Global demographic trends, capital mobility, saving and consumption in Latin America and Caribbean (LAC)

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Abstract

In this paper we study the effect of demographic transitions on the economy of Latin America and Caribbean (LAC). We build a model of multi-regions of the world and derive the path of macroeconomic variables including aggregate output, capital, labor and saving rate, as the economies face a rapid shift in the demographics. The timing and the extent of the demographic transition differ across regions. We simulate the model in both closed economy and open economy assumptions to quantify the roles played by the factor mobility across regions in shaping capital accumulation and equilibrium factor prices.

Keywords: Capital Flows, Demographic Trends, Latin America and Caribbean (LAC).

JEL Classification: E21, F21, F41, J11.

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1 Introduction

Demographic trends in the last century have changed dramatically the size and composition of the world population. Developed and mature economies have experienced dramatic reductions in fertility rates and increases in longevity. These trends have led to a considerable ageing of the populations of developed countries and increases in old age dependency ratios. Aging demographics have implied that many public pension systems, based on Pay-As-You-Go schemes became, at the pre-existing levels of benefits and contributions, unsustainable in many developed countries. As a consequence, there has been a tendency to move towards funded systems often based on defined contribution schemes. Several papers have pointed out that large changes in the age structure of the population are likely to imply large changes in factor prices. A large cohort preceded and followed by a small one will experience relative low wages when on the job market and relatively low returns in later life. The same mechanisms that make PAYG system unsustainable imply (in a world with funded pensions) movements in rates of return that will affect negatively the welfare of the large cohort. These effects are mediated by existing pension and social security arrangements, as well as the presence of government debt. These issues are discussed in studies, for instance Attanasio, Kitao and Weber (2014, "AKW"), Attanasio, Kitao and Violante (2006 and 2007), Boersch-Supan, Ludwig and Winter (2006) and Krueger and Ludwig (2007).

Middle income countries have started on demographic transitions and trends that resemble those of developed countries but with a delay of several decades. Fertility rates have declined fast in these countries and longevity has increased. As these trends are much more recent, old-age dependency ratios are still substantially below those currently observed in developed countries.

Among Middle Income countries, the demographic trends in China and the Latin America and Caribbean (LAC) are particularly interesting and noticeable. On the one hand China, which is the country with the largest population in the world, has successfully implemented, for many years, a one-child policy that has decreased fertility rates to a very low level and has changed dramatically the predicted absolute and relative size of China. On the other hand, LAC is a region where fertility rates have decreased dramatically and very rapidly.

Low income/developing countries still have relatively high fertility rates and lag behind in mortality improvement. They are therefore the youngest region in the world and will remain so for the coming decades. The relatively high fertility rates imply that they are projected to become, by far, the largest region, in terms of population size, of the world.

All these changes have implied large shifts in the relative composition of the world population and its age structure in several regions. These changes will continue and if anything will become even more dramatic over the next decades. As we discuss below, this has important implications for factor prices and for the financing of old age public systems throughout the world.

The effects of demographic transition might be compounded (or attenuated) by different degrees of development and different level of productivity. In the presence of mobile factors of productions, the presence of un-synchronized trends affords important possibilities that attenuate the type of adverse effects on some generations that we mentioned in the previous paragraph.

Large and un-synchronised demographic changes create incentives for the mobility of factors of production. These can occur in a number of ways: capital flows, migration, outsourcing. However, factor mobility is not without problems. Migration can imply large social problems connected with the integration of potentially large numbers of migrants with different cultures. At the same time, these large inflows can cause changes in the real wages of sectors of society and, as a consequence, generate political resistance.

Capital mobility might also be problematic: financial and political institutions need to be developed well enough to guarantee that the return to capital invested in certain regions goes back to the regions where the savings were originated. These tensions increase the pressure on financial markets. Political risks can also be important in this respect.

Given the large demographic changes it is important to quantify the potential impacts of different projections. As the size of the effects will depend on the nature of government policies, it is important to quantify different scenarios. The other major forces that can affect the size of the impacts are: productivity (of both capital and labor), longevity and fertility rates.

In this paper, we consider a stylized model of the world to quantify the possible effects of demographic trends. We will also consider capital flows across regions of the world. We will exclude from our analysis migration and labor mobility. Given this simplifications and our other assumptions, our results need to be taken with some caution. However, the simulations we present constitute a useful benchmark to quantify the importance of the demographic and macroeconomic trends we observe.

