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International Diversification of Pension Assets is No Panacea For Population Aging

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Abstract

Six years ago, *The Economist* wrote that investing retirement savings from aging developed countries in the emerging markets of still-youthful developing countries promised to "beat demography." As labor force growth slows in the North, runs this argument, capital becomes abundant relative to labor and the rate of return to this capital declines. By investing in the South, not only do OECD investors earn a higher rate of return on their savings, but the rate of return to that capital which remains in the North is boosted as well, because there is less of it.

Working with a two-region neoclassical economic-demographic model, the authors show that reallocating capital from North to South can, at most, only slightly attenuate the negative macroeconomic impacts of population aging. Moreover, the reallocation gives rise to significant, and thus politically challenging, shifts in the distribution of income between working- and retirement-age populations in both regions.

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Landis MacKellar and Helmut Reisen

Introduction

"Once freed, money may well flow disproportionately to developing countries. For this is the surest way to beat demography", wrote *The Economist* six years ago (20 June 1992). This paper aims at quantifying and testing that proposition via simulation analysis with a two-region neoclassical economic-demographic growth model. The two regions considered are "fast aging countries" (FACs; Region 1) and "slow aging countries" (SACs; Region 2), corresponding fairly closely to the traditional "industrial-less developed" and "OECD- non-OECD" aggregates. This paper will discuss two different scenarios with respect to international capital mobility, comparing a baseline Autarchy Scenario with a scenario of rapid financial integration between the two regions, the Globalization Scenario. While the Autarchy Scenario corresponds to a continuation of home-asset preference currently observed among portfolio managers, the Globalization 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 aging and financial globalization 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). What is gained from economic simplicity is added demographic-, sectoral-, and distributional detail.

How can we summarize the relationship between global demographic dynamics and financial globalization? It is widely understood that unfunded pay-as-you-go (PAYG) pension schemes are locked into the aging 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 aging 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.

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 globalization 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.

Table 1 documents the strong growth in OECD and non-OECD pension assets. The table also shows that these are heavily invested into home assets (defined as assets held in the home country of the investor only) although 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 was held by OECD pension funds in the emerging markets.

Table 1. The home-asset preference in funded pension assets.

	1990	1995[a]
Total pension assets (billion $)		
- OECD	4,813	7,865
- non-OECD	109	311
Home-asset share (% of Assets)[b]		
- OECD pension assets	92.8	88.9
- non-OECD pension assets[c]	100.0	99.3

(a) Estimate

(b) Home-assets share refers only to the share of assets invested in the home country of the investor.

(c) This excludes Hong Kong where the foreign asset share is 60%.

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 conclusion, we discuss the basic policy implications of our analysis of the interaction between population aging and financial globalization.

1. Demographic trends and their implications

"Global population aging" is a shorthand phrase used to describe a complicated set of regionally distinct changes in population age composition (see Table 1). Closely

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

associated with changes in population age distribution are trends in aggregate population growth, i.e., continued very slow rates of demographic increase in the North and rapidly decelerating population growth in the South.

If "population aging" is defined as an increase in the average age of the population, all populations are aging. However, when "population aging" is (as is more conventional) defined as the 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 group, 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 aging countries (FACs) and slow-aging countries (SACs).[2]

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

- FAC populations will age from the 'middle' of the age pyramid as the large baby-boom cohort becomes elderly in approximately 2010. SAC populations, by contrast, are aging from the 'bottom', suggesting that as today's young persons move into the working years, they are being replaced by a much smaller cohort of children (due to rapid recent fertility decline). Therefore, the prospective demographic changes imply divergent trends in labor force growth across the two regions. Assuming that age- and sex-specific labor force participation rates remain unchanged, labor force growth rates will rapidly decline in the FAC area and turn negative after 2010. In strong contrast, age-distribution changes are increasing the labor force in the SAC area; the proportion of the population in the working-age bracket (15-59) will remain roughly constant despite a 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 characterized 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 prime savers ratio (population aged 40-59 divided by population aged 15+) will rise until approximately 2010 in FACs and then commence an extended decline (see Table 2). In SACs this ratio will also rise until 2010; however, in contrast, it will remain fixed at approximately 0.3 throughout the rest of the century.

[2] To confuse matters, the rate of growth of the elderly population in the SACs is much more rapid than the corresponding rate of growth in FACs, because the SACs are starting from a small base. The appelations "fast-aging" and "slow-aging" make sense only with respect to the level of the support ratio.

Table 2. Population, by age group

	1995	2010	2020	2030	2040	2050	2100
Fast-aging countries							
Total population (million)	1,251	1,315	1,339	1,350	1,344	1,317	1,212
Average annual % change		0.3	0.2	0.1	0.0	-0.2	-0.2
Age 0-14	256	226	218	207	200	196	197
Average annual % change		-0.8	-0.3	-0.5	-0.3	-0.2	0.0
Age 15-59	774	812	784	750	716	678	613
Average annual % change		0.3	-0.3	-0.4	-0.5	-0.5	-0.2
Age 60+	221	278	336	392	428	443	402
Average annual % change		1.5	1.9	1.6	0.9	0.4	-0.2
Age structure (%)							
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
Slow-aging countries							
Total population (million)	4,451	5,696	6,539	7,321	7,995	8,593	9,188
Average annual % 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
Average annual % 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
Average annual % 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
Average annual % change		3.0	3.4	3.4	2.4	2.1	0.9
Age structure (%)							
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

In a closed economy, the neoclassical response to slowing labor force growth is to substitute capital for labor, 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 a reduced supply of savings. In long-run equilibrium, the result of population aging (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; Masson and Tryon, 1990; Yoo, 1994; Börsch-Supan, 1996; Higgins, 1997; OECD 1998) have concluded that global demographic divergences should stimulate capital flows from the most rapidly aging regions (especially Europe and Japan) to less rapidly aging 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 autarchy 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 aging 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 aging. … 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 the fact that a simple accounting model is used. We extend previous studies by incorporating detailed demographic trends and providing more fine-grained results for sectoral and distributional outcomes.

2. A simulation model

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

Age-specific saving and labor 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 labor force as it affects the number of workers relative to nonworkers; 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 that give rise to saving. In concentrating on relatively detailed age-structure effects, our work complements other analyses (e.g., Cutler *et al.*, 1990; Börsch-Supan, 1996), where the impact of population aging 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; OECD 1998), in which the impact of aging 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 residental 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]

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.

