Demographic Changes and the Gains from Globalisation: An Overlapping Generations CGE Analysis

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Abstract

This paper develops a multi-country overlapping-generations general equilibrium model to gauge the economic impacts of demographic changes in the global economy and its transmission effects on different countries. Although severe demographic pressures contribute to significantly lower real GDP per capita across several regions in the world, globalisation through international trade generates an improvement in the terms of trade of older OECD countries, which sustains their real consumption per capita, while globalisation through capital flows stimulates capital deepening and therefore growth in younger countries such as India and various parts of the Rest of the World. The general equilibrium nature of the ageing process is crucial to understand the net foreign asset dynamics of countries during the demographic transition, and this is particularly relevant for a country like China that is caught, in the global economy, between relatively older and younger countries. On this regard China, unlike older countries, does not benefit from a terms of trade improvement which could otherwise sustain its consumption, nor does it benefit, unlike India, from capital deepening, which could otherwise sustain its GDP growth.

JEL Classification: D58, F41, J11

Key words: Demographic transition, ageing, globalisation, overlapping generations, computable general equilibrium modeling

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1. Introduction

According to the United Nations (UN) demographic projections, population ageing will be a defining feature of the economic landscape of major industrialised and emerging countries in the world during the course of the 21st century. Population ageing is typically explained by a combination of factors: declining fertility rates, rising life expectancy, and net migrations. Most OECD countries, albeit at different degrees, have experienced significant declines in fertility rates and increases in life expectancy since the 1960s and 1970s. When we look at non-OECD countries, population growth in China is also slowing and its population will age at a rapid pace over the next decades, while the population in other emerging non-OECD countries, like India is still growing rapidly and their populations remain relatively young. Latin America is also at the beginning stages of a demographic process with a relatively young population.

More specifically, Table 1 provides the assumptions behind the "medium variant scenario" of the UN demographic projections in each region of the world. Over the next 10 years, the total fertility rate (i.e., the number of children per woman in her lifetime) is assumed to average 1.3 in Japan, 1.5 in Europe and Canada, 1.8 in China, 2.0 in the U.S., and 2.3 in India. The UN demographic projections also assume that the total fertility rate in many regions of the world will eventually converge to 1.85 by 2050 although it will remain lower in Japan (1.6) and in Europe (1.76).

Also, according to the data, Japan and Canada enjoy higher life expectancy at birth, followed by the US, Europe, and China. Moreover, the UN demographic projections assume that life expectancy will rise by 5 to 6 years over the next 50 years for these countries. In contrast, India has a much lower life-expectancy at birth, although the UN demographic projections assume that life expectancy in India will rise rapidly over the next decades, from 65 years in 2005-2010 to 75.6 years in 2040-2050. Finally, the projections assume that Canada, Europe, the U.S. and Japan will continue to enjoy net in-migration over the next decades, while India, China and the rest of the world will face net international out-migration.

The ageing process will affect countries in various ways. In fact, both goods and factors (labour and capital) markets will be affected by the demographic changes. For goods and services markets, population ageing is likely to cause sectoral shifts in demand – demand for health services will increase disproportionately while demand for housing services is likely to decline as the rate of household formation slows and the size of households declines, resulting in smaller and fewer houses being constructed. Therefore, the composition of the aggregate basket of consumption is projected to change with feedback effects on the average capital intensity of the economy as the demand shift from high to low capital intensive goods (Guest, 2007), and on job opportunities in all major occupational groups (Fougère, Mercenier and Mérette, 2007; Lührmann, 2005).

Factor markets and factor remunerations will also be affected directly. Labour is projected to become a scarce factor with respect to capital, increasing its relative price (gross wages and social charges) with respect to the rental price of capital (Cutler, Poterba, Sheiner and Summers, 1990). On the other hand, net wages might fall as a consequence of increases in contribution rates required to finance pay-as-you-go (PAYG) pension plans. As capital is projected to become a relatively abundant factor, the price of capital and therefore its rate of return are projected to fall, possibly leading to an asset meltdown after the initial rise in the stock market prices in the 1990s and 2000s often attributed to the size of the baby boom cohort (Poterba, 2001). Another well-know effect is that the ageing of the labour force has an impact on the aggregate labour productivity to the extent that labour productivity of various age groups differs.

Although these well-documented economic effects of ageing are common across most industrialised countries, the extent and timing of ageing across OECD countries, let alone, across developed and developing countries differ substantially. The objective of this paper is to quantify the economic impact of ageing within the perspective of an overall ageing world, when globalisation is intensifying international trade and capital flows. For this, we have developed a multi-country computable general equilibrium model. The model represents four regions of the world: North-America, Europe, Asia, and the rest of the world (ROW). Most European countries are aggregated into one region. North-America is disaggregated into both the USA and Canada to distinguish the ageing and globalisation impact on a relatively close versus an open economy.

Asia is disaggregated into three countries: Japan, as it represents a developed country with an already aged population, and China and India as they are emergent countries with very different demographic projections. All remaining countries form the ROW, which is aggregated into one region to close the model. The model also has an overlapping generations structure based on Samuelson (1958), Diamond (1965) and Auerbach and Kotlikoff (1987). Each region produces one single good which is an imperfect substitute to the good produced in any other region (the Armington assumption). Consumers in each region consume a basket of all the imperfectly substitute goods produced in all regions of the world. In this paper we restrict our analysis to endogenous capital flows, assuming immobility of labour between countries. In further developments of the model we plan to introduce endogenous migration flows between countries, and endogenous labour supply decisions -- as introduced in Fougère, Harvey, Mercenier, and Mérette (2009) for Canada as a closed economy -- into our multi-country model. In the following, we provide a selective review of the literature and also highlight key differences between our model and the existing literature.

There is a rich and abundant literature of country-specific studies examining the macroeconomic and fiscal implications of population ageing. However, country-specific analyses usually neglect the aspects of globalization. Ignoring the rest of the world can be misleading in terms of implications for growth in living standards, labour market flows, and international capital flows, for a number of reasons. First, globalization and the rise of a huge, but relatively unskilled labour force in China and India may have significant implications for incomes in North America and Europe. For example, based on the Heckscher-Ohlin model and the factor price equalisation theorem, it has often been argued that trade with China may be one of the factor contributing to the tendency for a distributional shift in rich countries against unskilled workers in favour of the higher skilled, even in the context of immobility of labour across countries. While much of the initial research suggested that trade has played only a small role in raising inequality -- as skill-using and unskilled-labour-saving technological change would have the same effect -- more recent work focusing on the role of imported intermediate inputs has generated larger estimates of the negative impact of trade on unskilled wages in rich countries (Feenstra, 2000, and Feenstra and Hanson, 2004).

Second, country-by-country demographic analysis might lead to the conclusion that greater immigration is a valuable option to offset declining fertility rates. This may not be true in a global context, where immigration is a zero-sum game. For example, while Canada may think of itself as a 'small open economy' for immigration purposes, and thus able in theory to import as many immigrants as it wants, (see Fougère, Harvey, Mérette, and Poitras, 2005), this is simply not true of the OECD as a whole. In particular, international competition for skilled workers is becoming a more important issue, and it can only be examined in a global context, preferably with endogenous labour flows.

Finally, there is empirical evidence that demographic changes induce international capital flows. According to Higgins (1998), the demographic "center of gravity" for investment demand should be earlier in the age distribution than that for the savings supply. Thus, regions that have a higher proportion of their population in the high savings years (45-60 years old) should, other things equal, tend to export their excess savings and thus run a current account surplus. Using simulated multi-regions overlapping generations models, Börsch-Supan, Ludwig, and Winter (2001, 2003, 2004, 2006), Krueger and Ludwig (2007), Fehr, Jokisch and Kotlikoff (2004, 2005), Équipe Ingénue/Ingenue Team (2001a, 2001b, 2007) and Feroli (2003, 2006), have shown that population ageing will indeed induce capital flows between countries.

Börsch-Supan et al. (2001) argue that the difference in the pace and magnitude of demographic changes across countries may influence international capital flow movement between faster and slower ageing regions of the world. In such a case, the international capital market would be able to offer better returns to savings and partly accommodate faster ageing countries. They also argue, as does Équipe Ingénue (2001b), that closed-economy models of public pension reforms are likely to miss important effects due to international capital mobility. Feroli (2006) finds that demographic factors alone can do a good job of accounting for the timing (but not the magnitude) of the American and Japanese net foreign asset position, though his model does not do as well for Europe.

Feroli (2006), Fehr, Jokisch and Kotlikoff (2004), and Krueger and Ludwig (2007) typically assume that capital mobility is restricted to the OECD countries. As argued by Feroli, one reason for doing this is that the relatively small capital flows between the developing and developed worlds suggest that there exist significant capital market imperfections and capital controls. Furthermore, the political risk hypothesis that Lucas (1990) conjectured might prevent massive amounts of capital from flowing to poor countries from rich countries. On the other hand, Börsch-Supan et al. (2004, 2006) introduce different scenarios of perfect capital mobility, either within the three largest economies in continental Europe (France, Germany, and Italy), within the European Union, within the OECD countries, or across the entire world. In this last case, the non-OECD countries are modeled as an aggregate region representing the rest of the world. Given the increased trade and capital integration of China and India into the world economy, it might nevertheless be useful to specifically model these two countries, as we do in our analysis. Furthermore, although the political risk hypothesis of Lucas (1990) is well taken, the long-term trend of globalisation suggests that a prospective analysis of the impact of ageing in a world of capital mobility between OECD and non-OECD countries is far from being irrelevant and might, as we will see, shed a new light on issues related to Chinese aggregate savings and investment. For example, Fehr, Jokisch and Kotlikoff (2005) find that adding China into the framework of their earlier paper (2004) might dramatically alter the simulated results because its saving behaviour, growth rate, and fiscal policy are very different from the rest of the world. They argue that although its population is ageing at a rapid pace, China could become the world's saver over the next decades.[1] Also, rather than seeing real wages falling (as in their previous study) in developed countries because of a major capital shortage and tax hikes needed to pay for social security benefits, their simulations show real wages increasing over and above those associated with technical progress.

Introducing a more detailed developing world in such models also matters because of possible feedbacks from the ageing developed world into the developing world. Kenc and Sayan (1998) argue that international commodity and capital flows provide channels for the transmission of changes in terms of trade and interest rates coming from large countries that experience population ageing onto small countries. Using a two-region CGE model with overlapping generations parameterized for Turkey and the European Union (EU), they show that the economic effects of population ageing in the EU will magnify the effects in Turkey even if its population is relatively younger. Using a similar two-country modeling framework, Sayan and

[1] It is now well-known that China is the most important buyer of U.S. Treasury Bonds in the 2009 economic and financial crisis.

Uyar (2002) find that when labour is mobile across countries, wage differentials provide incentives for workers in the country with the relatively younger population to migrate to the country that experiences population ageing.

Although North America is included in many of the multi-country studies cited above, Canada is expected to age faster than the USA, and very little work has been done so far to analyse the Canadian long-term economic and labour market implications of ageing in the context of globalization. Fougère and Mérette (1998, 2000) have examined the impact of population ageing on the economic growth and the current account for both Canada and five other OECD countries, assuming that these countries are small open economies and that interest rate movements in the world market are determined by demographic changes that occur in the U.S. economy. However, they ignore the fact that these countries as a group influence international capital markets. They also ignore the contribution of emerging countries, like China and India, who play an increasingly influential role in international markets. Finally, their analysis does not account for other economic interactions across countries, such as international trade.