Based on heterogeneous demographic trends, we consider five regions of the world

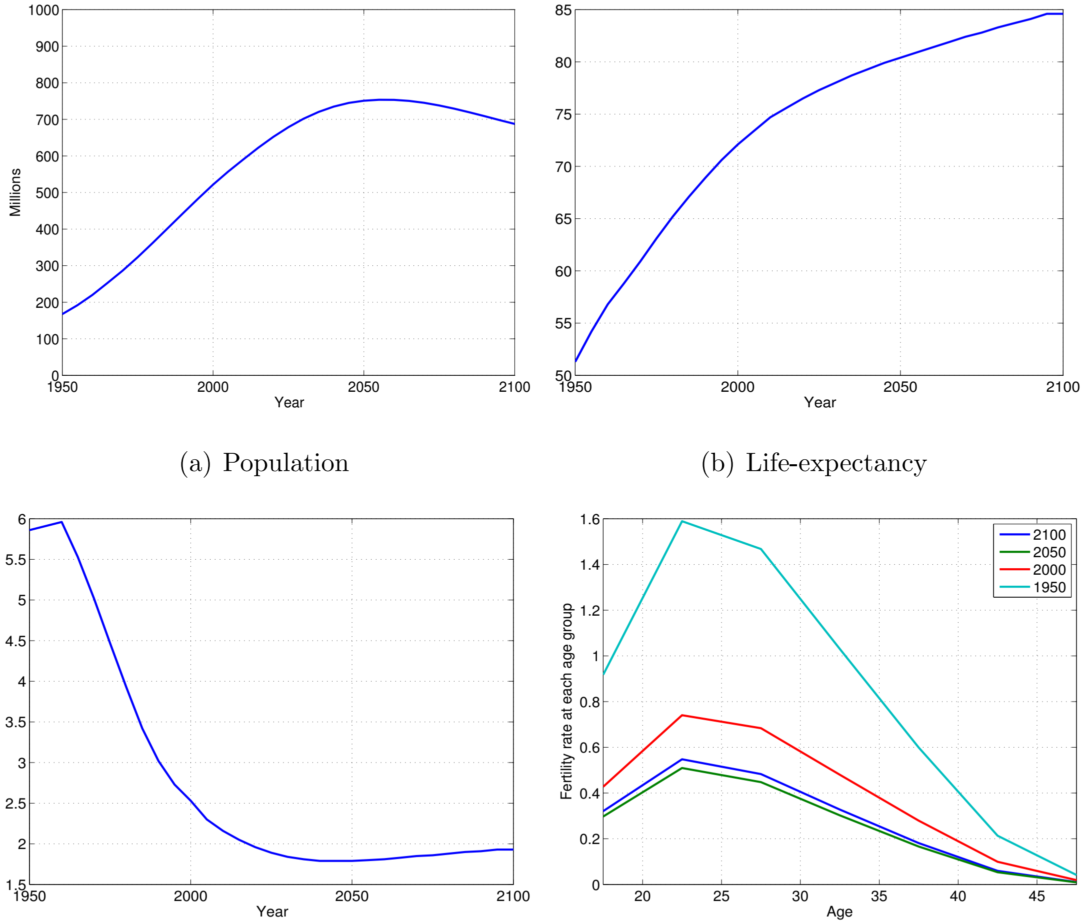
1. High Income: U.S., Europe, Japan, Canada, Australia, NZ
2. Latin America and Caribbean (LAC)
3. Medium Income: India, Russia, South Africa, South Korea, Taiwan, Thailand, Turkey
4. Low Income: Africa and rest of Asia
5. China

In AKW, we had considered Medium Income region Latin America as a unified region. We think the present exercise is useful not only because of the policy focus on Latin America but because, as we will see, LAC is different from other regions in many aspects as we discuss below. The focus of the paper will obviously be Latin America and Caribbean region. However, it should be clear that the results we present can only be properly understood if we consider them within the global context.

The rest of the paper is organized as follows. We first present some of the demographic trends we mentioned. We then sketch our 5 region model. We calibrate the parameters of the model using a number of different data sources. We then present the simulations of the model and discuss them.

2 Demographic Trends

In this section, we present figures that show more details of the main demographic trends in LAC, which constitutes the focus of the analysis. We focus on four statistics: population size, life expectancy, total fertility rate and fertility rates by age. The sources are either actual data or UN projections. In figure 1 we report the figures for LAC, while in Figure 2 we consider all other regions.