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[3] However, 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 one-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 (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 in turn is 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. Elderly persons, who receive annuity income from the PPS and OIs, also pay no 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.

Table 3: Sources of savings, FACs, Region 1.

Households

1. Population aged 15-59

Receipts
- Compensation of employees
- Entrepreneurial income (net of depreciation and indirect tax)
- Imputed housing services (net of depreciation 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 retirees

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

Net savings of households (sum of receipts minus disbursements over 1-4)

Firms

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

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

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 (e.g., the Pension Benefits Guarantee Corporation in the US), as a result of which, the distinction 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 firm 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 globalization strategies.

In our model, we recognize 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 that 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). However, profits on that portion of Region 1's capital stock that represent 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 in 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 years) and retirement-age (60+ years) 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

[7] FDI is defined as the acquisition of 20% or more of the outstanding equity in a foreign corporation, whereas acquisition of less than 20% of the outstanding equity of a foreign firm is referred to as portfolio investment.

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 that is expected as the baby boomers begin to retire (Schieber and Shoven, 1994).

Persons in the 15-59 year-old age bracket do not consume out the dividends that are distributed from earnings on the capital they own (or, to put it more accurately, the PPS and OIs that hold claims on behalf of persons 15-59 do not pass them along to the claimants). Persons over 60, whether they are still in the labor force or not, are assumed to annuitize their portion of the capital stock, meaning that they receive (from the PPS and OIs) an annuity that 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]

Persons aged 15-59 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 "annualizes" 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.

[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 labor force or not.

3. Simulation results

Model parameterization and scenario assumptions are presented in Annex 3. The simulation period is effectively from 1995 to 2050; however, we solved the model out to 2100 and will occasionally refer to ultra long-term results. These obviously must be taken with a degree of skepticism, and we will 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% 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%, the higher number being largely due to the role of FDI.

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

In the alternative scenario, designed to illustrate the impacts of financial globalization, the allocation of FAC investment is shifted to reflect the share of SACs in global stock market capitalization (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 capitalization, approximately 15% in 1995, rising to over 40% in 2050, and over 60% 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 capitalization 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% in 1995 to 66.7% 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 that 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% to 17% in the immediate term, rising to 50% in 2050 and 66% 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 favorable 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 behavior of SAC portfolio managers are an important aspect of scenario design.

In the Autarchy Scenario, the domestic investment share of SAC pension fund managers is assumed to decline gradually from 99% in 1995 to 90% in 2005, after which it

[10] This is made up of explicit claims, and does not include 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.

remains fixed. The domestic investment share of OIs is assumed to remain constant at 90% throughout the simulation period. These assumptions precisely mirror those made for the FACs.

An alternative scenario where FAC portfolio managers diversify while SAC portfolio managers continue to invest most 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 Globalization Scenario that SAC portfolio managers also begin to diversify internationally, although less aggressively than their FAC counterparts. Whereas FAC portfolio managers are assumed to rationalize 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% in 2005, is assumed to decline linearly by one-half percentage point per year until it equals the SAC region´s share in global stock market capitalization. This occurs at a domestic investment share of approximately 55% 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 capitalization, rising to 60% 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 shares in both stock market capitalization and in world GDP. This target was reached at a domestic market share of 58% in 2070, after which the domestic investment share rose gradually to 66% in 2100. The share of FDI in OI foreign assets was assumed to rise linearly from 50% to 66.7% over the simulation period and the share of FDI earnings reinvested in the host region was set equal to the host region´s share in world GDP. These assumptions are identical to those made in the case of FACs.

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

Baseline (Autarchy) Scenario. In the baseline Autarchy 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% to 6.0% (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% in 1995 to 6.6% 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 aging 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% of FAC GDP in 1995 to 0.8% in 2010-2030, 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

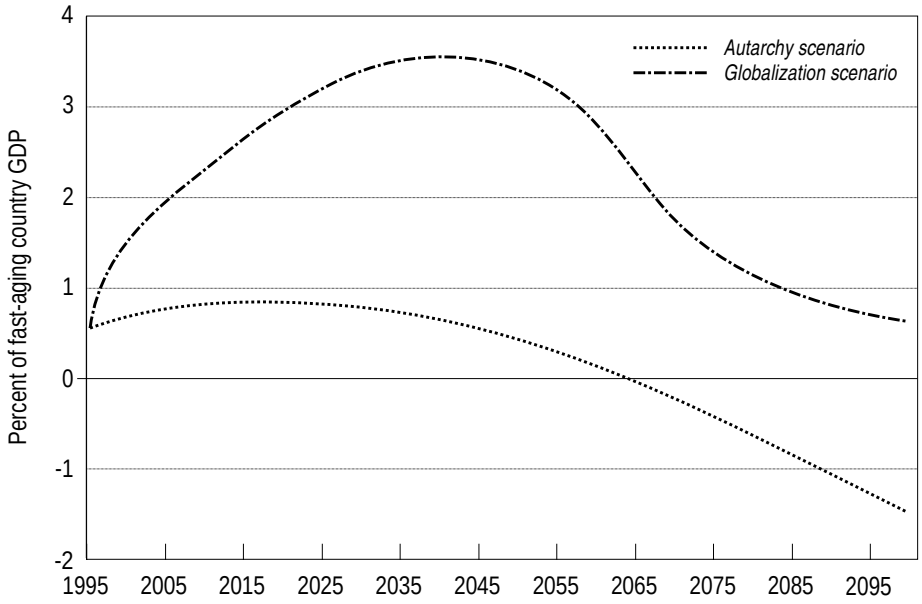
Table 4. Macroeconomic aggregates.