The multi-country OLG literature reviewed above does not truly model international trade. Typically, these models feature a one-good world. All countries produce the same perfectly substitutable good so that, although the investment-saving balance will lead to current account deficits or surpluses, the only transaction with other countries takes place in the form of physical capital investment. Other traded goods flowing between countries are not modeled. One objective of this paper is to formally introduce trade in goods between countries by using the Argminton assumption of imperfectly substitutable goods. Each region in our model produces one single good which is an imperfect substitute to the good produced in any other regions. Therefore, households in each region consume a basket of all the imperfectly substitute goods produced in all regions of the world. From this perspective, this makes our paper closer to the analysis of Batini, Callen and McKibbin (2006) as they claim that the full (non-documented) version of their model includes this feature. For the purpose of this study, we aggregated all sectors of the GTAP6 database into one single (imperfectly substitutable) good for each country. However the code of the model is written more generally to allow for a sectoral decomposition and multi sectoral production in each country.

The rest of the paper is divided as follows. Section 2 describes the model in some details. Section 3 presents the simulation results and Section 4 concludes and gives possible extensions for future research.

2. The Model

The OLG model that we have built to analyse demographic change in a context of globalisation is composed of seven regions that make up the world economy: Canada, the United States, Japan, the European Union, China, India and the rest of the world (ROW). In the following we describe some aspects of the production sector in each country, the household sector, the PAYG pensions systems, the government sector, and the trade in goods between countries. We also describe the demographic process which is superimposed on the OLG model and which provides the exogenous shock or driving force behind the simulations results, and discuss some aspects of the calibration of the model. A more technical description of the model and calibration is given in Georges and Mérette (2007).

2.1 Production Sector

In each region *j*, a representative firm produces at time *t* a single good using a Cobb-Douglas technology. The firm hires labour and rents physical capital. Both factors are region specific. With *Q* representing output, *Kdem* physical capital, *Ldem* effective units of labour, *ScCoQ* a scaling factor and *AlK* the share of physical capital in value added, a region specific production function is:

(1) $$Q_{j,t} = ScCoQ_{j,t}\left(Kdem_{j,t}\right)^{AlK_j}\left(Ldem_{j,t}\right)^{1-AlK_j}$$

Firms are assumed to be perfectly competitive and factor demands follow from profit maximization:

(2) $$\frac{Rent_{j,t}}{PQ_{j,t}} = AlK_j ScCoQ_{j,t}\left(\frac{Kdem_{j,t}}{Ldem_{j,t}}\right)^{AlK_j-1}$$

(3) $$\frac{WLdem_{j,t}}{PQ_{j,t}} = (1 - AlK_j) ScCoQ_{j,t} \left(\frac{Kdem_{j,t}}{Ldem_{j,t}} \right)^{AlK_j}$$

where *Rent* and *WLdem* are the rental rates of capital and wages, and *PQ* is the output price.

Labour is distinguished by two skill levels, high-skilled and low-skilled workers, denoted by the binary index of skills *qual*. Therefore, firms also disaggregate their demand for labour $Ldem_{j,t}$ into a demand for skills based on a constant-elasticity-of-substitution (CES) function:

(4) $$LdemQ_{j,qual,t} = \left(AlLdemQ_{j,qual} \right)^{SigLdem_j} \left[\frac{WLdem_{j,t}}{wage_{j,qual,t}} \right]^{SigLdem_j} Ldem_{j,t}$$

where $wage_{j,qual}$ is the regional market wage rate for a specific type of skills, and $AlLdemQ_{j,qual}$ and $SigLdem_j$ are respectively share of skill levels and substitution elasticity parameters. It follows from optimization that the *composite* wage rate *WLdem* of the firm's aggregate labour input is related to market wages $wage_{j,qual,t}$ by the following expression:

(5) $$WLdem_{j,t} = \left\{ \sum_{qual} \left(AlLdemQ_{j,qual} \right)^{SigLdem_j} \left[wage_{j,qual,t} \right]^{1-SigLdem_j} \right\}^{\frac{1}{(1-SigLdem_j)}}$$

2.2 Household Behaviour and Pension Plan

Each region of the world is represented by 7 representative households in an Allais-Samuelson overlapping generations structure. Individuals enter the labour market at the age of 15, retire (in average) at age 65 and die at the end of their 84^{th} year. We classify generations into seven age groups {*g*, *g*+1, *g*+2,…, *g*+6}, (*i.e.*, 15-24, 25-34, …75-84 age groups). Younger children are fully dependent on their parents and play no active role in the model. Variations across countries, in particular about the age of retirement, are taken into account in the model. However, in the following, we only describe the household behaviour in an unspecified country *j*.

A household's optimization problem in country *j* consists of choosing a profile of consumption over the life cycle, in order to maximize a CES type inter-temporal utility function of consumption, subject to discounted lifetime income. Inter-temporal preferences of an individual born at time *t* are as follows:

$$U_j = \frac{1}{1-\gamma} \sum_{k=0}^{6} \left\{ \left[\frac{1}{1+\psi_j} \right]^{k+1} \left((Con_{j,t+k,g+k})^{1-\gamma} \right) \right\} \qquad (6)$$

with $0 < \gamma < 1$. *Con* denotes consumption; ψ is the pure rate of time preference and γ is the inverse of the constant inter-temporal elasticity of substitution. Each period in the model effectively corresponds to 10 years and a unit increment in the index *k* represents both the next period and, for this individual, a shift to the next age group ($g+k$). The household is not altruist, that is, it does not leave bequests to its children in this simple framework.

The dynamic budget constraint of the regional household is given by:

$$\begin{aligned} \underbrace{Lend_{j,t+1,g+1} - Lend_{j,t,g}}_{\text{Asset accumulation during period t}} = & \\ & \underbrace{\sum_{qual} \left(1 - WTxR_{j,qual,t} - CTR_t\right) Y^L_{j,qual,t,g}}_{\text{Net Labour Income}} \\ & + \underbrace{\left(1 - KTxR_{j,t}\right) ret_{j,t} Lend_{j,t,g}}_{\text{Net Capital Income}} \\ & \underbrace{- \left(1 + ConTxR_{j,t}\right) \underbrace{PCon_{j,t,g} Con_{j,t,g}}_{\text{Net Consumption Spending}}}_{\text{Gross Consumption Spending}} + \underbrace{Pens_{j,t,g}}_{\text{Pension}} \end{aligned} \qquad (7)$$

where *ret* is the rate of return on physical assets (defined later on in equation (20) in relation to the rental price of capital, *Rent*), *WTxR* the effective tax rate on labour*, KTxR* the effective tax rate on capital, *ConTxR*, the consumption tax rate, *CTR* the contribution to the public pension system, *PCon* the consumption price index, and *Pens*, the pension benefit (accruing only to a retired household). An assumption which is made here is that the representative household is a *composite* of different types of labour skills (and hence the summation over the skills index *qual*). Labour income is defined as:

$$Y^L_{j,qual,t,g} = wage_{j,qual,t} EP_{j,qual,g} LS_{j,qual,g} \qquad (8)$$

where LS_{qual} is the exogenous supply of a specific type of skills. We assume that skills dependent labour income is a function of the individual's age-dependent productivity (earnings) profile ($EP_{j,qual,g}$) itself defined as a quadratic function of age g:

(9) $$EP_{j,qual,g} = \omega_{qual} + (\xi_{qual})g - (\phi_{qual})g^2, \qquad \omega, \xi, \phi \geq 0$$

with parametric values chosen to ensure that the maximum is reached between mid-life and retirement.

Retirees' pension benefits are proportional to their lifetime labour earnings. The fraction is defined by the pension replacement rate *PensR*. For example, pension benefits received in the sixth period of live (the first period of retirement in our model) is equal to an average of the labour incomes received in all previous periods:

(10) $$Pens_{j,t+5,g+5} = PensR_{j,g}\left[\frac{1}{5}\sum_{k=0}^{4}\sum_{qual} Y^{L}_{j,qual,t+k,g+k}\right]$$

Pay-as-you-go pension benefits are financed by contribution rates on labour income. The pension regime is represented by the following equation:

(11) $$\sum_{gm} Pop_{j,t,gm} Pens_{j,t,gm} = CTR_{j,t} \sum_{gi} Pop_{j,t,gi} \sum_{qual} Y^{L}_{j,qual,t,gi}$$

where gi are the working-age generations ($g+k$, k=0,…4), and gm are the retired generations ($g+k$, k=5,6) and where *CTR* is the endogenous regional contribution rate for the defined-benefit pay-as-you-go program. Recall that there are 7 generations in each country, living together at a point in time, each of them being characterized by one representative household. However, for aggregate variables, we must take into account the population *size* of working-age and retired cohorts $Pop_{j,t,gi}$ and $Pop_{j,t,gm}$, that are exogenously given by demographic laws of motion described later on (equation 31).

Rewriting the dynamic budget constraint as a life-time constraint and differentiating the household utility function yields the following first-order Euler condition for consumption:

(12) $$\frac{Con_{j,t+1,g+1}}{Con_{j,t,g}} = \left[\frac{\left[1+\left(1-KTxR_{j,t+1}\right)ret_{j,t+1}\right]}{(1+\psi_j)} \frac{PCon_{j,t,g}(1+ConTxR_{j,t})}{PCon_{j,t+1,g+1}(1+ConTxR_{j,t+1})} \right]^{\frac{1}{\gamma}}$$

In the next (intra-temporal) optimization step, households of each generation must allocate their consumption expenditures across the available seven imperfectly substitutable regional final goods using CES sub-utilities. Hence, using first order conditions, household-*g* of region-*j*'s consumption demand for a region-*i* good is:

(13) $$ConI_{i,j,t,g} = ALCI_{i,j}^{SigC_j} \left(\frac{PCon_{j,t}}{PQ_{i,t}} \right)^{SigC_j} Con_{j,t,g}$$

where $ALCI_{i,j}$ and $SigC_j$ are respectively country-*i* share of consumption demand and Armington substitution elasticities. The composite consumption price index is consistently defined as a non-linear weighted average of regional prices:

(14) $$PCon_{j,t} = \left[\sum_i ALCI_{i,j}^{SigC_j} \left(PQ_{i,t}\right)^{(1-SigC_j)} \right]^{\frac{1}{1-SigC_j}}$$

2.3 Investment and Asset Returns

The accumulation of each region's capital stock, *Kstock* is subject to depreciation:

(15) $$Kstock_{j,t+1} = Inv_{j,t} + (1-\delta_j)Kstock_{j,t}$$

where *Inv* represents investment and δ the depreciation rate of capital. The investment technology is characterized by a CES function that also combines goods from the seven different regions; the optimal mix implies that region *i*'s goods are demanded by region *j* for investment purposes in the following amounts:

(16) $$InvI_{i,j,t} = ALII_{i,j}^{SigI_j} \left(\frac{PInv_{j,t}}{PQ_{i,t}} \right)^{SigI_j} Inv_{j,t}$$

where $ALII_{i,j}$ and $SigI_j$ represent share of investment demand and Armington substitution elasticity parameters, and *PInv* is the composite price of the investment good, defined (as a result of optimization) as:

$$(17) \qquad PInv_{j,t} = \left[\sum_i ALII_{i,j}{}^{SigI_j} \left(PQ_{i,t}\right)^{(1-SigI_j)} \right]^{\frac{1}{1-SigI_j}}$$

Physical and financial assets are perfectly substitutable. Furthermore, financial capital is perfectly mobile across countries and undifferentiated so that interest rate parity holds. The expected (*ex ante*) rate of return of physical capital purchased at time *t*-1 and rented to firms throughout period *t* is made up of three components: rental price of capital, expected capital gains, and depreciation cost:

$$(18) \qquad ret_{j,t} = \underbrace{\frac{Rent_{j,t}}{PInv_{j,t-1}}}_{\substack{\text{rental price of capital} \\ \text{in terms of the investment good}}} + \underbrace{\frac{PInv_{j,t} - PInv_{j,t-1}}{PInv_{j,t-1}}}_{\text{expected capital gains}} - \underbrace{\frac{\delta_j PInv_{j,t}}{PInv_{j,t-1}}}_{\text{Depreciation cost}}$$