(a) Population

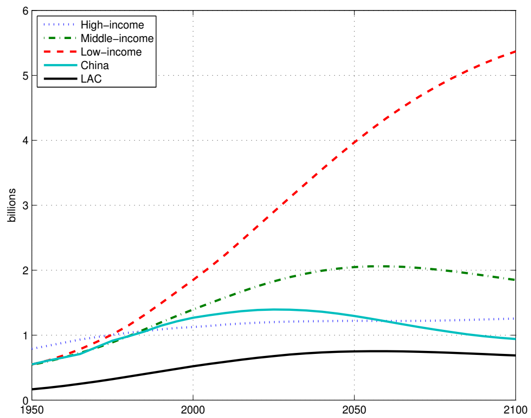
(b) Life-expectancy

(c) Total fertility rate

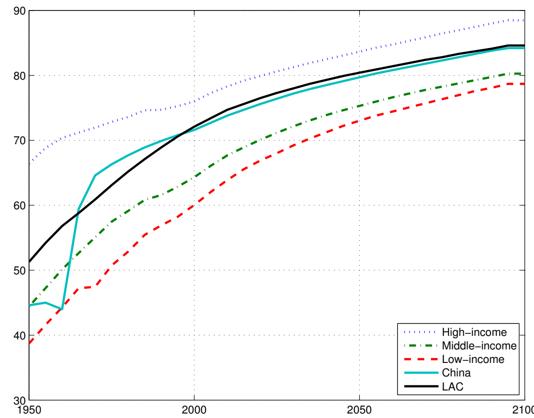
(d) Fertility by age

Figure 1: Demographic transition in LAC

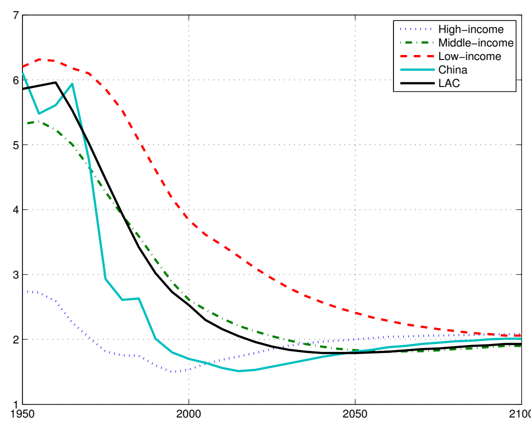
As shown in Figure 1(b), improvement in medical technology and health quality contributed to a rise in longevity and a rapid improvement in life-expectancy, which increased from about 52 in 1950 to 72 in 2000. According to the U.N. projections, the life-expectancy will continue to rise and reach almost 85 by the end of the century. At the same time, total fertility rates have declined rapidly from about 6 children per woman to 2.5 in 2000. The U.N. projects it will fall below the replacement rate and stays below 2.0 for several decades starting in mid 2020s. A rise in longevity will have a positive effect on total population, as shown in Figure 1(a), but the low fertility rates will dominate in the net effect and the population will start to decline after 2050.



(a) Population



(b) Life-expectancy



(c) Total fertility rate

Figure 2: Demographic transition of the world

As shown in Figure 2, other regions of the world share similar trends in the paths of life-expectancy and fertility rates. The timing, however, of the demographic transition varies across regions. High Income region already had a high life-expectancy of 68 in 1950, which has increased moderately since then. Low and Middle Income regions and China started at a much lower life-expectancy than High and Middle Income regions, but the difference has shrunk over the last several decades. The gap will continue to shrink but the difference will persist even at the end of the century. All regions have experienced a decline in fertility rates since 1950, with a most dramatic drop observed in China due to its unique one-child policy. Fertility rates in Low Income region is close to 4 in 2000 and remain above 2 throughout the century. As a result of the unsynchronized demographic trends, the population distribution of the world is projected to change dramatically, as shown in Figure 2(a). When the population in LAC will start to decline in 2050s, Low Income region will continue to grow and the population will exceed 5 billion by 2100. China will start to see a decline in population earlier than LAC and its population will reach below 1 billion by the end of the century.