	1995	2010	2020	2030	2040	2050	2100
GDP (1995 US$ per capita)							
Fast-aging countries							
Autarchy	24,939	32,316	37,099	42,340	48,462	55,762	119,845
Globalization	24,939	32,005	36,474	41,383	47,210	54,333	121,337
Difference (%)	0.0	-1.0	-1.7	-2.3	-2.6	-2.6	1.2
Slow-aging countries							
Autarchy	1,554	2,488	3,381	4,581	6,237	8,398	37.950
Globalization	1,554	2,579	3,547	4,817	6,532	8,726	37,751
Difference (%)	0.0	3.7	4.9	5.2	4.7	3.8	-0.5
World							
Autarchy	6,685	8,083	9,112	10,458	12,313	14,695	47,494
Globalization	6,685	8,099	9,144	10,508	12,385	14,788	47,493
Difference (%)	0.0	0.2	0.4	0.5	0.6	0.6	0.0
GNP (1995 US$ per capita)							
Fast-aging countries							
Autarchy	25,013	32,610	37,551	42,934	49,179	56,568	119,595
Globalization	25,013	32,594	37,568	43,079	49,615	57,535	128,669
Difference (%)	0.0	0.0	0.0	0.3	0.9	1.7	7.6
Slow-aging countries							
Autarchy	1,533	2,420	3,288	4,472	6,117	8,275	29,052
Globalization	1,533	2,443	3,324	4,505	6,128	8,235	29,413
Difference (%)	0.0	1.0	1.1	0.7	0.2	-0.5	1.2
Capital-output ratio							
Fast-aging countries							
Autarchy	3.14	3.37	3.62	3.85	4.05	4.23	4.60
Globalization	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
Slow-aging countries							
Autarchy	2.50	2.46	2.50	2.54	2.58	2.64	2.94
Globalization	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							
Fast-aging countries							
Autarchy	8.3	8.7	8.1	7.5	7.0	6.6	6.2
Globalization	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
Slow-aging countries							
Autarchy	9.0	10.6	10.8	10.7	10.6	10.3	9.1
Globalization	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-aging countries							
Autarchy	0.081	0.076	0.070	0.066	0.063	0.060	0.055
Globalization	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
Slow-aging countries							
Autarchy	0.092	0.094	0.092	0.090	0.089	0.087	0.078
Globalization	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 slow-aging countries (billion 1995 US$)							
Private pension system							
Autarchy	9	102	134	160	177	182	-187
Globalization	9	320	492	669	831	957	607
Difference	0	217	358	508	654	775	794
Other institutions							
Autarchy	163	248	281	282	233	126	-1,969
Globalization	163	653	949	1,227	1,431	1,483	310
Difference	0	405	668	945	1,198	1,358	2,279
Total							
Autarchy	172	350	415	442	410	308	-2,156
Globalization	172	972	1,441	1,896	2,262	2,440	917
Difference	0	623	1,026	1,454	1,851	2,132	3,072
Net capital flows, fast- to slow-aging countries (% of fast-aging country GDP)							
Private pension system							
Autarchy	0.0	0.2	0.3	0.3	0.3	0.2	-0.1
Globalization	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							
Autarchy	0.5	0.6	0.6	0.5	0.4	0.2	-1.4
Globalization	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							
Autarchy	0.6	0.8	0.8	0.8	0.6	0.4	-1.5
Globalization	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 (%)							
Fast-aging countries							
Autarchy	2.6	7.7	9.9	10.8	10.3	8.4	-19.2
Globalization	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
Slow-aging countries							
Autarchy	-11.7	-23.0	-22.2	-18.3	-13.4	-8.6	8.0
Globalization	-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 % of total assets)							
Fast-aging countries							
Private pension system							
Autarchy	0.9	4.7	6.4	7.4	8.0	8.4	9.4
Globalization	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							
Autarchy	3.5	6.8	7.9	8.7	9.2	9.6	10.9
Globalization	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
Slow-aging countries							
Private pension system							
Autarchy	0.3	6.8	8.4	9.1	9.5	9.7	9.9
Globalization	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							
Autarchy	3.4	6.2	7.9	8.8	9.3	9.6	10.0
Globalization	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 capitalization (%)							
Fast-aging countries							
Autarchy	85.0	77.6	73.2	68.7	64.1	59.5	39.9
Globalization	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
Slow-aging countries							
Autarchy	15.0	22.4	26.8	31.3	35.9	40.5	60.2
Globalization	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

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



funds peak at $182 billion in mid-century, and flows from OIs peak earlier (2030) at $282 billion.

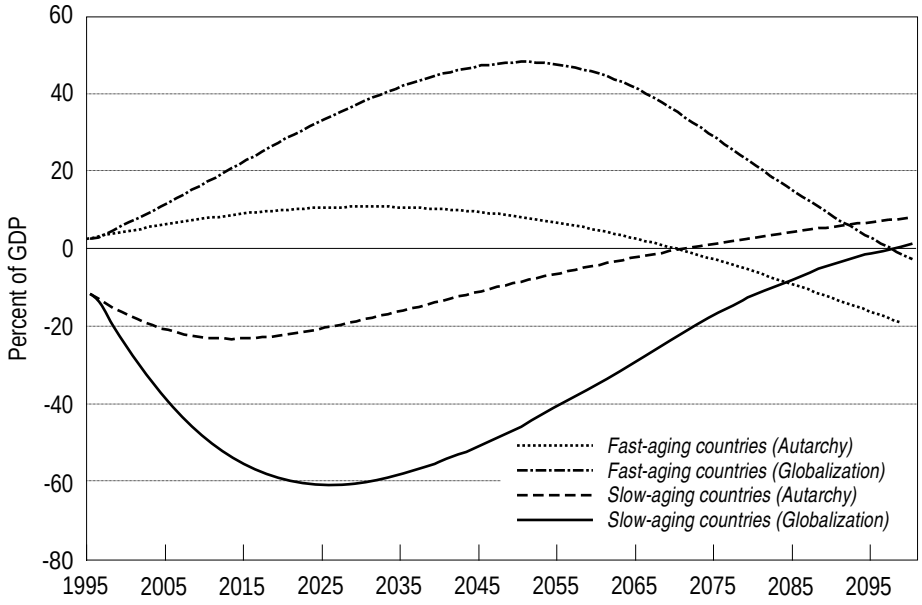
Net foreign assets of FACs peak at 10.8% of GDP in 2030 and turn negative in roughly 2070 (see Table 5 and Figure 2). In the Autarchy Scenario, the share of SAC assets in the portfolio of FAC-based private pension funds rises from 0.9% in 1995 to 8.4% in 2050 and 9.4% at the end of the century. The share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

The pressures of population aging 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 year, outright decline during the period 2010-2030), a period over which the real wage rate grows at a rate of 1.8% 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 (Globalization) Scenario. Neoclassical theory suggests that the greater international integration of capital markets in the Globalization 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 characterized by a 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 globalization, 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 also rise in SACs.