The government and its deficit-financing policy will be introduced in next sub section. Here, let us mention that the expected rate of return on a government bond issued at end of *t*-1 and held throughout period *t* is made up of two components, the promised (coupon) rate of return and the expected capital gains:

$$(19) \qquad \underbrace{ri_{j,t-1}}_{\substack{\text{coupon rate of return on bonds} \\ \text{promised by the government}}} + \underbrace{\frac{PGov_{j,t} - PGov_{j,t-1}}{PGov_{j,t-1}}}_{\text{expected capital gains}}$$

where *ri* and *PGov* are respectively the rate of interest promised on, and the price of, bonds issued by a region's government. In the model, perfect substitutability between physical assets and governments bonds implies that *ex ante* rate of returns (expected as of time *t*-1 for period *t*), on both type of assets, although not necessarily *ex post* rates, must be equalised:

$$(20) \qquad ret_{j,t} = ri_{j,t-1} + \frac{PGov_{j,t} - PGov_{j,t-1}}{PGov_{j,t-1}}$$

Furthermore, with perfect capital mobility across countries, rates of returns on governments bonds of all countries are equalized *ex ante*, leading to a unique world interest rate, *r*int, expected at the end of time *t*-1 for period *t*:

(21) $$r\,\text{int}_t = ri_{j,t-1} + \frac{PGov_{j,t} - PGov_{j,t-1}}{PGov_{j,t-1}} \qquad \text{for all country } j\,.$$

Finally, because physical capital has the same *ex ante* return than financial capital, we have that:

(22) $$ret_{j,t} = r\,\text{int}_t$$

2.4 Government Sector

For each region, the government budget constraint is defined as:

(23) $$\underbrace{PGov_{j,t}Bond_{j,t+1} - PGov_{j,t-1}Bond_{j,t}}_{\text{Debt accumulation (if rhs}>0\text{) or decumulation (if rhs}<0\text{) over period }t} = PGov_{j,t}Gov_{j,t} + \left(ri_{j,t-1} + \frac{PGov_{j,t} - PGov_{j,t-1}}{PGov_{j,t-1}}\right)PGov_{j,t-1}Bond_{j,t} - \sum_g POP_{j,t,g}\left\{\begin{aligned}&\sum_{qual} WTxR_{j,qual,t}\left(Y^L_{j,qual,t,g}\right)\\ &+ ConTxR_{j,t}\left(Pcon_{j,t,g}Con_{j,t,g}\right) + KTxR_{j,t}\left(ret_{j,t}Lend_{j,t,g}\right)\end{aligned}\right\}$$

where, *Gov* is public expenditures and *Lend* is the stock of wealth accumulated by households. The left hand side of the equation shows the change in the stock of public debt (public dissaving if positive term) from one period to the next. The right hand side shows public expenditure, debt services (including the refinancing of the entire stock of (one-period) debt at current bond prices), and tax revenues from different sources. Note that the size of each cohort must be taken into account when computing total tax revenues generated by the government in a specific period of time. Each period the government sets the tax rate on labour income *WTxR*, in order to maintain a constant public debt-to-GDP ratio. In this simple model, we also assume that real government spending per capita is kept constant.

The government, just like the household, will purchase goods from all regions *i* according to:

(24) $$GovI_{i,j,t} = ALGI_{i,j}{}^{SigG_j}\left(\frac{PGov_{j,t}}{PQ_{i,t}}\right)^{SigG_j} Gov_{j,t}$$

where $ALGI_{i,j}$ and $SigG_j$ are respectively the share of government consumption demand and Armington substitution elasticities. The composite price index is consistently defined as a non-linear weighted average of regional prices:

(25) $$PGov_{j,t} = \left[\sum_i ALGI_{i,j}{}^{SigG_j} \left(PQ_{i,t} \right)^{(1-SigG_j)} \right]^{\frac{1}{1-SigG_j}}$$

2.5 Market and Aggregation Conditions

The model assumes that all markets are perfectly competitive. The equilibrium condition for the goods market is that each regional output must be equal to total demand E originating from all countries i:

(26) $$Q_{j,t} = \sum_i E_{j,i,t} = \sum_i \left[\left(\sum_g Pop_{i,t,g} ConI_{j,i,t,g} \right) + InvI_{j,i,t} + GovI_{j,i,t} \right].$$

Labour and physical capital are immobile across regions, so a market exists for these two production factors in each region. The demand for labour of a specific skill is equal to the supply of this skill:

(27) $$LdemQ_{j,qual,t} = \sum_{gi} Pop_{j,t,g} LS_{j,qual,gi} EP_{j,qual,gi}$$

and the stock of capital accumulated at a point in time in period t in country j is equal to the demand expressed by firms:

(28) $$Kstock_{j,t} = Kdem_{j,t}$$

The current account of country j is the difference between national savings (private savings of all generations and public savings) and domestic investment:

$$CA_{j,t} = \underbrace{\left(\sum_g Pop_{j,t+1,g} Lend_{j,t+1,g} - \sum_g Pop_{j,t,g} Lend_{j,t,g} \right)}_{\text{Private Saving}} \tag{29}$$
$$- \underbrace{\left(PGov_{j,t}\, Bond_{j,t+1} - PGov_{j,t-1}\, Bond_{j,t} \right)}_{\text{Public Dissaving}} - \underbrace{\left(PInv_{j,t}\, Kstock_{j,t+1} - PInv_{j,t-1}\, Kstock_{j,t} \right)}_{\text{Domestic Investment}}$$

Alternatively, the current account is either given as the trade balance plus the interest revenues from net foreign asset holdings, or as the difference between nominal GNP (GDP including interest revenues on net foreign assets) and domestic absorption.[2]

Finally, the world capital market must be in equilibrium, that is, the world stock of wealth (*Lend*) accumulated at end of period *t* must be equal to the value of the world stock of government bonds at end of *t* and the world stock of capital at end of *t* :

$$\sum_i \sum_g Pop_{i,t+1,g} Lend_{i,t+1,g} = \sum_i PGov_{i,t} Bond_{i,t+1} + \sum_i PInv_{i,t} Kstock_{i,t+1} \tag{30}$$

2.6 Demography, Data, and Calibration

Detailed demographic projections of the UN are the exogenous forcing process of our OLG simulation model. In other words, demographic factors such as fertility rates, life expectancy and net migrations are exogenous to the model, a simplifying assumption given that these factors are typically endogenous to economic growth in the long run.

In each country *j*, the size of population of generation (or age group) *g*+*k* in period *t* is given by two laws of motion:

$$Pop_{j,t,g+k} = \begin{cases} Pop_{j,t-1,g+k} NN_{j,t-1} & \text{for } k = 0 \\ Pop_{j,t-1,g+k-1} \left(s_{j,t-1,g+k-1} + nm_{j,t-1,g+k-1} \right) & \text{for } k \in \{1,...7\} \end{cases} \tag{31}$$

The first law of motion simply says that the number of young adults (of age group $g+k = g$) at time *t* is equal to the size of their parents' generation times the (country-specific) per-capita number of children (*NN*) that this generation had in period *t*-1. Roughly speaking, if in average

[2] All three alternative formulations have been coded as an internal check.

any couple have two children, the number of children per capita is $NN = 1$ and the size of the young generation g at time t is equal to the size of their parent generation. The second law of motion gives the size of any age group ($g+k$) besides the very first generation g, as a function of the age specific conditional survival rate $s_{j,t-1,g+k-1}$ ($0 \leq s_{j,t-1,g+k-1} \leq 1$) and the net migration ratio nm ($nm \geq 0$). In this model, we have assumed that $s_{j,t-1,g+k-1}$ =1 for k=1 to 6, and $s_{j,t-1,g+k-1}$ =0 for k=7, which means that the probability of dying is zero as long as k is less or equal to 6 and is 1 for $k > 6$ (*i.e.*, age group g+7 does not exist). Furthermore, the parameter nm is assumed equal to zero (no migration flows).

We superimpose the above laws of motion of population into our multi-country OLG model and calibrate for the parameter $NN_{j,t}$ in order to generate a baseline old-age dependency ratio consistent with the UN medium variant demographic projections, which are available for the period 1980 to 2050. Chart 1 illustrates the magnitude of the demographic shock by giving the simulated elderly dependency ratio (population 65+ as a ratio of the population 15-64) by regions of the world, over the period 1980 to 2070. Of course, the demographic assumptions behind Table 1 are the main factors driving the simulation results.[3] As can be seen, Japan is by far the fastest ageing country, with the elderly dependency ratio rising from 25% in 1990 to 70% by 2040. The European Union (EU) has the second highest elderly dependency ratio, followed by Canada, although the *change* between 1990 and 2040 is similar to Canada. The elderly dependency ratio is expected to rise from 25% in 1990 to about 50% in 2040 in the EU, compared to a rise from 18% to 43% for Canada. In contrast, the U.S. has a more moderate increase in the elderly dependency ratio, which is projected to move from 20% in 1990 to 32% in 2040 in part because the US has a much higher total fertility rate than in most industrialised countries.

The Chinese elderly dependency ratio follows a quite different pattern than in the other regions of the world. In 1990, China had one of the lowest elderly dependency ratio (about 10%) after India and other non-OECD countries. However, the drastic fall in the fertility rate combined with net out-migration will lead to a sharp increase in the elderly dependency ratio over the next

[3] We only have one parameter *NN*, to fit UN population projections that depend on diverse assumptions on fertility rates, survival rates and net migration flows. This implies that our calibrated *NN* has no direct demographic interpretation and should not be strictly interpreted as fertility rates -- the values for *NN* will reflect fertility rates, survival rates and migration flows.

several decades, reaching 30% in 2040 and continuing to rise. Finally, India and the rest of the world have relatively younger populations. Therefore, their elderly dependency ratio is expected to rise more modestly from 10% in 1990 to less than 20% in 2040.

Other calibration parameters are summarized in Table 5.1. The wage income tax rates, capital income tax rates and consumption tax rates for Canada, US, EU and Japan are directly based on Carey and Rabesona (2002), while the pension benefit rates are taken from OECD (2005). However, for China, India and ROW, it is extremely difficult to set these rates with precision since there is little reliable data available. In this paper, we assume lower pension benefit rates for them compared to the developed regions.

Considering that the tax collecting system and social security programs of India may not be as advanced as in developed regions, we have set relatively lower tax rates and pension benefit rate compared to other regions. Correspondingly, it is also reasonable to set moderate tax rates for ROW. Moreover, because of the heavy presence of state-owned enterprises in China's economic structure, its wage and capital income tax rates are assumed to be relatively higher compared to other economies in order to incorporate the crowding out effects. Meanwhile, the consumption tax rate of China is set to be lower to ensure that its overall tax levels are consistent with other regions.

According to the definition of economically active population, we assume workers retire at age 65 with the exception of workers in EU and Japan who are assumed to retire at age 60 and 70 respectively, reflecting their different working culture. The intertemporal elasticity of substitution ($1/\gamma$) is set to 1.5 for all countries, which is in the standard range of 1-4. The (10-year) rate of time preference is solved endogenously in the calibration procedure in order to generate realistic country specific consumption profiles and capital ownership profiles *per age group* for which no data are easily available.[4] A higher rate of time preference reflects a bias towards current versus future consumption and the values generated endogenously are consistent with the priors that, say, Indians are more patient than Americans or Japanese. The Armington

[4] The rate of time preference and the intertemporal elasticity of substitution determine together the slope of the consumption profiles *across age groups* in the calibration of the model (where population is assumed stable) and this is also the slope of the consumption profile of an individual *across his lifetime* in the simulated model in absence of demographic shocks.

elasticity of substitutions between goods of different countries are set uniformly equal to 2.5 across countries for private consumption, investment and government consumption. A sensitivity analysis on this parameter is given at the end of the paper. Finally, the remaining parameters in the model are calibrated on the GTAP-6 database [Dimanaran and McDougall (2005)].