3 The Model

The model we present in this chapter extends the one developed by AKW. The model is a general equilibrium, overlapping generations model of five interdependent economies. We exogenously limit migration flows, and compare the situation where there are no capital flows (closed economy) and where there are capital flows (open economy).

Most of the assumptions we make are relatively standard or discussed in AKW. However, we do make some slightly different modelling choices that need to be discussed and motivated, which we do at the end of this section. The two issues we discuss are discount factor heterogeneity and assumptions about technical progress convergence.

3.1 Economic Environment

Preliminaries: The world economy is composed of five regions, (1) High Income region H, (2) Middle Income region M, (3) Low Income region L, (4) China C and (5) Latin America and Caribbean LAC. The five regions differ in demographic structure, total factor productivity level, individual endowment profiles, subjective discount factor, and fiscal institutions. In what follows these differences are spelled out more in detail. There is no aggregate or region-specific uncertainty, but since we will model a deterministic transition across two steady states, equilibrium factor prices will be time-varying in a deterministic way. The only source of individual risk is related to the uncertain life span, which is region specific. We let t denote time, i individual's age, and r the five regions, with $r \in \{H, M, L, C, LAC\}$.

Technology: In each region r, a constant returns to scale, aggregate production function $F(Z_t^r, K_t^r, H_t^r)$ produces output of a final good Y_t^r which can be used interchangeably for consumption C_t^r and investment X_t^r. Among the arguments of the production function, Z_t^r denotes the total factor productivity level in region r at time t, H_t^r is the stock of human capital (i.e., the aggregate efficiency units of labor), and K_t^r is the aggregate stock of physical capital used in production in region r. Physical capital depreciates geometrically at rate δ each period. The level of technology in region r grows exogenously at rate λ_t^r between t and $t+1$, but in the long-run all regions reach the same productivity level and grow at the same constant rate λ.

Demographics: Each region is populated by overlapping generations of ex-ante identical "pairs of individuals" who may live for a maximum of $\overline{I}$ periods and their age is indexed by $i = 1, 2, ..., \bar{I}$. Pairs of individuals are dependent children for the first I^d periods of their life and then they turn adult and form a household. For a pair of individuals born in region r, denote by $s_{i,t}^r$ the probability of surviving until age i at time t, conditional on being alive at time $t-1$ (with age $i-1$). Hence, in region r, the unconditional probability of surviving i periods up to time t is simply

$$S_{i,t}^r = \prod_{j=1}^{i} s_{j,t+(j-i)}^r,$$

where $S_{1,t}^r = s_{1,t}^r \equiv 1$ for all t by definition. In each period t, pairs of age i in region r have an exogenously given fertility rate (i.e., a probability of giving birth to another pair of individuals) equal to $\phi_{i,t}^r$. During childhood, i.e. until age I^d, fertility is assumed to be zero. For what follows, it is useful to define $d_{i,t}^r$ as the total number of (pairs of) dependent children living in a (adult) household of age i at time t, i.e.

$$d_{i,t}^r = \begin{cases} 0 & \text{for } i \leq I^d \\ \sum_{k=i-I^d+1}^{i} \phi_{k,t-(i-k)}^r S_{i-k+1,t}^r & \text{for } i > I^d \end{cases}$$

We denote by $\mu_{i,t}^r$ the size of the population of age i at time t in region r and by $\boldsymbol{\mu}_t^r$ the $\left(\overline{I} \times 1\right)$ vector of age groups. Thus, in each region the law of motion of the population between time t and $t+1$ is given by $\boldsymbol{\mu}_{t+1}^r = \Gamma_t^r \boldsymbol{\mu}_t^r$ where Γ_t^r is a time-varying $\left(\overline{I} \times \overline{I}\right)$ matrix composed by fertility rates and surviving probabilities for households of region r described by

$$\Gamma_t^r = \begin{bmatrix} \phi_{1,t}^r & \phi_{2,t}^r & ... & ... & \phi_{\bar{I},t}^r \\ s_{2,t+1}^r & 0 & ... & ... & 0 \\ 0 & s_{3,t+1}^r & 0 & ... & 0 \\ 0 & 0 & \ddots & \ddots & 0 \\ 0 & 0 & ... & s_{\bar{I},t+1}^r & 0 \end{bmatrix}$$

The first row of this demographic transition matrix contains all the age-specific fertility rates, the elements $(i+1,i)$ contain the conditional surviving rates, whereas all the other elements are zeros. Lee (1974) shows that the largest eigenvalue of Γ_t^r is the growth rate of the population between time t and $t+1$, which we denote as γ_t^r (see also Rios-Rull, 2001).