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

Figure 2. Net foreign assets



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

Under the Globalization Scenario, net annual capital flows from FACs to SACs rise steadily from 0.6% of GDP in 1995 to 3.6% in 2040, then recede to 3.4% in 2050 and 0.6% 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 (Taylor, 1997) of the Feldstein-Horioka criterion (i.e., the historically strong association between domestic savings and investment). 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.

Because output and assets grow more rapidly in SACs than in FACs, the long-term evolution of net foreign assets is sensitive to the investment allocation behavior of SAC portfolio managers. Under the assumptions of the Autarchy Scenario, net foreign assets of FACs are projected to peak at 10.8% of FAC GDP in 2030 before diminishing (see Table 5 and Figure 2); under the Globalization Scenario they peak at roughly 50% of GDP in 2050. Under the Autarchy Scenario, the FACs switch from being a net creditor region to a net debtor region in approximately 2070; under the Globalization 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 neoclassical theory (see Table 4). Per capita GDP in the FACs is reduced by 1.0% (vis à vis the Autarchy Scenario) in 2010, with the impact rising steadily to 2.6% by 2040-50. Per capita GDP in SACs increases by 3.7% in 2010, with the impact rising to 5.2% in 2030 and then lessening to 3.8% 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 globalization. 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 Globalization Scenario is estimated to increase GDP per capita for the world as a whole (versus the autarchy case) by 0.2% in 2010, with the impact rising to 0.6% in 2050 and then disappearing entirely by 2100.

Globalization has no impact on per capita GNP in FACs until 2030, when it is estimated to lead to a 0.3% increase vis à vis the Autarchy Scenario. Unlike the case of GDP, the impact steadily rises, to 0.9% in 2040, 1.7% in 2050, and 7.6% in 2100. The explanation for the growing impact lies in the fact that net factor payments reflect cumulative capital flows. Globalization increases per capita GNP in SACs by roughly 1.0% in 2010-2020, after which the impact diminishes. By mid-century, GNP per capita is estimated to be marginally lower in the Globalization Scenario than in the Autarchy Scenario; however, by the end of the simulation period this has reversed itself. Once again, results for the end of the simulation period should be taken with a degree of skeptizism.

Rates of return to capital. As expected, increased investment abroad under the Globalization Scenario causes the rate of return to capital in FACs to rise vis à vis the Autarchy Scenario (see Table 4 and Figure 3). However, the magnitude of this increase (10 basis points in 2010, rising to 30 basis points in 2030-2050) is virtually

insignificant. This attenuates only one-seventh of the aging-induced decline in the rate of return to capital envisioned in the Autarchy 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] However, when the question is posed in terms of the ex post gain to retirement savers, the risk-return picture is more reasonable. Under the Globalization Scenario, annuity income per capita of the 60+ year-old population is increased by 7.1% (as compared to the Autarchy Scenario) in 2010, rising to 12.9% in 2040 before starting to decline (see Table 8).

Both absolutely and proportionally speaking, the decline in SAC rates of return to capital that can be attributed to globalization (70 basis points in 2010, 90 basis points in 2020-2030, returning to 70 basis points in 2050) is much more significant. This is because the capital transfer implied by globalization is greater relative to the SAC capital stock than it is relative to the FAC capital stock. Even under conditions of globalization, the rate of return to capital in SACs is projected to stay well above that in FACs throughout the simulation period. However, the convergence of rates of return attributable to globalization, on the order of 100-120 basis points in 2020-2050, is significant.

Net saving rates. Globalization is estimated to augment the net saving rate in FACs by one-tenth of a percentage point in 2010, rising steadily to seven-thenths of a percentage point by 2050 and continuing to rise into the very long term (see Table 4 and Figure 3). 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 globalization 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, globalization acts to depress savings, mostly through downward pressure on profits.

Distributional impacts. The distributional impacts of globalization are much discussed, but the generational dimension is under-appreciated (see Tables 7, 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-labor ratio, thus reducing the wages of FAC workers, and hence their savings. On the contrary, however, 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

[13] Rates of return implicitly incorporate sovereign and other risk premia. Global financial markets have been characterized 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 (Larrain et al., 1997). If the model were to incorporate a risk premium in SAC rates of return, which would rise in line with net foreign liabilities, the story would change accordingly.

Figure 3. Rate of return to capital

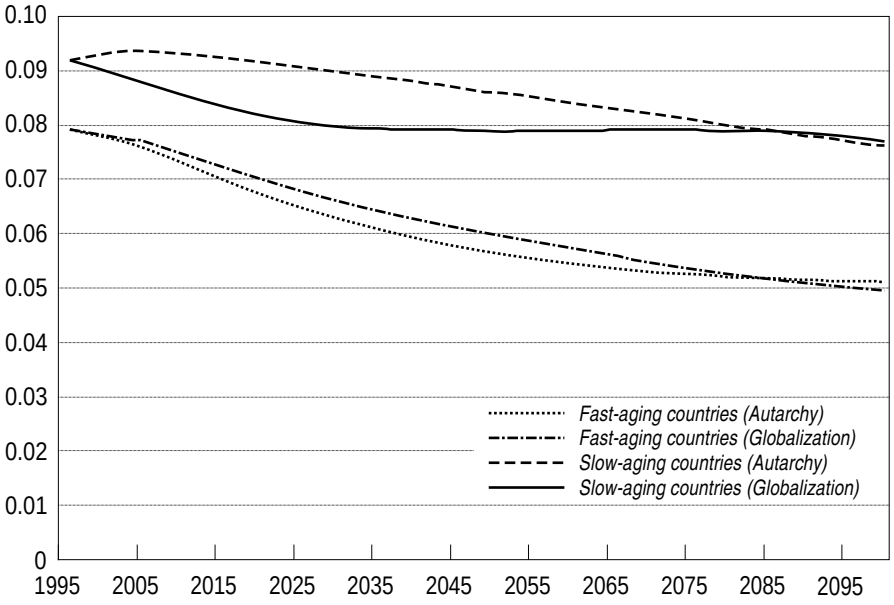


Table 6. Savings, by sector.