3. Anticipated and Simulated Results

Our modeling approach is as follows. We project the world economy from 1930 to 2200 by superimposing on our OLG model the demographic shock -- the historical baby boom, followed by the UN demographic projections (medium variant scenario) until 2050, and thereafter, a demographic path which assumes that the population progressively stabilises and returns to a steady state once the generation born in 2050 "exits" the model (*i.e.*, dies) around 2120. Although populations are at a steady state in 2120, we do not force the economy to return to a full steady-state by 2120 but provide instead a few additional periods, until around 2200.

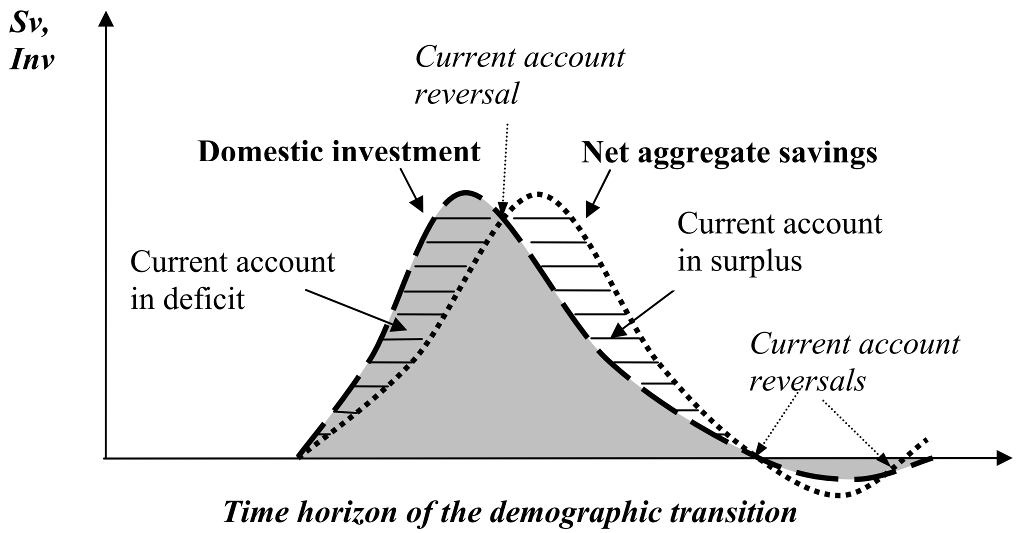
Our objective is to gauge the impact of ageing with respect to a control scenario without ageing --a "non-ageing" steady state scenario. Establishing a "shock minus control" measure of ageing by "removing" a large demographic shock is not a conceptually easy exercise because the model assumes rational expectations in a variety of markets. For example, we cannot simply subtract from our simulated results the calibrated values generated for a specific year or a specific period of time (1980-2000), and which are based on the assumptions that the economy, in that period, is at a steady state with stable populations. By doing this we would remove both the "pure" demographic shock as well as the impact of the change in expectations about the future demographic shock. To better capture the pure demographic shock we therefore subtract, from the simulated values obtained over the 1980-2070 horizon, (the most pertinent horizon in regard to the demographic transition), the simulated values reached in year 1980. This procedure cancels off the expectations about demographic transition already embodied in stock variables such as physical capital stocks and net assets position in 1980 and therefore provides a better approximation of the pure impact of ageing.

3.1 Some Anticipated Results

In an overlapping generation model where agents have finite life-time horizons, net aggregate savings is zero in a steady state with stable population. A necessary condition for positive aggregate saving is population growth which would imply that the number of young individuals who are likely to be net savers is larger than the number of dissavers (Blanchard and Fischer, 1989). Figure 1 shows stylistic time paths for aggregate savings (*Sv*) and investment (*Inv*) over a demographic transition process from one steady state to another. As the population age distribution shifts towards the center, the baby boomers move from young to middle-age (40-60) and they significantly increase their savings in expectation of their retirement while older generations (65+) born before the baby boom dissave their lifetime savings, but, to a lesser extent at the aggregate, as they are outnumbered; hence, the net positive aggregate savings resulting from demographic transition. However, the baby boomers progressively retire and dissave, while younger cohorts that move to their prime saving years are much smaller in size (the *baby bust*), and national savings starts to decline from its previously high levels. Eventually, when most baby boomers are in retirement, they outnumber the younger savers and aggregate savings turn negative. Finally, when the demographic transition is completed and the population reaches a new steady state, net aggregate savings reaches zero.

Of course, aggregate investment is also affected by the demographic transition. In the initial stage, the increased labour force due to the entry of baby boomers on the labour market raises the marginal productivity of capital, which generates a positive net (of depreciation) investment -- see the stylistic path for *Inv* in Figure 1. As the baby boomers retire, however, the labour force falls in size, which lowers the marginal productivity of capital and reduces the investment demand, with aggregate net investment possibly turning negative (when the gross investment rate falls short of the depreciation rate). According to Higgins (1998), the demographic “center of gravity” for investment demand should be earlier in the age distribution than for savings supply. Investment demand should be most closely related to the youth share through its connection with labour-force growth, while savings supply should be most closely related to the share of mature adults through its connection with retirement needs. The divergence between these two centers of gravity implies that the effects of a demographic change on savings and net capital flows will depend on the economy’s degree of openness to capital flows. In a closed economy, observed (*i.e.*, equilibrium) national savings equals domestic investment and movements in the domestic real interest rates will adjust the savings and investment distributions so that they "overlap". This suggests an initial increase in the real interest rates (when planned investment is above planned savings), eventually followed by a decrease (when planned savings is above planned investment).

Figure 1: Aggregate savings and investment "centers of gravity"



For an open economy, however, national savings does not need to be equal to domestic investment, and the difference is identically equal to the current account of the economy. As the baby boomers enter the labour force, planned domestic investment outgrows planned savings, and foreigners invest in the domestic economy (inward foreign capital flows into the domestic economy, *i.e.*, negative net foreign investment) to take advantage of the increased marginal productivity of capital. This automatically leads to a current account deficit for the domestic economy. However, as the population age distribution shifts towards the center, savings supply should increase, even as investment demand slackens, pushing the current account into a surplus as the domestic economy invests outside the country (capital outflows, *i.e.*, positive net foreign investment). Hence, it is typically expected that a country would see a reversal of its current account and, actually, several of these reversals over the complete demographic transition period, as Figure 1 illustrates. In a multi-country setting with perfect capital mobility, and assuming that countries are at different stages in their demographic transition, older countries (that is, countries more advanced in their demographic transition) will typically develop a current account surplus while younger countries will develop a current account deficit.

The world economy is a closed economy and assuming perfect capital mobility, the world real interest rate will equilibrate world savings (the sum of regional/countries savings flows) with world investment (the sum of regional investment). Given that the world economy is ageing, what would we expect in terms of the real world interest? As most countries experienced a demographic (baby boom) shock around World War II, this must have led to changes in the balance between physical capital and labour, with labour becoming first more abundant, and physical capital less abundant, making investment more attractive and creating downward pressures on real wages but upward pressures on the return to physical capital and the world real interest rates, also stimulating world savings. As the world population distribution is shifting towards the center, however, the ensuing accumulation of world savings puts downward pressures on the world real interest rate. Eventually, when baby boomers around the world will start to retire, labour will become more scarce and physical capital more abundant, making investment less attractive. This should create upward pressures on labour cost, downward pressures on the return to physical capital and further cuts in the world real interest rate. Finally, as a large share of world population live off their wealth during retirement, savings gradually declines and the fall in interest rates would progressively stop and eventually converge to more normal levels associated with a steady state population.

Although this process of an increase followed by a decrease in world real interest rates is similar to the scenario of a demographic transition for a closed country, the impact on the world real interest rate is expected to be smoother because countries are not at the same stage of the demographic transition. For example, even when labour becomes scarcer and investment less attractive in older countries, younger countries are still short of savings to finance their investment projects. Therefore, net foreign capital flows across countries are global economy channels that could mitigate the otherwise strong expected decrease in real interest rates and the asset meltdown scenario (a substantial decrease in assets values) in older countries.

3.2 Simulated Results

Population ageing will lead to a reduction in labour force growth. Thus, it can be interpreted as a negative labour supply shock which reduces potential output. Chart 2 presents the impact of population ageing in our multi-country model on real GDP per capita over the period 1980 to 2070. As expected, among the seven regions, Japan and Europe are the most negatively affected by population ageing, with an earlier and sharper decline in real GDP per capita. Relative to the "no-ageing" steady state scenario, real GDP per capita in both Japan and Europe begins to fall at the start of the 21st century, while it continues to increase for a while in the other regions. The fall in the Japanese and European GDP per capita (due to ageing) is about 15% between 2000 and 2050. Although Japanese workers typically retire later than workers in other regions, this is not sufficient to offset the negative effect of population ageing on real GDP.

Soon, North America will also be negatively affected by ageing. Indeed, real GDP per capita for Canada and the U.S. peaks in 2010 and declines thereafter. The impact of ageing on Canada is however much more pronounced with a fall of 13% between 2010 and 2050 versus 8% for the US during the same period. Looking at the other side of the ageing spectrum, India and the ROW have relatively younger populations and a similar profile in the elderly dependency ratio. As can be seen in Chart 2, India strongly benefits from the demographic changes as its real GDP per capita increases until 2030 with respect to the initial steady state and then stabilises thereafter at that level. Like India, the ROW has a relatively younger population and its impact on GDP is similar to one experienced by India, although real GDP falls very modestly after 2030.

Finally, the impact of ageing in China is stunning. The Chinese economy has an abundant workforce at the turn of the 21st century, and this contributes to raise real GDP per capita until 2010. Eventually however, as the demographic shock in China due to the one-child policy starts to kick off, the supply of labour falls and contributes to lower real GDP per capita below the initial steady state. By 2070, the fall in real GDP per capita (of close to 20 percentage points with respect to 2010) is even stronger than the one Japan is likely to experience.

Although the fall in GDP should contribute, through an income effect, to lower consumption per capita, globalisation through international trade should help sustaining consumption in most OECD countries through favourable terms of trade effect. Most of the multi-country OLG literature discusses a "one-good" world and therefore cannot capture this terms of trade effect. However, in our model, as in the study of Batini, Callen and McKibbin (2006), the goods produced are assumed to be imperfectly substitutable across countries.

Therefore, if the relative supply of a country's good shrinks with respect to the supply of other countries for demographic reasons, then the relative price of its good should increase. Thus, older than average countries should see an improvement in their terms of trade and younger than average countries, a deterioration, as also shown in Table 3. An improvement in the terms of trade means that countries can import more than before, for unchanged real export, so that *ceteris paribus*, their real consumption can increase. Thus, in an open economy context with imperfectly substitutable goods, real consumption per capita is not likely to fall as much as it would in either a closed-economy or a one-good world-economy context. In contrast, younger countries might have a smaller increase in their consumption per capita (relative to a closed economy or a one-good world benchmark) as they experience deterioration in their terms of trade which requires, *ceteris paribus*, supplying more of their goods on world markets.

Globalisation permits consumers of all countries to access a geographically more diversified basket of goods and to increase the foreign share of their basket. Chart 3 illustrates that older and more "open" countries benefit from consuming a larger share of those goods produced by younger countries and which price did fall relatively. Real consumption per capita in Japan tends to fall because of the strong negative income effect (Chart 2). Although Japan could potentially benefit from a strong appreciation in its trade of trade, it does not materialise because it is a relatively "closed" economy. In contrast, the much more open economies of Europe and Canada strongly benefit from the terms of trade appreciation. Indeed, this "price" effect more than offsets the income effect of Chart 2 and real consumption per capita continues to increase up to 2020, after which it stabilises around that level, albeit with a small downward trend for Canada until 2050. Notice that in North-America, the relative performance between the economies of the U.S. and Canada is reversed. While in terms of GDP per capita, the U.S. is doing better, Canada's per capita consumption, thanks to its more open economy, does not fall below its 2010 level for most of the 21st century, whereas the U.S. will be below its 2010 level for most of the century. India and the ROW get a strong boost in their consumption per capita despite terms of trade deterioration, as they also benefit from a strong positive income effect. Chart 4 illustrates that this income effect is itself stimulated by capital deepening in India and the ROW. We will discuss shortly how capital deepening is itself originating from foreign capital flows into these regions developing current account deficits for demographic reasons.

