,ivCons_1 - GovCons$$

Accounting Checks

Two accounting checks are applied. The first is that net national savings as calculated “top down” in each region is equal to the sum of net savings from income of households, firms, and government:

$$NatNetSvng_1 = NetSvngYHH_1 + NetSvngYFirms_1 + NetSvngGov_1$$

$$NatNetSvng_2 = NetSvngYHH_2 + NetSvngYFirms_2 + NetSvngGov_2$$

The second is that net saving in each region is equal to the change in capital assets:

$$NatNetSvng_1 = dK_{11} + dK_{12}$$

$$NatNetSvng_2 = dK_{22} + dK_{21}$$

The algebraic proofs that these identities hold can be found in MacKellar and Reisen (1998).

NOTE

1. In accounting for the annuitisation of the 60+ population's assets consisting of capital operated by PUEs and residential capital, we assume that OIs play the intermediary role. However, in order to simplify notation, we define KOI as consisting entirely of capital operated by firms and deal with $KPUE^{60+}$ and $KRes^{60+}$ separately. One way of interpreting this is that households retain title to these assets, but assign the income earned from them to OIs in return for an annuity.

ANNEX 2: THE AGE STRUCTURE OF CAPITAL OWNERSHIP

Let the age of retirement be denoted *R* (60 in our model), assumed to remain constant. If the length of working life *(LWL)* is also assumed to remain constant, then average age during the working age-span be (A_w) will also be constant. Average age during the retirement age-span (A_R) will depend on age at retirement and life expectancy at *R* in year *t*:

$$A_R\ (t) = \frac{\left(R + E_R(t)\right)}{2}$$

Assume that the age distribution of the population in year *t* is such that the average worker is, indeed, aged A_w and the average person over age *R* is aged A_R. This need not be the case, but extreme departures from the assumption are unlikely.

The economic growth rate, *g*, the real rate of return to capital, *r*, and the saving rate, *s*, are all assumed to remain constant over time. In any year there is a uniform wage rate earned by all workers, *w(t)*, which is assumed to grow over time at rate *g*. All savings come out of wage income, and we ignore the fact that some workers die before they retire.

Assume that saving takes place at a constant rate over the working age-span. Then, ignoring the effects of compounding, the assets of the average member of the working-age population in year *t* are

$$k\left(A_W, t\ \right) = 0.5\ s\ w(t)\ LWL$$

Assume that, upon retirement, capital ceases to earn a rate of return (i.e. retirees convert their assets into cash) and that retirees dissave so that, when they reach A_R, half of their original accumulation is depleted. Then the assets of the average member of the retirement-age population are

$$k\left(A_R, t\ \right) = 0.5\ k\left[R, t - \left(A_R - R\right)\right]$$

For example, if the retirement age is 60 and the average age of the post-retirement age-span is 70, the assets of a 70 year-old in year *t* are equal to half his/her assets at age 60 in year *t – 10*. Since all saving in this individual's life span occurred at age A_w,

$$k\left(A_R, t\ \right) = 0.5\ k\left[A_W, t - \left(A_R - A_W\ \right)\right]\left(1 + r\right)^{\left(R - A_W\right)}$$
$$= 0.25\ s\ w\left[t - \left(A_R - A_W\ \right)\right] LWL\ \left(1 + r\right)^{\left(R - A_W\right)}$$

To continue the example, if the average age of saving is 40, our 70 year-old acquired his/her assets, on average, 30 years ago and earned a rate of return *r* for 20 years, at which point he/she retired and began to consume the accumulation.

Let K_W, and K_R denote capital owned by the working-age population and capital owned by the retirement-age population, respectively. Then the share of total capital owned by persons in the working age-span, $S_W(t)$, is

$$S_W(t) = \frac{k(A_W, t)\,POP_W(t)}{k(A_W, t)\,POP_W(t) + k(A_R, t)\,POP_R(t)}$$

$$S_W(t) = \frac{s\,w(t)\,LWL\,POP_W(t)}{s\,w(t)\,LWL\,POP_W(t) + \left\{0.25\,s\,w\left[t - (A_R - A_W)\right]LWL\,(1+r)^{(R-A_W)}\right\}POP_R(t)}$$

Because wages grow at rate g,

$$w\left[t - (A_R - A_W)\right] = \frac{w(t)}{(1+g)^{(A_R - A_W)}}$$

and the expression reduces to

$$S_W(t) = \frac{POP_W(t)}{POP_W(t) + 0.25\,\frac{(1+r)^{(R-A_W)}}{(1+g)^{(A_R-A_W)}}\,POP_R(t)}$$

Thus, the share of capital owned by the working age population is directly related to the rate of economic growth and inversely related to the rate of return to capital. This makes sense; workers' savings grow faster as g increases, whereas retirees' decumulation is unaffected. Higher r redistributes capital towards the older population because the elderly have more time to reap the benefits of compounding. Finally, an increase in life expectancy at 60, resulting in higher A_R, increases the share of capital owned by older persons (even holding population age structure constant) because it increases the number of years over which capital is held prior to depletion.