	1995	2010	2020	2030	2040	2050	2100
Fast-aging countries							
Total savings (% of GDP)							
Autarchy	8.3	8.7	8.1	7.5	7.0	6.6	6.2
Globalization	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							
Autarchy	5.4	5.2	4.6	4.3	4.0	3.9	4.0
Globalization	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							
Autarchy	3.1	3.9	4.0	4.0	3.9	3.8	3.5
Globalization	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							
Autarchy	-0.2	-0.4	-0.6	-0.8	-0.9	-1.1	-1.3
Globalization	-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
Slow-aging countries							
Total savings (% of GDP)							
Autarchy	9.0	10.6	10.8	10.7	10.6	10.3	9.1
Globalization	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							
Autarchy	5.0	5.2	4.9	4.6	4.5	4.3	3.8
Globalization	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							
Autarchy	2.3	3.8	4.2	4.4	4.5	4.5	4.0
Globalization	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							
Autarchy	1.6	1.7	1.6	1.6	1.5	1.5	1.3
Globalization	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 aged 15-59 years.

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

Table 8. Income, population aged 60+ years.

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

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 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 labor 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 Globalization 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% (vis à vis the Autarchy Scenario) in 2010, 0.4% in 2020-2040 (estimated to be the years of greatest stress on public pension systems); and by 2050, any gain has disappeared.

However, the apparently marginal impact of globalization 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, globalization 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 Autarchy Scenario: 0.6% in 2010, rising to a peak of 1.7% in 2040-2050.

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 Globalization Scenario relative to the Autarchy Scenario) by 2.5% in 2010, rising to 3.8% 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% in 2010, with the impact gradually diminishing but still amounting to 2.5% in 2050. The effect on the working-age population is obvious: more capital per worker translates into a 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 globalization 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.

Conclusion

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

First, capital flows from fast-aging, mostly industrialized countries to slow-aging, mostly developing countries can slightly attenuate, but not reverse, the consequences of

an aging population. Population aging 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 approximately 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% in 1995 to 7.3% in 2050 even under the Globalization Scenario, as opposed to 6.6% under the Autarchy 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%.

Second, our simulation finds that significant distributional effects are likely to arise from the interaction of population aging and financial integration. While increased mobility of capital will hurt the working-age population in FACs, it will benefit much more significantly the working-age population in SACs. Within the elderly population, impacts are likely to differ by 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 that are still dependent on unfunded, payroll tax-financed PAYG pension systems. In other words, globalization benefits elderly lifetime-savers, consisting disproportionately of the well-to-do, but hurts elderly lifetime nonsavers, consisting disproportionately of the poor. One interpretation of this is that globalization increases the urgency of implementing policies that encourage or force poor households to save. Such neoclassical 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 globalization debate, namely the age dimension.

In conclusion, 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 aging.

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Annex 1:The IIASA Multiregional Economic-Demographic Model

While generalizable to the multi-region case, we present the model in terms of two regions: Region 1 corresponds to fast-aging countries (FACs) and Region 2 corresponds to slow-aging countries (SACs). Since model structures in Region 1 and 2 are symmetrical, we present only Region 1. Unless necessary for clarity, the time argument is suppressed. The subscripts 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 (e.g., 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, etc.

Population, labor force, employment, and households

Population is divided into three age groups, 0-14 years, 15-59 years, and 60+ years, 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 labor-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 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 nonresidential (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 that collect dividends and pay out annuities.

These institutions are subdivided into those that comprise the private pension system (PPS) and other institutions (OIs) 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 that 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.[14] 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

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

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

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

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

Because 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 that operates the capital (i.e., to the region in which the capital is installed). Earnings, and net savings therefrom, which

[14] In accounting for the annuitization 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.

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 nonresidential; 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 that results in the following expression:

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

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

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:

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

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, 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:

$$SocSecContWageYPop_1^{15-59} = SocSecContRate_1 \; WageYPop_1^{15-59}$$

$$PPSContWageYPop_1^{15-59} = PPSContRate_1 \, WageYPop_1^{15-59}$$

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 $KPUE^{15\text{-}59}$. The treatment of entrepreneurial income derived from PUEs is identical:

$$EntrYPop_1^{15-59} = r_1 \; KPUE_1^{15-59}$$

$$DispEntrYPop_1^{15-59} = EntrYPop_1^{15-59} - DirTaxEntrYPop_1^{15-59} - SocInsContrEntrYPop_1^{15-59}$$

$$DirTaxEntrYPop_1^{15-59} = DirTaxRate_1 \; EntrYPop_1^{15-59}$$

$$SocInsContEntrYPop_1^{15-59} = SocSecContEntrYPop_1^{15-59} + PPSContEntrYPop_1^{15-59}$$

$$SocSecContEntrYPop_1^{15-59} = SocSecContRate_1 \; EntrYPop_1^{15-59}$$

$$PPSContEntrYPop_1^{15-59} = PPSContRate_1 \; EntrYPop_1^{15-59}$$

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$^{15\text{-}59}$. Imputed rents to residential housing are taxed similar to 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 those aged 15-59 years. This includes the annuity value of the wealth of the 60+ population; in this way, bequests are "annualized":

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

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

Total net savings. Total net savings are equal to the sum over net savings 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, outlay, 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 PAYG 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 aging 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 years of age regardless of labor-force status.

For the same reason, annuitization 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 from that 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 60 derive annuity income from the PPS and OIs, which 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 annuitized 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 savings of the PPS and OIs

The PPS and OIs 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 untaxed. 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´ annuitization 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. However, this would contribute very little to our basic purpose, which is to make explicit the accumulation of assets prior to age 60 and their annuitization after age 60.

Net saving of households

Because 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 savings 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: (i) what proportion of earnings abroad to repatriate (and, the complementary decision, what proportion to reinvest); and (ii) 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, once 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:

$$\text{Re}\, invErngsKOIFDI_{12} = \text{Re}\, InvShareErngsFDI_{12} \; YFirmsKOIFDI_{12}$$

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:

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

where dividends are distributed:

$$DivDist\,\text{Re}\; patrErngsKOIFDI_{12} = DivDistRate_1\; \text{Re}\; patrErngsKOIFDI_{12}$$

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 savings 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 that 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 this 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, i.e.:

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

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 as:

$$NetSvngGov_1 = YGov_1 - GovCons_1 - SocSecBen_1$$

Because 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 nonresidential 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; however, nonresidential investment can take place either at home or abroad. Investment in PUEs is estimated as a share of nonresidential investment (apart from reinvestment of FDI earnings):

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

Total investment minus residential investment minus investment in PUEs equals investment in capital operated by firms; claims on these 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 as 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 sharedown

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:

$$dKPPS_{11} = dKPPS_{1*}\,\varphi_{11}^{PPS}$$

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

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:

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

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

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 as this has already been netted out in calculating saving.