The case of China is again striking, especially when observing the diametrically opposite directions taken by China and India's real consumption paths from 2020 on. For China, both income and price effects contribute to reinforce the negative impact on real consumption per capita. Indeed, the timing of the one-child policy makes the Chinese economy both a (still) relatively young country with respect to OECD countries but an old one with respect to India and other parts of the world. Being caught between younger and older countries, the relatively closed Chinese economy does not benefit from terms of trade appreciation occurring to the older, more open, OECD countries, nor does it strongly benefit from capital deepening (Chart 4) through net foreign capital inflows. Indeed, as we will see shortly, unlike India, China develops current account surpluses for demographic reasons and therefore net capital outflows. Given the ageing of the Chinese population, aggregate savings is large in anticipation of retirement but aggregate investment falls short of savings as the currently "middle-age" working population outnumbers younger generations, which reduces both the need for strong capital accumulation and the incentive for domestic investment as the marginal productivity of capital is expected to fall.

Excess national savings should therefore be invested outside China (through net capital outflows) in order to benefit from world interest rates higher than those that would exist in a closed-economy China. Incidentally, the accumulation of huge foreign reserves by the Central Bank of China is a symptom of this demographic challenge, intertwined with Chinese controls of private capital outflows. Private Chinese capital outflows would most likely relay the current official capital outflows in case of full capital control liberalisation, therefore reducing the level of Chinese official reserves, but leaving little credit to the popular thesis that China could indeed substitute its relatively low interest-bearing official foreign reserve position with more profitable private domestic investment.

As discussed in Section 3.1, world population ageing changes the balance between physical capital and labour, so that, at some point when the baby boomers retire, labour becomes more scarce and physical capital more abundant, making investment less attractive. This creates upward pressures on real wages and downward pressures on the return to physical capital and the world real interest rate determined in the world capital market. Chart 5 presents a comparison of these labour cost pressures across countries as well as the impact of ageing on the world real interest rate. As shown, the world interest rate (right scale) falls by nearly 200 basis points over the 1980 – 2070 period, with as much as 110 basis point reduction up to 2000 and an additional 60 basis point between 2000 and 2020. This is a magnitude similar to the one reported in Batini, Callen and McKibbin (2006). Between 2020 and 2050, the world interest rate stabilises around a somewhat downward trend, illustrating two offsetting forces: younger countries moving towards the center of their population age distribution start accumulating savings while countries more advanced in their demographic transition continue to dissave. Observe that year 2030 is a turning point in the real consumption path of most OECD countries in Chart 3. This is also related to the stabilisation of the world interest rate around this period of time. As long as the interest rates fall, it is rational to increase current versus future consumption, but this tendency tends to reverse once interest rates stabilise.

According to our simulations, among all countries in the model, Japan and the EU will experiment the most robust labour cost increases over the next decades. This is explained by stronger labour market pressures in these countries, due to a more severe ageing workforce. Early retirement behaviour in the EU also exacerbates labour market pressures (effective retirement age is 60). In contrast, the Japanese older workforce retires at 70, mitigating somewhat the pressures on real wages. Canada and the US experience a labour cost increase that is less severe than in Japan and the EU while China's real wages grow somewhat slower at first, but eventually, with its faster ageing population, experiences a labour cost pressure similar to the US by 2050. In contrast, India and the ROW go through modest real wage increases as they experience a moderate increase in labour market pressures.

The impact of ageing on the contribution rate of the pay as you go pension scheme is illustrated in Table 5. As expected, most countries will experiment an upward pressure on their contribution rate between 2000 and 2010. Among OECD countries, Japan, Canada, and Europe will experiment the largest increase, while the impact on the U.S. contribution rate will be much more modest. Although it can be argued that there is no official PAYG pension schemes in China, such an arrangement is, however, implicitly organised and expected between parents and children, and the burden of the one-child policy of China on this intergenerational link is again quite apparent in Table 5. Although Chart 5 illustrates the labour cost pressures across countries, Chart 6 provides an index of the purchasing power of the net of tax labour income (wage rate in terms of the cost of the typical domestic basket of goods, net of tax and contribution rates). This figure clearly shows that the purchasing power of workers across most OECD countries will start to decline between 2010 and 2020. For non-OECD countries, India and China follow, again, diametrically opposite paths.

Charts 7 (a-g) present the impact of population ageing on current account, savings, and investment, in proportion of GDP. Japan, EU, Canada and the US have all larger savings than investment rates at the beginning of the 21^{st} century and therefore have current account surpluses and capital outflows (net investment abroad) for demographic reasons. Japan is at a more advanced stage of ageing and, by 1990, is the first to experience deterioration in its current account, as savings rate falls by more than investment rates. Its current account, however, only turns into a deficit by 2030. EU current account starts deteriorating around 2000 although it will effectively turn negative in 2040. Our results for EU are roughly similar to those given in Börsch-Supan et al. (2006). The current account of Canada starts to deteriorate in 2020 but is projected to turn into a deficit just before 2050.

On the other hand, at the start of the 21^{st} century, India and the Rest of the World have lower savings than investment rates and therefore have current account deficits for demographic reasons, and associated foreign capital inflows as foreigners invest in these countries. Actually, the current account of these regions should turn into a surplus only later in the second half of this century. The general equilibrium nature of the ageing process is crucial to understand the net foreign asset dynamics of countries during the demographic transition, and this is again particularly relevant for China that is trapped in the global economy, between relatively older and younger countries. China's relatively younger population with respect to OECD countries suggests, *ceteris paribus*, the occurrence of a current account deficit for demographic reasons. However, as shown in Chart 7.e, China actually develops current account surpluses since 1990. One main reason is that India and other regions of the rest of the world do not face the Chinese one-child policy challenge and are therefore expected to remain much younger than China. As young workers in India and other regions of the world continue to enter the labour force, they sustain and reinforce the marginal productivity of capital which, unlike China, transforms these regions into an attractive pole for foreign capital flows.

Table 4 decomposes the current account into its trade balance component and the interest revenues on net foreign assets. Chart 8 illustrates this decomposition for Japan and for Canada. As Japan has developed current account surpluses for most of the second half of the 20th century, it has acquired net foreign assets and therefore continues to receive interest revenues from foreigners. However, its current account is projected to turn negative by 2020, deteriorating both Japan's net foreign assets position and the ensuing interest revenues. Japan is projected to become a net foreign debtor slightly after 2070 when its net interest revenues turn negative while eventually developing a positive trade balance in order to service its foreign debt.

Canada which has accumulated a series of current account surpluses for demographic reasons as soon as 1980, should become a net foreign creditor just before 2010 and its ensuing interest revenues on foreign assets should lead Canada to a trade balance deficit by 2030. As the demographic transition ends and the economy goes back to a steady state with stable populations, Canada's current account will stabilise to zero but its trade balance is projected to remain in deficit, offsetting the net interest revenues on accumulated foreign assets.

Finally, Chart 9 illustrates the result of a sensitivity analysis. The Armington elasticity of substitution between goods of the seven regions of the model is set in the benchmark analysis at 2.5. We now vary the value of this parameter by about ±30% (+1.8; +3.2) and show the impact of this on the real consumption path per capita for OECD countries. Recall that our analysis shows that international trade is a channel that, through terms of trade effects, can sustain real consumption in the OECD countries despite population ageing (Chart 3). As shown in Chart 9, the higher the Argminton elasticity of substitution and the stronger is this effect because consumers are assumed to react more to price effects.

4. Conclusion and extensions

This paper develops a multi-country overlapping-generations CGE model to gauge the long-term impact of population ageing in a context of globalisation of trade and capital flows among seven regions of the world: the USA, the EU, Canada, Japan, China, India, and a composite region representing the rest of the world. Although assuming perfect capital mobility between these regions of the world is clearly a strong hypothesis to make, it permits to gauge the *prospective* gains from more liberalized trade and capital flows across regions of the world that are experiencing various demographic pressures.

As expected, the analysis shows that the productive capacity in faster ageing countries like Japan will be most affected by population ageing, followed by the EU and Canada, while the USA will be moderately affected. In contrast, India should benefit from a relatively younger population. Although the fall in GDP should contribute, through an income effect, to lower real consumption per capita, globalisation through international trade helps sustaining consumption in most OECD countries. Indeed, in an open economy context with imperfectly substitutable goods, real consumption per capita is not likely to fall as much as it would in either a closed-economy or a one-good world-economy context. For example, the much open economies of Europe and Canada might strongly benefit from a terms of trade appreciation. This "price" effect tends to offset the negative income effect so that real consumption per capita continues to increase up to 2020, after which it stabilises around that level. In contrast, younger countries might have a smaller increase in their consumption per capita (relative to a closed economy or a one-good world benchmark) as they experience deterioration in their terms of trade which requires, *ceteris paribus*, supplying more of their goods on world markets. India and the ROW, however, get a strong boost in their consumption per capita despite terms of trade deterioration, as they also benefit from a strong positive income effect.

The general equilibrium nature of the ageing process is crucial to understand the net foreign asset dynamics of countries during the demographic transition, and this is particularly relevant for a country like China that is caught, in the global economy, between relatively older and younger countries. That China does not develop current account deficit for demographic reasons at the start of the 21st century, can only be understood in a general equilibrium setting by considering that other countries such as India and other parts of the world are expected to remain much younger and to benefit from increasing marginal productivity of capital, making these regions attractive poles for foreign capital flows. Although the growth potential of China has attracted much attention worldwide, an analysis that takes into account the global demographic context shows that India, more so than China, is a key promising developing country of the 21st century if it pursues its effort to integrate the world economy through both trade and capital flows liberalisation and if it accelerates the movement of the workforce out of agriculture into the unskilled-labour intensive industry of the "organised" sector (Panagariya, 2006).

We plan several future researches with the multi-country model both in terms of modeling perspective and scope of analysis. From a modeling perspective, we plan to introduce the possibility of international labour mobility to investigate the impact of population ageing and pressures coming from emerging countries on international flows of labour and their impact on national labour markets. We will also introduce endogenous labour supply into our multi-country model, as is done in Fougère, Harvey, Mercenier, and Mérette (2009) for Canada in a closed economy context.

In terms of broader themes of analysis, we plan to investigate the economic impact of the demographic shift between JEU (Japan, Europe, and the US) on one side and BRIC (Brazil, Russia, India and China) on the other side. The decline in working-age population is projected to take place later in BRIC than in JEU, but will be steeper in Russia and China than in India and Brazil. More favorable demographic shifts in BRIC suggest that JEU may want to develop further north-south trade. The later ageing process in India and Brazil over Russia and China also suggests that the economic opportunities may become larger in the former two economies in the second quarter of this century.

Second, in Canada, a recurrent theme from politicians and commentators alike is that the Canadian economy is too much exposed to the U.S. economy and that Canadians could benefit from further diversifying its trade flow pattern. The case for diversification is often justified, although not proved, by analogy to the so-called gains from international portfolio investment diversification. We plan to examine whether these calls are sensible in a context of world population ageing, independently of the political feasibility of such shifts.