Since we are interested in the economically active population, we reshape the matrix Γ_t^r and the vector $\boldsymbol{\mu}_t^r$ down to size $I = \overline{I} - I^d$ and we normalize the first period of adulthood (and economically active) life to be period 1 of life for households. We also restrict the parameters of the two matrices Γ_t^r to converge across regions as t becomes large, in order to generate a common long-run growth rate of the population γ.[1]

Household Preferences: Households of age i at time t in region r are composed by a pair of adults and a number $d_{i,t}^r$ of pairs of dependent children living with their parents. The adults in the household jointly make consumption allocation decisions for themselves and their dependent children so to maximise expected life time utility. The only uncertainty faced by the consumer is that about longevity. The utility function over the life cycle is assumed to be inter temporally separable and the future is discounted geometrically by a factor β^r. Note that the discount factor, unlike other parameters of the utility function is region specific, an assumption that we discuss below.

The within period felicity function is given by:

$$u^r(c_{i,t}^a, c_{i,t}^d) = \frac{\left(c_{i,t}^a\right)^{1-\theta}}{1-\theta} + d_{i,t}^r \omega\left(d_{i,t}^r\right) \frac{\left(c_{i,t}^d\right)^{1-\theta}}{1-\theta}, \tag{1}$$

where $c_{i,t}^a$ denotes consumption for the adults, $c_{i,t}^d$ consumption per dependent child,

[1]This restriction, similar to the one we impose for productivity growth, is necessary to achieve a long-run growth path where neither region is negligible in terms of output and population compared to the rest of the world.

and $\omega\left(d^r_{i,t}\right)$ is a positive function that weighs consumption of children in households' utility. The intertemporal elasticity of substitution for consumption is $1/\theta$.

This preference specification is convenient, because it permits to express utility only as a function of the total consumption of the household $c_{i,t} = c^a_{i,t} + d^r_{i,t} c^d_{i,t}$. From the optimality condition of the household with respect to $c^d_{i,t}$ one obtains

$$c^d_{i,t} = c^a_{i,t} \omega\left(d^r_{i,t}\right)^{\frac{1}{\theta}}, \tag{2}$$

which sets optimally the consumption of children to a fraction of the consumption of parents proportional to their weight in the utility function. Using (2) into (1), together with the definition of the total consumption of the household $c_{i,t}$ one obtains

$$u^r(c_{i,t}) = \Omega^r_{i,t} \frac{c_{i,t}^{1-\theta}}{1-\theta}, \tag{3}$$

where $\Omega^r_{i,t} = \left[1 + \omega\left(d^r_{i,t}\right)^{\frac{1}{\theta}} d^r_{i,t}\right]^{\theta}$ and acts like an age- and time-dependent preference shifter. Finally, as mentioned above, the discount factor β^r which weights future utility, is region specific. There is no explicit altruistic motive.

To summarise, the intertemporal preference ordering for households born (adult of age $i = 1$) at time t is given by

$$U^r = \sum_{i=1}^{I} (\beta^r)^{i-1} S^r_{i,t+i-1} \Omega^r_{i,t+i-1} \frac{c_{i,t+i-1}^{1-\theta}}{1-\theta}, \tag{4}$$

Household Endowments: Households derive no utility from leisure. They have a fixed time endowment, normalized to one unit, that they can devote either to productive activities in the labor market or to child care at home. We denote by $\mathbf{d}^r_{i,t}$ the $(I^d \times 1)$ vector of pairs of children's by age groups for a household of age i at time t. Labor supply for households of region r at age i at time t is given by

$$l^r_{i,t} = \begin{cases} \Lambda^r_t\left(\mathbf{d}^r_{i,t}\right) & \text{if } i < I^R \\ 0 & \text{otherwise,} \end{cases} \tag{5}$$

$\Lambda^r_t\left(\mathbf{d}^r_{i,t}\right)$ is an exogenous fraction of time that each household of age i in region r devotes to the market work at time t. The function $\Lambda^r_t\left(\mathbf{d}^r_{i,t}\right)$ is decreasing in the number of dependent children and captures the time trend and a rise in labor force participation of women. At age I^R, households are subject to compulsory retirement from any working activity. Households of age i at time t in region r are endowed with $\varepsilon^r_{i,t}$ efficiency units of labor for each unit of time worked in the market. Finally, we assume that the initial asset holdings of each household is zero, i.e. $a_{1,t} = 0$ for any t in all regions.