Domestic capital formation also includes investment from Region 2, using the same procedure 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 national disposable income minus consumption:

$$NatNetSvng_1 = NatDispY_1 - \Pr ivCons_1^* - GovCons_1$$

Accounting checks

Two accounting checks are applied to confirm the consistency of the model. The first of these is to prove that net national savings calculated as national disposable income minus consumption is equal to the sum of net savings across sectors. The second is to prove that net national savings equals total acquisition of capital assets, i.e. that the flow of funds is consistent with changes in the balance sheet.

The first may be stated mathematically as

$$NatNetSvng_1 = NatDispY_1 - \Pr ivCons_1 - GovCons_1 = NetSvngYHH_1 + NetSvngYFirms_1 + NetSvngGov_1$$

where $NatDispY_1$ is defined as above. We proceed by building up net savings sector by sector.

<u>Net savings of households</u>

$$NetSvngYHH_1 = NetSvngPop_1^{15-59} + NetSvingPPS_1 + NetSvngO1_1 + NetSvngPop_1^{60+}$$

$$NetSvngPop_1^{15-59} = WageYPop_1^{15-59} - DirTaxWageYPop_1^{15-59} - SocSecContWageYPop_1^{15-59} - PPSContWageYPop_1^{15-59} - ConsWageYPop_1^{15-59} + r_1 KPUE_1^{15-59} - DirTaxEntrY_1^{15-59} - SocSecContEntrY_1^{15-59} - PPSContEntrY_1^{15-59} - ConsEntrYPop_1^{15-59} + r_1 K\,\mathrm{Re}\,s_1^{15-59} - DirTax\,\mathrm{Re}\,ntY_1^{15-59} - Cons\,\mathrm{Re}\,ntYPop_1^{15-59} + TransPop_1^{60+,15-59} - ConsTransPop_1^{60+,15-59}$$

$$NetSvngPPS_1 = PPSContRate_1(WageYPop_1^{*} + EntrYPop_1^{*}) + DivDistYFirmsKPPS_{11} + DivDistYFirmsKPPS_{12} - KPPS_{1*}^{60+}\left[\frac{r_1}{1+r_1-\left[\frac{1}{1+r_1}\right]^{LifeExp60_1}}\right]$$

$$NetSvngOI_1 = DivDistYFirmsKOI_{11} + DivDistYFirmsKOIPort_{12} + DivDist\,\mathrm{Re}\,PatEarngsKOIFDI_{12} + r_1 KPUE_1^{60+} + r_1 K\,\mathrm{Re}\,s_1^{60+} - \left[\frac{r_1}{1+r_1-\left[\frac{1}{1+r_1}\right]^{LifeExp60_1}}\right]\left[KOI_{1*}^{60+} + KPUE_{1*}^{60+} + KRES_{1*}^{60+}\right]$$

Net savings of the population aged over 60 are equal to zero because all unspent income is transferred to the population aged 15-59, however, we will need some terms for cancellations:

$$NetSvngPop_1^{60+} = WageYPop_1^{60+} - DirTaxWageYPop_1^{60+} - SocSecContWageYPop_1^{60+} - PPSContWageYPop_1^{60+} - ConsWageYPop_1^{60+} + \left[\frac{r_1}{1+r_1-\left[\frac{1}{1+r_1}\right]^{LifeExp60_1}}\right]\left[KPPS_{1*}^{60*} + KOI_{1*}^{60+} + KPUE_{1*}^{60+} + KRES_{1*}^{60+}\right] - ConsAnnYPop_1^{60+} + SocSecBen_1 - ConsSocSecBen_1 - TransPop_1^{60+,15-59}$$

Net Savings of firms

$$NetSvngYFirms_1 = NetDomSvngYFirms_1 + NetForSvngYFirms_1$$

$$\begin{aligned} NetDomSvngYFirms_1 = {} & r_1 KPPS^*_{11} - DirTaxYFirmsKPPS_{11} - DivDistYFirmsKPPS_{11} + \\ & r_1 KOI^*_{11} - DirTaxYFirmsKOI_{11} - DivDistYFirmsKOI_{11} + \\ & r_1 KPPS^*_{21} - DirTaxYFirmsKPPS_{21} - DivDistYFirmsKPPS_{21} + \\ & r_1 KOIPort_{21} - DirTaxYFirmsKOIPort_{21} - DivDistYFirmsKOIPort_{21} + \\ & \mathrm{Re}\, patErngsKOIFDI_{12} - DivDist\, \mathrm{Re}\, patErngsKOIFDI_{12} \end{aligned}$$

$$NetForSvngYFirms_1 = r_2 KOIFDI_{12} - DirTaxYFirmsKOIFDI_{12} - \mathrm{Re}\, patErngsKOIFDI_{12}$$

where net foreign savings are simply reinvested earnings on FDI abroad.

Net savings of government

$$NetSvngGov_1 = YGov_1 - GovCons_1 - SocSecBen_1 \quad .$$

$$\begin{aligned} YGov_1 = {} & DirTaxWageYPop^*_1 + DirTaxEntrY^{15-59}_1 + DirTax\,\mathrm{Re}\,ntYPop^{15-59}_1 + \\ & DirTaxYFirms_{11} + DirTaxYFirmsKOIFDI_{21} + IndTax_1 + \\ & SocSecContWageYPop^*_1 + SocSecContEntrYPop^*_1 \end{aligned}$$

$$SocSecBen_1 = SocSecContWageYPop^*_1 + SocSecContEntrYPop^*_1$$

$$DirTaxYFirms_{11} = DirTaxYFirmsKPPS_{*1} + DirTaxYFirmsKOI_{11} + DirTaxYFirmsKOIPort_{21}$$