Finally, in our model, each country produces one single good. Given our assumption of imperfectly substitutable regional goods, there are seven goods in the model corresponding to the seven regions. However, we plan to increase the number of goods produced in each country. Why does that matter? If national economies are characterised by one-sector neoclassical production functions with diminishing returns to capital, a high level of savings in a country should create an incentive to export capital. However, that virtually all of what is saved in a country is also invested in that country has been initially interpreted by Feldstein and Horioka (1980) as evidence of segmented capital markets or low capital mobility -- a puzzle in a world of ongoing liberalization in capital markets that has led to an extended literature. Nonetheless, the incentive to export savings may disappear, even in a world of free capital market, in the presence of multiple sectors with differing capital intensities. In this case, national savings can be absorbed domestically, without a decline in its marginal product, through a shift in the sectoral composition of national production towards capital intensive goods – a variation on the Rybczynski effect as suggested by Debaere and Demiroglu (2008). On the other hand, ageing might also change the relative demand for goods towards higher labour-intensive goods such as health services. Combined together, this suggests the following trade pattern that ageing countries might want to export the services of their capital by exporting capital intensive goods while importing labour intensive goods. This also suggests the importance of continuing efforts to liberalize trade in services at the WTO.

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Table 1: Total Fertility Rate, Life-Expectancy at Birth and Net Migration by Region of the World

Country/Region of the World	2005- 2010	2015-2020	2025-2030	2035-2040	2045-2050
Canada					
Total fertility rate	1.53	1.55	1.65	1.75	1.85
Life-expectancy at birth	80.7	82.0	83.2	84.2	85.3
Net Migration (thousands)	200	200	200	200	200
USA					
Total fertility rate	2.05	1.94	1.85	1.85	1.85
Life-expectancy at birth	78.2	79.5	80.7	81.8	83.1
Net Migration (thousands)	1199	1100	1100	1100	1100
EU					
Total fertility rate	1.45	1.52	1.61	1.69	1.76
Life-expectancy at birth	74.6	76.4	78.2	79.7	81
Net Migration (thousands)	951	792	808	808	808
Japan					
Total fertility rate	1.27	1.30	1.40	1.50	1.60
Life-expectancy at birth	82.6	84.2	85.2	86.1	87.1
Net Migration (thousands)	54	54	54	54	54
China					
Total fertility rate	1.73	1.83	1.85	1.85	1.85
Life-expectancy at birth	73	74.9	76.6	78.1	79.3
Net Migration (thousands)	-350	-345	-320	-320	-320
India					
Total fertility rate	2.81	2.32	1.97	1.85	1.85
Life-expectancy at birth	64.7	68.4	71.4	73.7	75.6
Net Migration (thousands)	-250	-240	-240	-240	-240

Source: UN Population Division, World Population Prospects: The 2006 Revision, Medium Variant Scenario.

Table 2: Calibration Parameters

Region	Canada	USA	EU	Japan	China	India	ROW
Regional Share of GDP	0.021	0.306	0.249	0.125	0.054	0.015	0.229
Share of capital in production	0.408	0.379	0.442	0.387	0.448	0.547	0.513
Share of high-skilled workers	0.327	0.414	0.406	0.379	0.194	0.238	0.323
Intertemporal elast. of substitution	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Armington trade elasticity	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Rate of time preference (10-year)	0.22	0.28	0.22	0.28	0.25	0.21	0.17
Wage income tax rate	0.296	0.234	0.38	0.241	0.45	0.20	0.26
Capital income tax rate	0.368	0.273	0.287	0.279	0.50	0.25	0.30
Consumption tax rate	0.139	0.064	0.178	0.064	0.05	0.15	0.15
Effective retirement age	65	65	60	70	65	65	65
Pension benefit rate	0.425	0.386	0.536	0.503	0.30	0.20	0.35

Table 3: Terms of Trade (1980 = 1)

	1990	2000	2010	2020	2030	2040	2050	2060
Canada	1.00	1.00	1.01	1.01	1.02	1.03	1.04	1.04
U.S.A.	1.00	1.00	1.01	1.01	1.01	1.01	1.01	1.02
EU	1.01	1.02	1.03	1.04	1.06	1.07	1.08	1.09
Japan	1.00	1.01	1.02	1.03	1.04	1.05	1.05	1.06
China	1.00	1.00	1.00	1.00	1.01	1.01	1.02	1.02
India	1.00	1.00	0.99	0.99	0.99	0.99	0.99	0.98
ROW	0.99	0.99	0.98	0.98	0.97	0.97	0.97	0.97

Table 4: Impact of Population Ageing on Current Account Balances (proportion of GDP)

	1990	2000	2010	2020	2030	2040	2050	2060
Current Account/GDP								
Canada	0.007	0.012	0.016	0.016	0.011	0.004	-0.002	-0.004
U.S.A.	0.021	0.021	0.020	0.016	0.012	0.010	0.008	0.007
EU	0.035	0.039	0.036	0.027	0.015	0.003	-0.006	-0.010
Japan	0.012	0.012	0.008	0.002	-0.006	-0.012	-0.015	-0.014
China	0.001	0.004	0.007	0.009	0.008	0.005	-0.001	-0.008
India	-0.033	-0.033	-0.029	-0.023	-0.016	-0.011	-0.007	-0.004
ROW	-0.038	-0.035	-0.028	-0.019	-0.011	-0.004	-0.001	0.001
Trade Balance/GDP								
Canada	0.020	0.018	0.013	0.004	-0.009	-0.021	-0.028	-0.027
U.S.A.	-0.023	-0.025	-0.029	-0.034	-0.038	-0.041	-0.044	-0.045
EU	-0.009	-0.020	-0.036	-0.057	-0.078	-0.094	-0.103	-0.104
Japan	0.001	-0.006	-0.015	-0.024	-0.031	-0.034	-0.030	-0.020
China	0.023	0.019	0.016	0.011	0.004	-0.004	-0.012	-0.018
India	0.009	0.015	0.022	0.030	0.037	0.041	0.043	0.043
ROW	0.016	0.022	0.030	0.037	0.042	0.043	0.041	0.037
Interest revenue (+) or payments (-) on foreign assets (debts)/GDP								
Canada	-0.014	-0.006	0.003	0.012	0.020	0.025	0.026	0.024
U.S.A.	0.044	0.047	0.049	0.050	0.051	0.051	0.052	0.052
EU	0.045	0.059	0.073	0.084	0.093	0.097	0.098	0.094
Japan	0.011	0.018	0.023	0.025	0.025	0.022	0.015	0.006
China	-0.022	-0.015	-0.008	-0.002	0.004	0.008	0.011	0.010
India	-0.042	-0.048	-0.051	-0.053	-0.053	-0.051	-0.049	-0.046
ROW	-0.054	-0.058	-0.058	-0.057	-0.052	-0.047	-0.042	-0.036

Table 5: Contribution Rate Index of the "Pay As You Go" Pension Plan (1980 = 1)

	1990	2000	2010	2020	2030	2040	2050	2060
Canada	0.80	0.74	0.81	0.99	1.24	1.48	1.62	1.63
U.S.A.	0.80	0.71	0.73	0.85	0.99	1.13	1.22	1.25
EU	0.83	0.76	0.81	0.96	1.17	1.38	1.55	1.62
Japan	0.88	0.90	1.03	1.26	1.57	1.84	1.97	2.07
China	0.76	0.70	0.76	0.96	1.27	1.65	2.03	2.36
India	0.75	0.67	0.69	0.80	0.96	1.15	1.33	1.49
ROW	0.74	0.66	0.67	0.77	0.92	1.10	1.28	1.44

Chart 1: Simulated Elderly Dependency Ratio by Region of the World

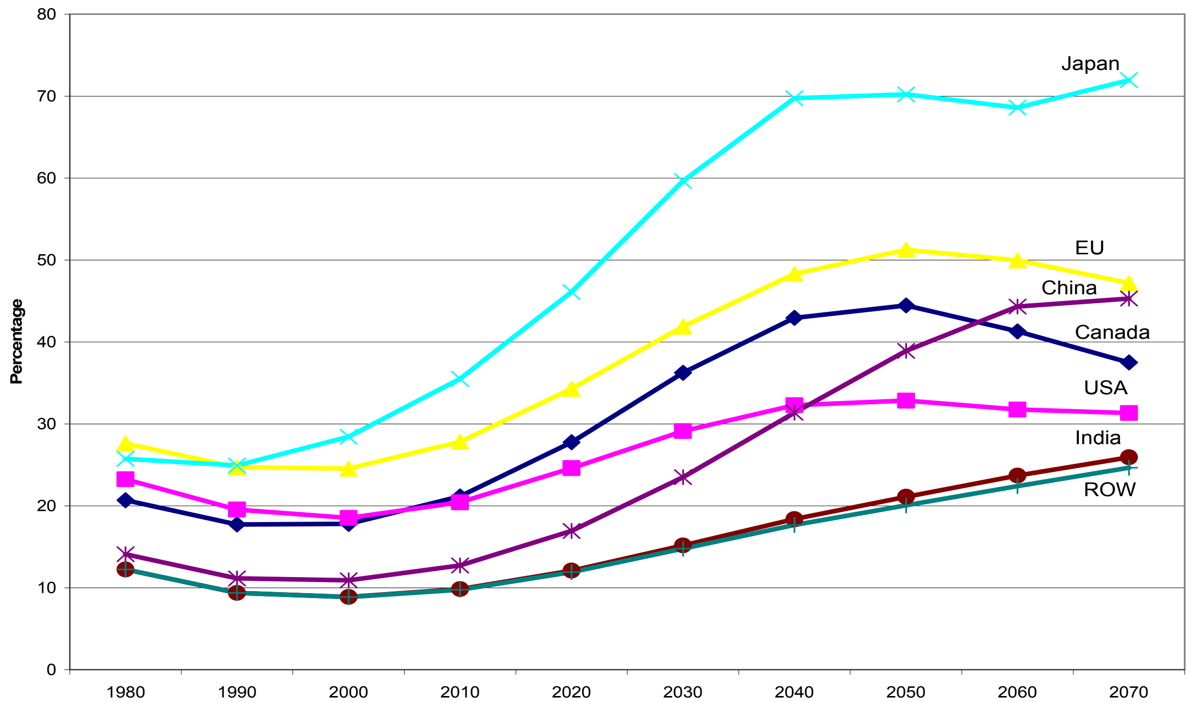


Chart 2: Real GDP per Capita -- Relative deviation with respect to initial steady state

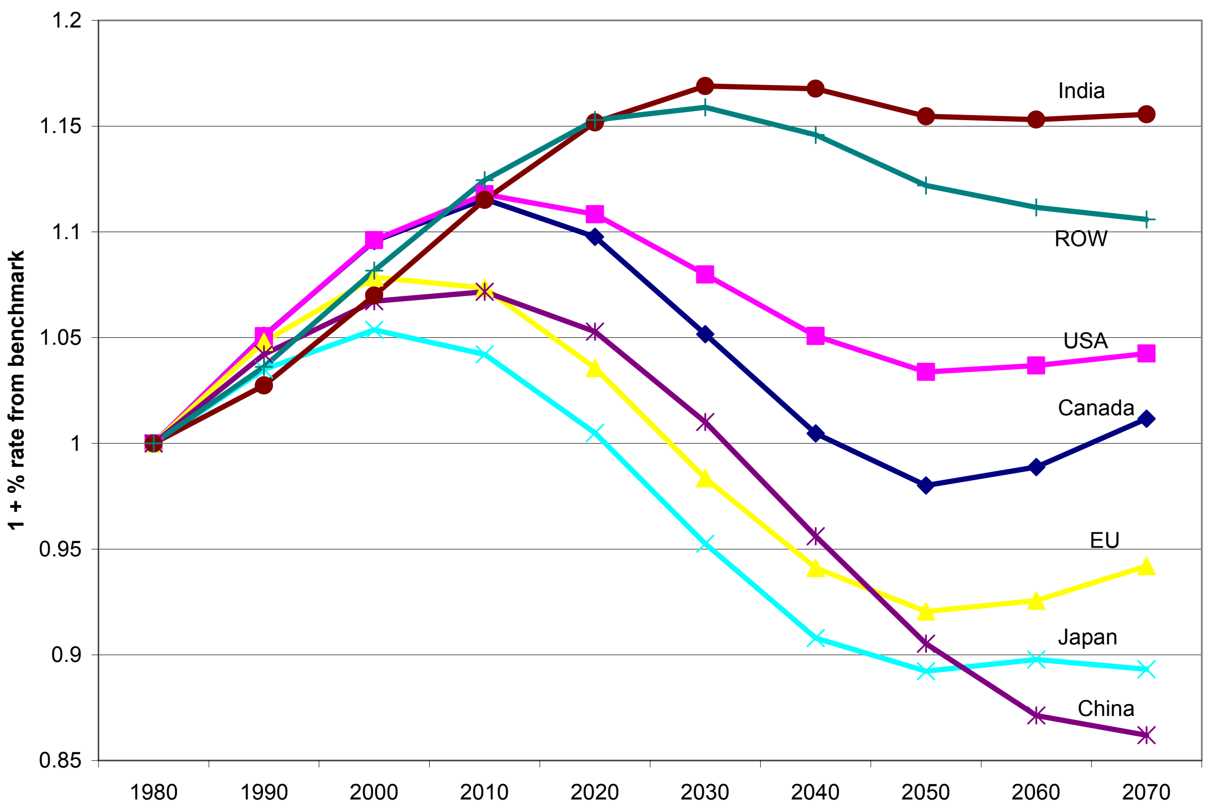


Chart 3: Real Consumption per Capita -- Relative deviation with respect to initial steady state