Household Budget Constraint: Let $a^r_{i,t}$ be the net asset holding of individual i at time t in region r. We assume that there are annuity markets to cover the event of early death. Every household has the right to keep the share of assets of the deceased in the same cohort, thus we can write the budget constraint as:

$$\left(1 + \tau^r_{c,t}\right) c^r_{i,t} + s^r_{i+1,t+1} a^r_{i+1,t+1} = y^r_{i,t} + \left[1 + \left(1 - \tau^r_{a,t}\right) r_t\right] a^r_{i,t}. \tag{6}$$

We require households to die with non-negative wealth once they reach age I, but otherwise we impose no borrowing constraint during their life. Net income $y^r_{i,t}$ accruing to households of age i in region r at time t is defined as

$$y^r_{i,t} = \begin{cases} \left(1 - \tau^r_{w,t}\right) w^r_t \varepsilon^r_{i,t} l^r_{i,t} = \left(1 - \tau^r_{w,t}\right) \tilde{y}^r_{i,t} & \text{if } i < I^R, \\ p^r_{i,t} & \text{if } i \geq I^R, \end{cases} \tag{7}$$

where w^r_t is the wage rate, $\varepsilon^r_{i,t}$ is the efficiency units of labor of an individual of age i, and $p^r_{i,t}$ is pension income. $\tilde{y}^r_{i,t}$ is the before-tax labor income. Households pay taxes $\tau^r_{c,t}$ on consumption, $\tau^r_{a,t}$ on capital income, and $\tau^r_{w,t}$ on labor income. Residents of region r pay capital income taxes in region r, independently of where capital was invested. Social security benefits are given by the formula

$$p^r_{i,t} = \kappa^r_t \frac{W^r_{i,t}}{I^R - 1},$$

where κ^r_t is the replacement ratio of average past earnings. Cumulated past gross earnings $W^r_{i,t}$ are defined recursively as

$$W^r_{i,t} = \begin{cases} \tilde{y}^r_{1,t} & \text{if } i = 1 \\ \tilde{y}^r_{i,t} + W^r_{i-1,t-1} & \text{if } 1 < i < I^R \\ W^r_{i-1,t-1} & \text{if } i \geq I^R. \end{cases} \tag{8}$$

Government Budget Constraint: In each region r, public expenditures and social security program are administered by the government under a unique consolidated intertemporal budget constraint. The government can raise revenues through its fiscal instruments $\left(\tau^r_{c,t}, \tau^r_{a,t}, \tau^r_{w,t}\right)$ and can issue one-period risk-free debt B^r_t. Government borrowing and tax revenues finance a stream of expenditures G^r_t and the PAYG social-security program described above. The consolidated government budget constraint reads as

$$\begin{aligned}
&G^r_t + (1 + r_t)\, B^r_t + \textstyle\sum_{i=I^R}^{I} p^r_{i,t}\mu^r_{i,t} = \\
&\tau^r_{w,t} w^r_t \textstyle\sum_{i=1}^{I^R-1} \mu^r_{i,t}\varepsilon^r_{i,t}\Lambda^r_{i,t} + \textstyle\sum_{i=1}^{I} \mu^r_{i,t}\left(\tau^r_{a,t} r_t a^r_{i,t} + \tau^r_{c,t} c^r_{i,t}\right) + B^r_{t+1}.
\end{aligned} \tag{9}$$

Commodities, Assets and Markets: There are three goods in the world economy: a final good which can be used either for consumption or investment, the services of labor and the services of capital. The price of the final good (homogeneous across the five regions) is used as the world numeraire. Labor is immobile, thus wages are determined independently in regional labor markets. Physical capital is perfectly mobile across the five regions, so there is one world market for capital. We denote as N^r_t the external wealth of region r, i.e. the stock of capital productive in other regions which is owned by households of region r, with the convention that a negative value denotes ownership of capital used for production in region r held by households of the rest of the world. The sum of the positive and negative external wealth across regions is zero by definition, that is, $\sum_{r=1}^{5} N^r_t = 0$ at any time t. Finally, in every region there is a financial market for government debt. The markets where these goods and assets are traded are perfectly competitive. An intuitive no-arbitrage condition between assets and the absence of aggregate uncertainty imply that the return on all regional bonds is equal to the return on physical capital, as we have already implicitly assumed when we wrote the budget constraints of the government and households.