We add together net savings of households, firms, and government canceling terms across sectors. The major cancellations are (i) receipts and disbursements related to direct taxes and the social security, (ii) current receipts and disbursements related to the private pension system (not counting annuity payments to the retirement-age population), and (iii) receipts and disbursements in the form of annuities received by the retirement-age population. Then:

$$NetSvngYHH_1 + NetSvngYFirms_1 + NetSvngGov_1 =$$
$$WageYPop_1^{15-59} + WageYPop_1^{60+} +$$
$$r_1 KPUE_1^{15-59} + r_1 K\,\mathrm{Re}\,s_1^{15-59} + r_1 KPUE_1^{60+} + r_1 K\,\mathrm{Re}\,s_1^{60+} +$$
$$r_1 KPPS_{11}^{*} + r_1 KOI_{11}^{*} + r_1 KPPS_{21}^{*} + r_1 KOIPort_{21} +$$
$$DivDistYFirmsKPPS_{12} + DivDistYFirmsKOIPort_{12} - DivDistYFirmsKPPS_{21} -$$
$$DivDistYFirmsKOIPort_{21} + r_2 KOIFDI_{12} - DirTaxYFirmsKOIFDI_{12} +$$
$$DirTaxYFirmsKOIFDI_{21} + IndTax_1 - \mathrm{Pr}\,ivCons_1 - GovCons_1$$

r_1 in the expression above is equal to the marginal product of capital net of depreciation and indirect tax:

$$r_1 = \beta_1 \frac{GDP_1}{K_{*1}} - \frac{IndTax_1}{K_{*1}} - \delta_1$$

where

$$K_{*1} = KPPS_{*1} + KOI_{11}^{*} + KOIPort_{21}^{*} + KOIFDI_{21}^{*} + KPUE_1^{*} + K\,\mathrm{Re}\,s_{21}^{*}$$

Since income from $KOIFDI_{21}$ is assigned to firms in Region 2, savings from this income stream do not appear in the lengthy expression above. We rewrite as follows, incorporating the expanded expression for r_1:

$$NetSvngYHH_1 + NetSvngYFirms_1 + NetSvngGov_1 =$$
$$WageYPop_1^{15-59} + WageYPop_1^{60+} +$$
$$\left[\beta_1 \frac{GDP_1}{K_{*1}} - \frac{IndTax_1}{K_{*1}} - \delta_1\right]\left[KPUE_1 + K\,\mathrm{Re}\,s_1 + KPPS_{11} + KOI_{11} + KPPS_{21} + KOIPort_{21}^{*} + KOIFDI_{21}^{*}\right]$$
$$- r_1 KOIFDI_{21} + DivDistYFirmsKPPS_{12} + DivDistYFirmsKOIPort_{12} - DivDistYFirmsKPPS_{21} -$$
$$DivDistYFirmsKOIPort_{21} + r_2 KOIFDI_{12} - DirTaxYFirmsKOIFDI_{12} +$$
$$DirTaxYFirmsKOIFDI_{21} + IndTax_1 - \mathrm{Pr}\,ivCons_1 - GovCons_1$$

Collecting terms,

$$
\begin{aligned}
&NetSvngYHH_1 + NetSvngYFirms_1 + NetSvngGov_1 = \\
&WageYPop_1^{15-59} + WageYPop_1^{60+} + \\
&\beta_1 GDP_1 - \delta_1 K_{*1} - r_1 KOIFDI_{21} + \\
&DivDistYFirmsKPPS_{12} + DivDistYFirmsKOIPort_{12} - DivDistYFirmsKPPS_{21} - \\
&DivDistYFirmsKOIPort_{21} + r_2 KOIFDI_{12} - DirTaxYFirmsKOIFDI_{12} + \\
&DirTaxYFirmsKOIFDI_{21} - \Pr ivCons_1 - GovCons_1
\end{aligned}
$$

Taking the wage bill as the marginal product of labor times employment,

$$
\begin{aligned}
&NetSvngYHH_1 + NetSvngYFirms_1 + NetSvngGov_1 = \\
&(1-\beta_1)\frac{GDP_1}{EMP_1} EMP_1^* + \\
&\beta_1 GDP_1 - \delta_1 K_{*1} - r_1 KOIFDI_{21} + DivDistYFirmsKPPS_{12} + DivDistYFirmsKOIPort_{12} - \\
&DivDistYFirmsKPPS_{21} - DivDistYFirmsKOIPort_{21} + r_2 KOIFDI_{12} - DirTaxYFirmsKOIFDI_{12} + \\
&DirTaxYFirmsKOIFDI_{21} - \Pr ivCons_1 - GovCons_1
\end{aligned}
$$

$\beta_1 GDP_1$ in the second and third lines of the expression cancel out, leaving

$$
\begin{aligned}
&NetSvngYHH_1 + NetSvngYFirms_1 + NetSvngGov_1 = \\
&GDP_1 - \delta_1 K_{*1} - r_1 KOIFDI_{21} + DivDistYFirmsKPPS_{12} + DivDistYFirmsKOIPort_{12} - \\
&DivDistYFirmsKPPS_{21} - DivDistYFirmsKOIPort_{21} + r_2 KOIFDI_{12} - DirTaxYFirmsKOIFDI_{12} + \\
&DirTaxYFirmsKOIFDI_{21} - \Pr ivCons_1 - GovCons_1
\end{aligned}
$$

In order to account for depreciation and indirect taxes related to foreign investment, we break out K_{*1} and rearrange:

$$
\begin{aligned}
&NetSvngYHH_1 + NetSvngYFirms_1 + NetSvngGov_1 = \\
&GDP_1 + DivDistYFirmsKPPS_{12} + DivDistYFirmsKOIPort_{12} + r_2 KOIFDI_{12} - \\
&DirTaxYFirmsKOIFDI_{12} - DivDistYFirmsKPPS_{21} - DivDistYFirmsKOIPort_{21} - \\
&r_1 KOIFDI_{21} + DirTaxYFirmsKOIFDI_{21} - \delta_1 K_{11} - \delta_1 K_{21} - \Pr ivCons_1 - GovCons_1
\end{aligned}
$$