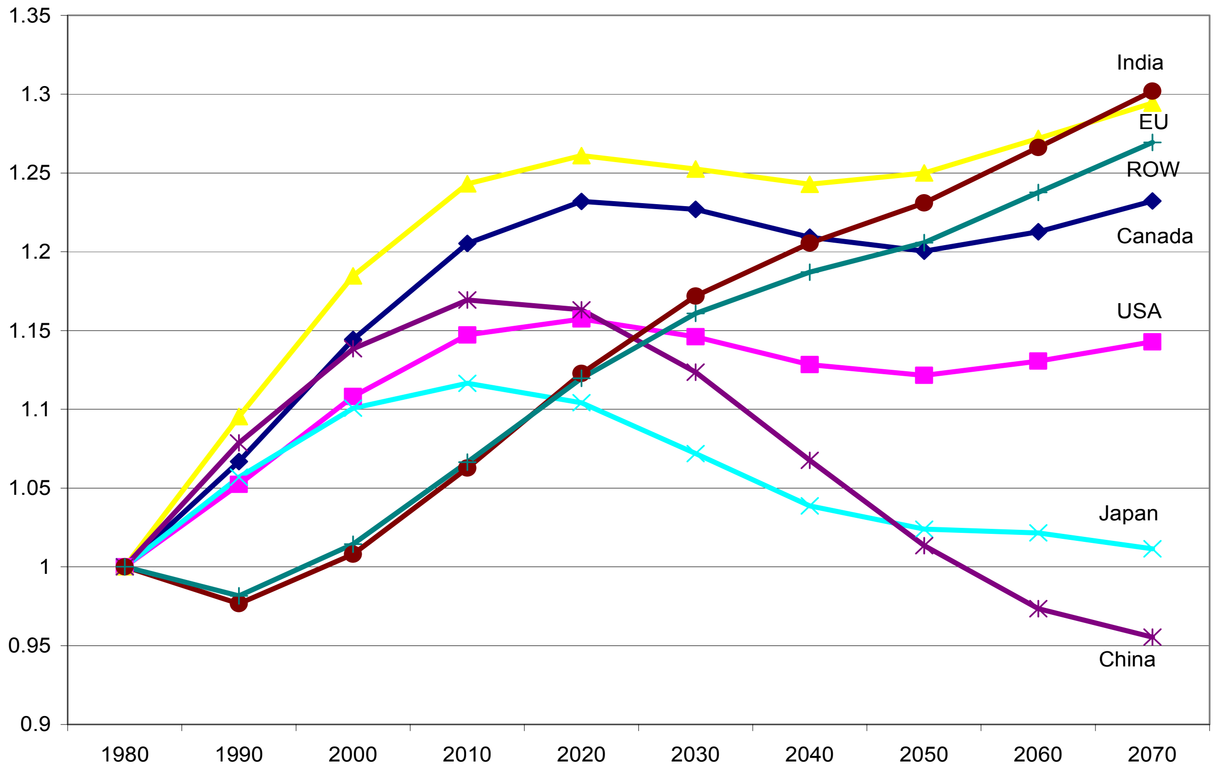


Chart 4: Index of Capital-Labour Ratio

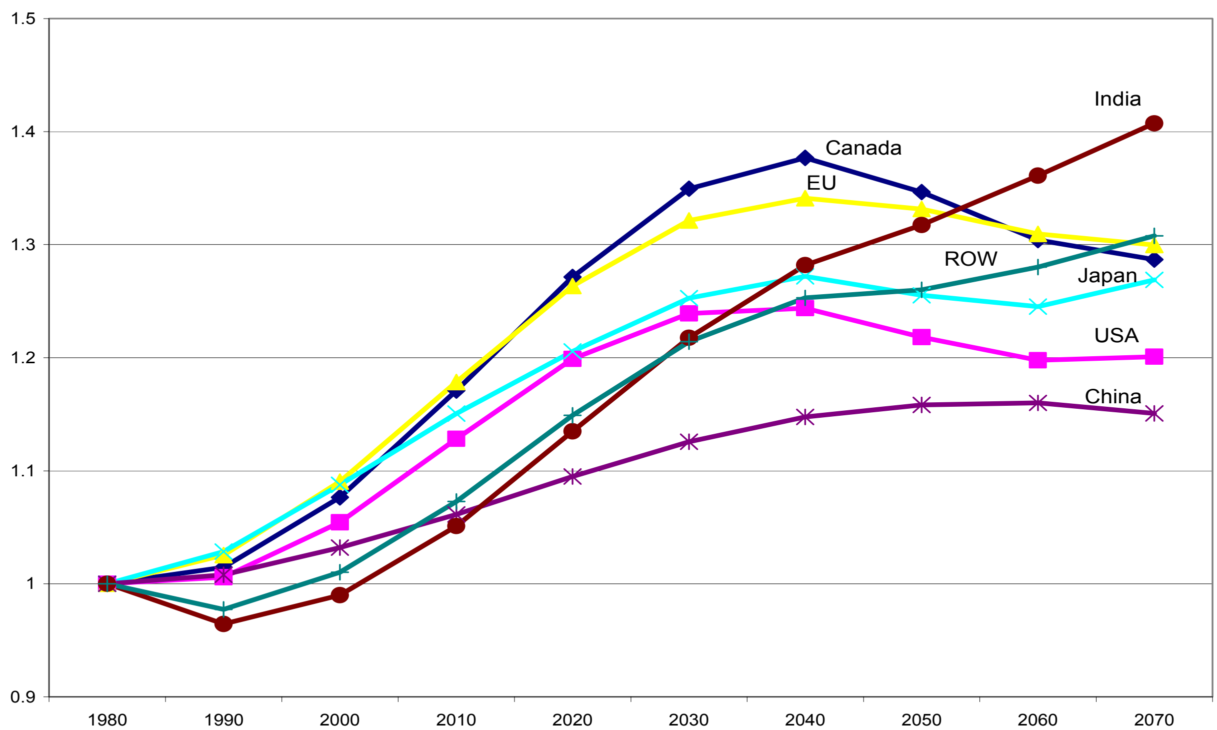


Chart 5: Impact of Population Ageing on Real Wages (Labour Costs) and on the World Interest Rate -- Relative deviation with respect to initial steady state

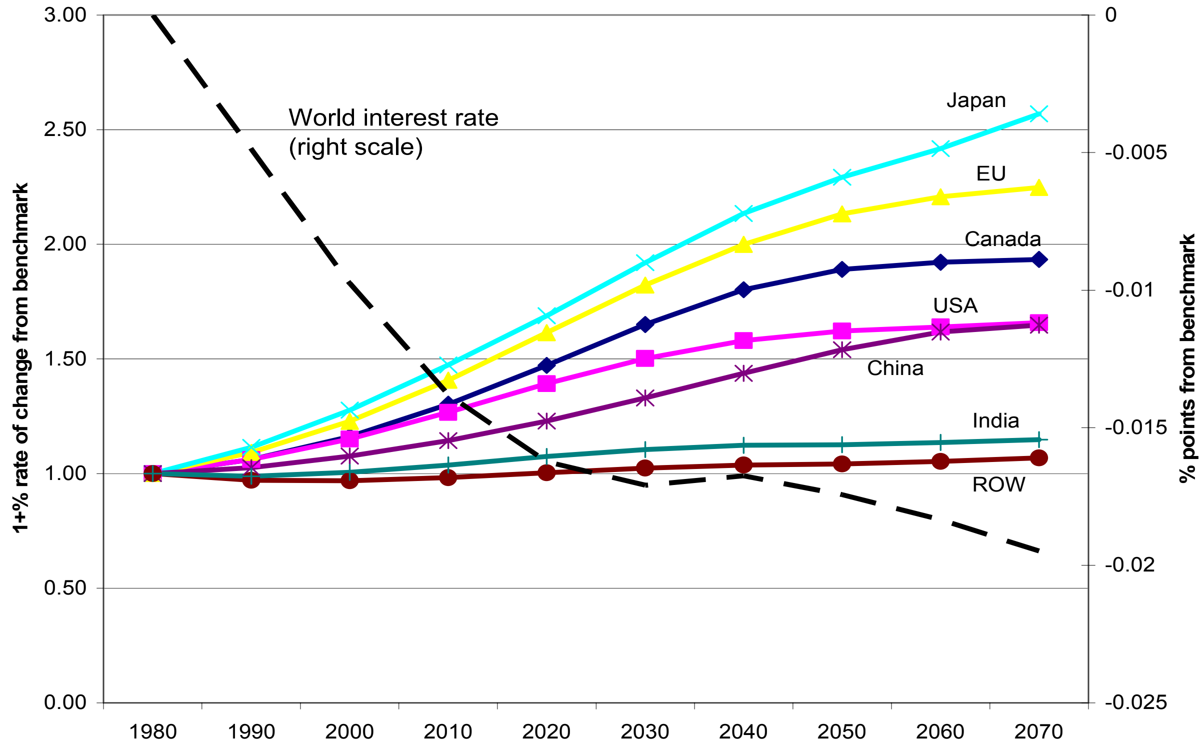
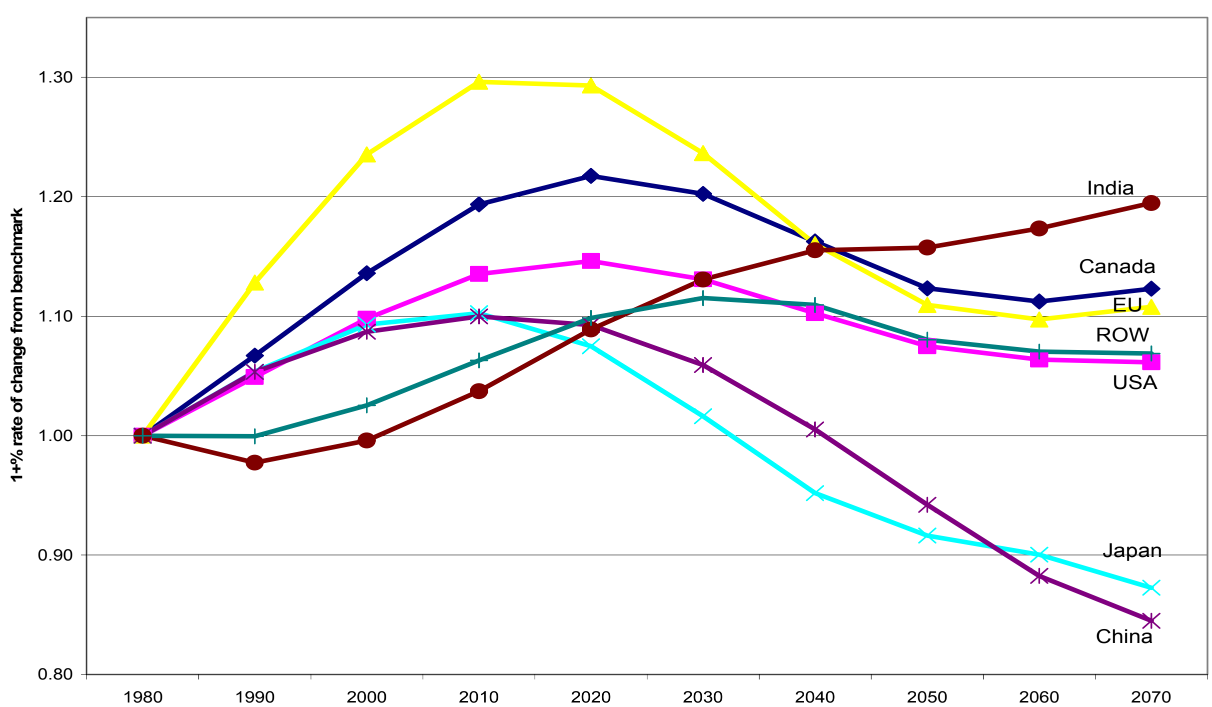
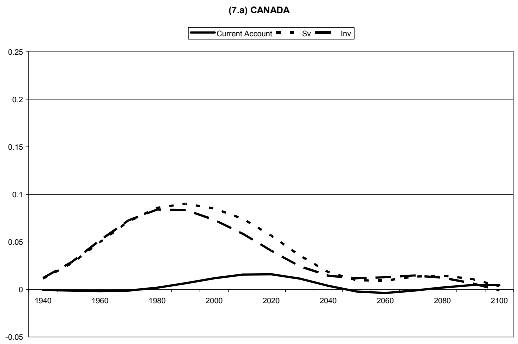
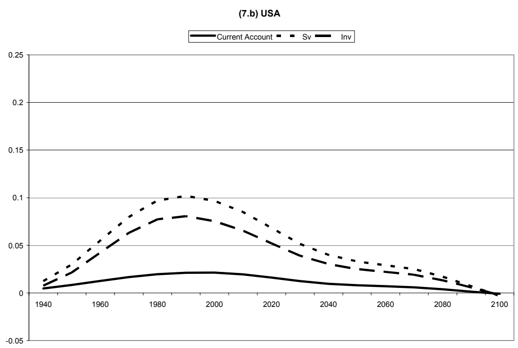