The discussion above assumed that r and g remain constant. In long-run model simulations, change in these rates will be incremental, so results will not be sensitive to dropping this assumption. Thus, the relationship incorporated in the model is

$$KShare_{1*}^{15-59}(t) = \frac{Pop_1^{15-59}(t)}{POP_1^{15-59}(t) + 0.25\,\frac{(1+r(t))^{(60-A_W)}}{(1+g(t))^{(A_R-A_W)}}\,POP_1^{60+}(t)}$$

A_R is taken (as above) as the average of 60 and life expectancy at 60; A_W is calculated based on the age-specific population projection as the average age of the 15-59 year-old population.

ANNEX 3: PARAMETERS AND ASSUMPTIONS

Parameterisation and initialisation assumptions were *ad hoc*, but this should not affect the marginal simulation properties of the model very much. In other words, refining the rough assumptions set forth below probably would not affect our baseline-versus-alternative scenario conclusions substantively.

Demography and Labour Markets

Demographic assumptions, taken from the IIASA Central Scenario population projection (Lutz, 1996), have been summarised above. “Fast-Ageing Countries” and “Slowly Ageing Countries” correspond to “Industrial” and “Developing” countries in the IIASA volume.

Life expectancy at age 60 was assumed to rise from 25 to 35 years in FACs and from 15 to 25 years in SACs over the period 1995-2100; these increases are in line with the mortality assumptions which underlie the IIASA population projection. Average age above age 60 was assumed to rise from 72.5 to 77.5 in FACs and from 67.5 to 72.5 in SACs. The average age of the population aged 15-59 was assumed to remain constant at 37.5 in both regions.

Based on estimates from the International Labour Organisation (ILO), labour force participation rates in the age range of 15-59 (both sexes combined) in both regions were assumed to be 0.75 over the entire simulation period. Labour force participation rates over age 60 were assumed to remain constant at 0.05 in FACs and 0.10 in SACs.

The Production Function

The *ß* coefficient in the Cobb-Douglas production function was assumed to be 0.33 in both FACs and SACs. The rate of total factor productivity growth was assumed to be 1 per cent per year in FACs and 2 per cent per year in SACs. Information from various sources led us to initialise the model on 1995 *per capita* GDP levels of approximately $25 000 and $1 500 in FACS and SACs.

Social Insurance Contribution Rates

It was assumed in FACs that 3 per cent of pre-tax compensation of employees was contributed to private pension plans. The contribution rate out of entrepreneurial income was likewise assumed to be 3 per cent. In SACs these contribution rates were assumed to be 2.5 per cent. The social security contribution rate was assumed to be 12.5 per cent in FACs and 2.5 per cent in SACs.

Consumption / Saving Rates

In both regions, it was assumed for the population aged 15-59 that the average propensities to consume out of disposable wage income, entrepreneurial income, and transfers / bequests were 0.95, 0.5, and 0.5, respectively. All imputed rental income was assumed to be consumed. For the population aged over 60, it was assumed in both regions that the consumption rates out of wage income, annuity income, and social security benefits were 0.95, 0.9. and 1.0, respectively.

Taxes and Government Consumption

The direct tax rate (relative to wages and profits) was assumed to be 0.15 in both FACs and SACs. The indirect tax rate (relative to GDP) was set at 0.075 in FACs and 0.100 in SACs. Government consumption was assumed to be 20 per cent of GDP in both regions.

Dividends and Reinvestment of Earnings on FDI

Firms in both regions were assumed to pay out 15 per cent of pre-tax profits to holders of claims, as well as 15 per cent of repatriated earnings on FDI abroad. Assumptions on the share of FDI earnings reinvested in the host country were discussed in the main body of the paper.

Residential Investment and Investment in PUEs

In both regions, the share of net domestic saving allocated to residential investment was assumed to be 20 per cent. The share of PUEs in total non-residential investment (excluding reinvestment of earnings on FDI from abroad) was also assumed to be 20 per cent.

Sharing out Investment between Regions

Assumptions made regarding the allocation of investment between domestic and foreign regions have been discussed in the main body of the paper.

Initialising Capital Stocks and Claims

Total initial capital stocks were calculated based on the assumed *per capita* GDP levels given above and assumed capital-output ratios of approximately 3.0 in FACs and 2.5 in SACs. The depreciation rate was assumed to be 4 per cent per year in FACs and 6 per cent per year in SACs.

In both regions, it was assumed that 1 per cent of all initial claims on capital consisted of claims on capital installed in the foreign region (i.e. $K_{12} / K_{1*} = 0.01$ and $K_{21} / K_{2*} = 0.01$). 33 per cent of K_{*1} and 33 per cent of K_{*2} were assumed to consist of residential capital; similarly, 33 per cent of K_{*1} and 33 per cent of K_{*2} were assumed to consist of capital operated by PUEs.

For FACs, total claims of the PPS were assumed to be $7 865 billion based on data given in Table 1 above; based on World Bank (1997) estimates, $70 billion of this total was assumed to consist of claims on capital installed in SACs. This allowed calculation of $KPPS_{11}$, KOI_{12}, and KOI_{11} as residuals. For SACs, total claims of the PPS were assumed to be $311 billion based on the data in Table 1, and the initial-year value of $KPPS_{21}$ was assumed to be zero.

FDI claims were assumed to account for 50 per cent of initial-year KOI_{12} and KOI_{21}.