Simultaneously adding and subtracting IndTax_{12} and IndTax_{21}, we obtain

$$
\begin{aligned}
&NetSvngYHH_1 + NetSvngYFirms_1 + NetSvngGov_1 = \\
&GDP_1 + DivDistYFirmsKPPS_{12} + DivDistYFirmsKOIPort_{12} + r_2 KOIFDI_{12} - \\
&DirTaxKOIFDI_{12} + \delta_2 K_{12} + IndTax_{12} - DivDistYFirmsKPPS_{21} - DivDistYFirmsKOIPort_{21} - \\
&r_1 KOIFDI_{21} + DirTaxKOIFDI_{21} - \delta_1 K_{21} - IndTax_{21} - \delta_1 K_{11} - \delta_2 K_{12} + IndTax_{21} - IndTax_{12} \\
&- \text{Pr}\, ivCons_1 - GovCons_1
\end{aligned}
$$

$$
\begin{aligned}
&NetSvngYHH_1 + NetSvngYFirms_1 + NetSvngGov_1 = \\
&GDP_1 + GFP_{21} - GFP_{12} - \delta_1 K_{11} - \delta_2 K_{12} + IndTax_{21} - IndTax_{12} \\
&- \text{Pr}\, ivCons_1 - GovCons_1
\end{aligned}
$$

$$
\begin{aligned}
&NetSvngYHH_1 + NetSvngYFirms_1 + NetSvngGov_1 = \\
&GDP_1 - \delta_1 K_{11} - \delta_2 K_{12} + IndTax_{21} - IndTax_{12} \\
&- \text{Pr}\, ivCons_1 - GovCons_1
\end{aligned}
$$

$$
\begin{aligned}
&NetSvngYHH_1 + NetSvngYFirms_1 + NetSvngGov_1 = \\
&NatDispY_1 - \text{Pr}\, ivCons_1 - GovCons_1
\end{aligned}
$$

where the last line is net national savings.

The second check consists of making sure that net national savings are completely accounted for by acquisition of capital assets. Using the operator d to denote absolute annual change,

$$
\begin{aligned}
NatNetSvng_1 &= dK_{11} + dK_{12} \\
NatNetSvng_2 &= dK_{22} + dK_{21}
\end{aligned}
$$

$$
\begin{aligned}
dK_{11} &= dK\,\text{Re}\, s_1 + dKPUE_1 + dKPPS_{11} + dKOI_{11} \\
dK_{12} &= dKPPS_{12} + dKOI_{12} \\
dK_{21} &= dKPPS_{21} + dKOI_{21}
\end{aligned}
$$

Residential and non-residential investment are calculated as shares of total domestic investment:

$$dKNon\,\mathrm{Re}\,s_{1*} = (1 - \mathrm{Re}\,sInvShare_1)NetDomSvngTot_1 + \mathrm{Re}\,InvErngsKOIFDI_{12}$$
$$dK\,\mathrm{Re}\,s_1 = \mathrm{Re}\,sInvShare_1 NetDomSvngTot_1$$

Re-expressing non-residential investment as the sum across types of investment

$$dKNon\,\mathrm{Re}\,s_{1*} = dKPUE_1 + dKPPS_{11} + dKOI_{11} + dKPPS_{12} + dKOI_{12} =$$

We now substitute these expressions in national net savings:

$$NatNetSvng_1 = dK_{11} + dK_{12} = dK\,\mathrm{Re}\,s_1 + dKPUE_1 + dKPPS_{11} + dKOI_{11} + dKPPS_{12} + dKOI_{12}$$
$$= dK\,\mathrm{Re}\,s_1 + dKNon\,\mathrm{Re}\,s_{1*}$$

$$NatNetSvng_1 = \mathrm{Re}\,sInvShare_1 NetDomSvngTot_1 + (1 - \mathrm{Re}\,sInvShare_1)NetDomSvngTot_1$$
$$+ \mathrm{Re}\,InvErngKOIFDI_{12}$$

$$= NetDomSvngTot_1 + \mathrm{Re}\,InvErngsKOIFDI_{12}$$

$$= NatNetSvng_1$$

Annex 2: The Age Structure of Capital Ownership

Let the age of retirement be denoted R (60 in our model) and assume that it remains constant. If the length of working life (LWL) is also assumed to remain constant, then average age during the working age span (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:

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

Assume that the age distribution of the population in year t is such that the average worker is 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:

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

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. The assets of the average member of the retirement-age population are then:

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

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. As all saving in this individual´s life span occurred at age A_W,

$$k(A_R, t) = 0.5\, k[A_W, t - (A_R - A_W)](1 + r)^{(R - A_W)}$$

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

To continue with this 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

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

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

Because wages grow at rate g,

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

and the expression reduces to

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

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 assumes 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

Parameterization and initialization assumptions were ad hoc, but this should not greatly affect the marginal simulation properties of the model. That is, refining the rough assumptions set forth below probably would not affect our baseline versus alternative scenario conclusions substantively.

Demography and labor markets

Demographic assumptions, taken from the IIASA Central Scenario population projection (Lutz, 1996), have been summarized above. "Fast-aging countries" (FACs) and "slow-aging countries" (SACs) correspond to "industrial" and "developing" countries in the IIASA projection.

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 that underlie the IIASA population projection. Average age above 60 years 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), labor-force participation rates at age 15-59 (both sexes combined) in the two regions were assumed to be 0.75 over the entire simulation period. Labor-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 year in FACs and 2% per year in SACs. Information from various sources led us to initialize the model on 1995 per capita GDP levels of approximately $25,000 and $1,500 in FACS and SACs, respectively.

Social insurance contribution rates

It was assumed in FACs that 3% 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%. In SACs these contribution rates were assumed to be 2.5%. The social security contribution rate was assumed to be 12.5% in FACs and 2.5% 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% of GDP in both regions.

Dividends and reinvestment of earnings on FDI

Firms in both regions were assumed to pay out 15% of pre-tax profits to holders of claims, as well as 15% of repatriated earnings on FDI abroad. Assumptions on the share of FDI earnings reinvested in the host country are 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%. The share of PUEs in total nonresidential investment (excluding reinvestment of earnings on FDI from abroad) was also assumed to be 20%.

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.

Initializing 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 year in FACs and 6% per year in SACs.

In both regions, it was assumed that 1% 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% of K_{*1} and 33% of K_{*2} were assumed to consist of residential capital; similarly, 33% of K_{*1} and 33% 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; 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% of initial-year KOI_{12} and KOI_{21}.