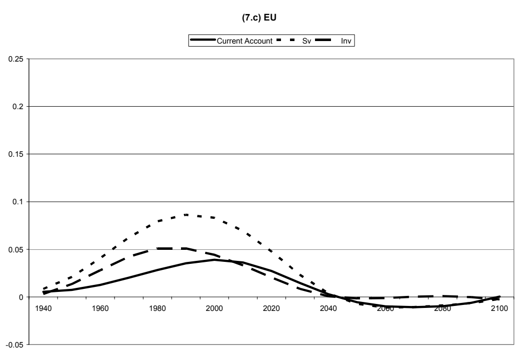
Chart 6: Index of Purchasing Power of Labour Income (Net of Taxes and Contribution rates --Relative deviation with respect to initial steady state

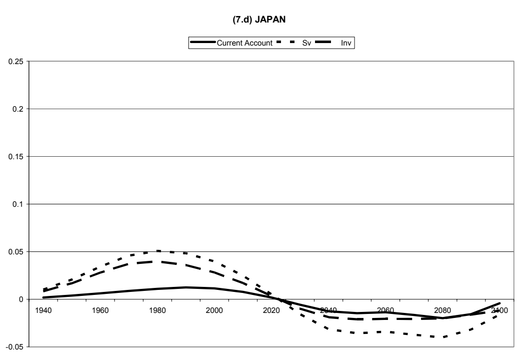


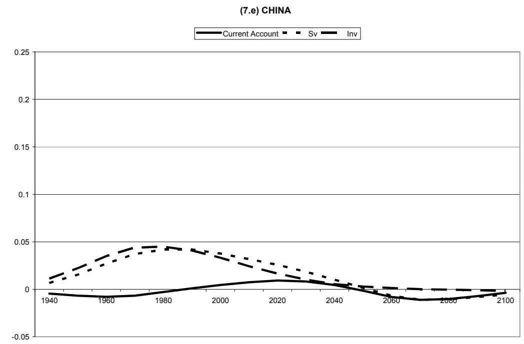
Charts 7 (a-g): Current Accounts, National Savings, and Domestic Investment

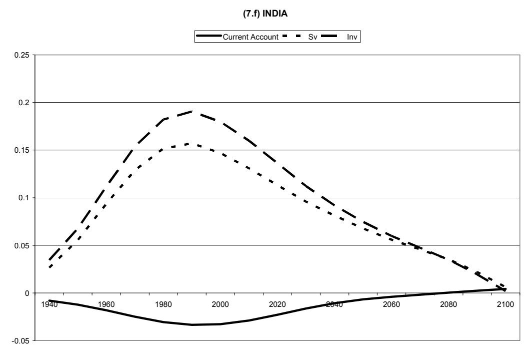












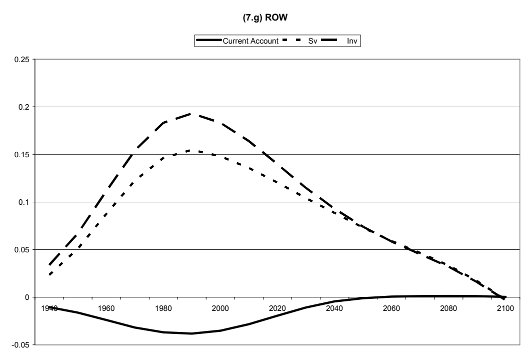
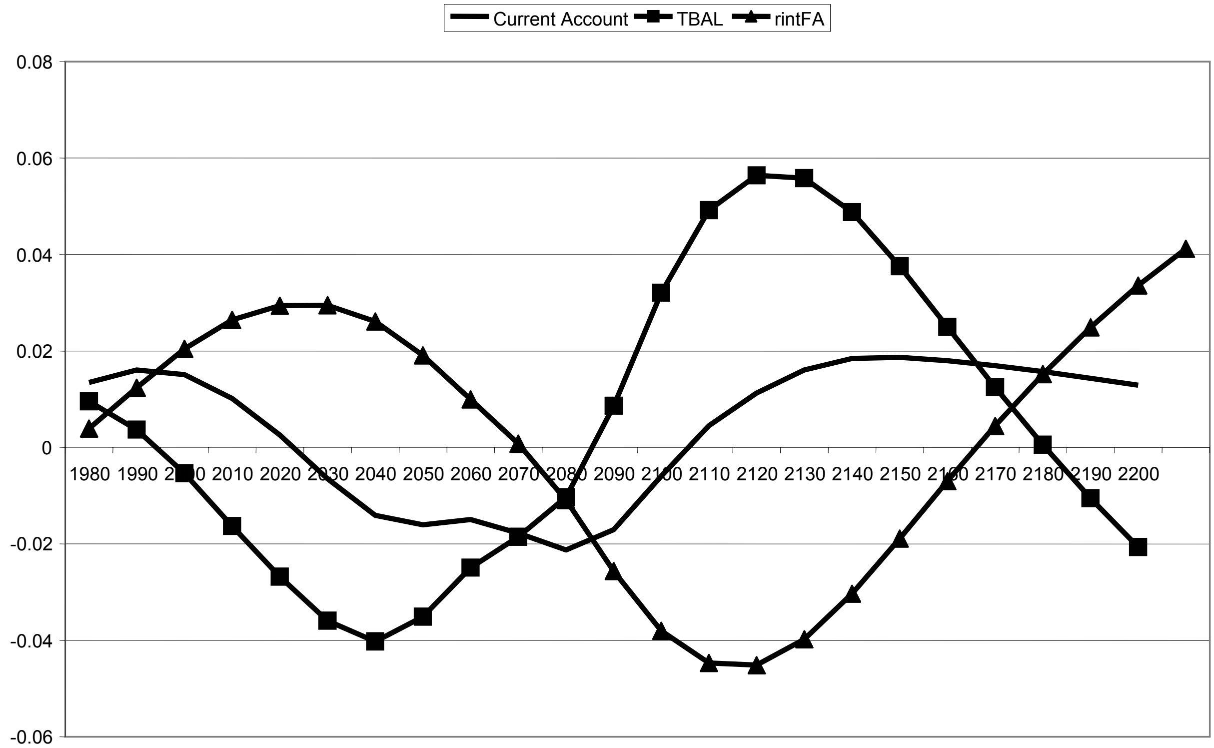


Chart 8 (a-b): CA, Trade Balances and Interest Revenues on Net Foreign Assets

(8.a) JAPAN -- Current Account, Trade Balance and Net Interest on Foreign Assets



(8.b) CANADA -- Current Account, Trade Balance and Net Interest on Foreign Assets

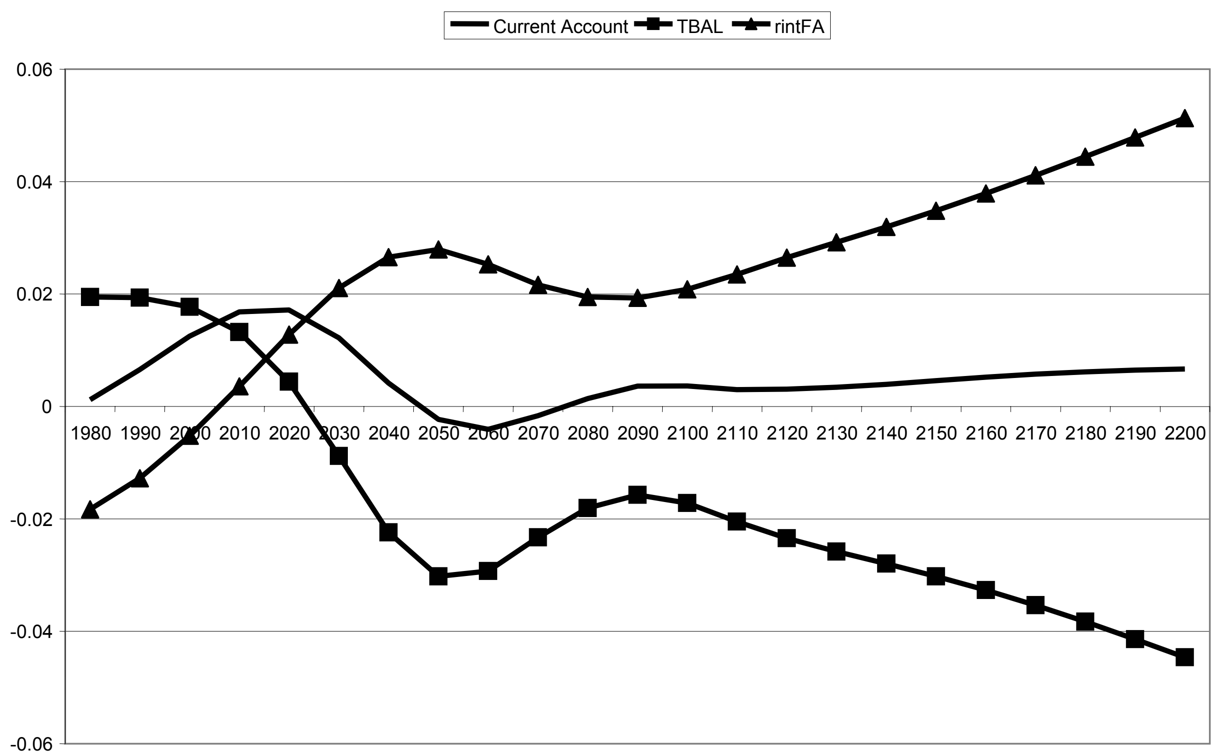


Chart 9: Sensitivity Analysis on Armington Elasticity of Substitution