3.2 Equilibrium

Before stating the definition of equilibrium, it is useful to point out that, without further restrictions, the equilibrium path of the fiscal variables $\left\{G^r_t, \kappa^r_t, \tau^r_{w,t}, \tau^r_{a,t}, \tau^r_{c,t}, B^r_t\right\}_{t=1}^{\infty}$ is indeterminate, as there is only one budget constraint we can operate on. In what follows, we define an equilibrium for the case where the paths of all fiscal variables are given, except for $\left\{\tau^r_{w,t}\right\}_{t=1}^{\infty}$. This case corresponds to our baseline experiment. It is straightforward to extend this definition to the case where the path of a different set of government policies is given exogenously. Finally, for brevity we omit the definition of the closed-economy equilibrium and state directly the equilibrium conditions for open economy.

A *Competitive Equilibrium of the Five-Region Economy*, for a given sequence of region-specific demographic variables $\{\Gamma_t^r, \Lambda_t^r\}_{t=1}^{\infty}$, TFP levels $\{Z_t^r\}_{t=1}^{\infty}$, and fiscal variables $\left\{G_t^r, \kappa_t^r, \tau_{a,t}^r, \tau_{c,t}^r, B_t^r\right\}_{t=1}^{\infty}$, is a sequence of:

(i) households' choices $\left\{\left\{c_{i,t}^r, a_{i,t}^r\right\}_{i=1}^{I}\right\}_{t=1}^{\infty}$,
(ii) labor income tax rates $\left\{\tau_{w,t}^r\right\}_{t=1}^{\infty}$,
(iii) wage rates $\{w_t^r\}_{t=1}^{\infty}$,
(iv) aggregate variables $\{K_t^r, H_t^r, X_t^r, C_t^r\}_{t=1}^{\infty}$ in each region r,
(v) world interest rates $\{r_t\}_{t=1}^{\infty}$, and
(vi) external wealth of each region $\{N_t^r\}_{t=1}^{\infty}$ such that:

1. Households choose optimally consumption and wealth sequences $\left\{\left\{c_{i,t}^r, a_{i,t}^r\right\}_{i=1}^{I}\right\}_{t=1}^{\infty}$, maximizing the objective function in (4) subject to the budget constraint (6), the income process (7), and the time allocation constraint (5) .

2. Firms in each region maximize profits by setting the marginal product of each input equal to its price, i.e.

$$w_t^r = F_H(Z_t^r, K_t^r, H_t^r), \tag{10}$$

$$r_t + \delta = F_K(Z_t^r, K_t^r, H_t^r). \tag{11}$$

3. The regional labor markets clear at wage w_t^r and aggregate human capital in each region is given by

$$H_t^r = \sum_{i=1}^{I^R-1} \mu_{i,t}^r \varepsilon_{i,t}^r \Lambda_{i,t}^r. \tag{12}$$

4. The regional bond markets and the world capital market clear at the world interest rate r_t, and the aggregate stocks of capital in each region satisfy

$$K_t^r + N_t^r + B_t^r = \sum_{i=2}^{I} \mu_{i-1,t-1}^r a_{i,t}^r. \tag{13}$$

5. The tax rates $\left\{\tau_{w,t}^r\right\}_{t=1}^{\infty}$ satisfy the consolidated budget constraint (9) in each region.

6. The allocations are feasible in each region, i.e., they satisfy the regional aggregate resource constraints

$$K_{t+1}^r - (1-\delta)\, K_t^r + N_{t+1}^r - (1+r_t)\, N_t^r = F(Z_t^r, K_t^r, H_t^r) - C_t^r - G_t^r. \quad (14)$$

Before concluding, it is useful to recall that aggregate gross investments in region r are given by

$$X_t^r = K_{t+1}^r - (1-\delta)\, K_t^r, \quad (15)$$

whereas aggregate (private plus public) savings in region r are,

$$S_t^r = F(Z_t^r, K_t^r, H_t^r) + r_t N_t^r - C_t^r - G_t^r.$$

As a result, the current account surplus of region r (or, the net capital outflow from region r into the rest of the world) is given by

$$S_t^r - X_t^r = CA_t^r = N_{t+1}^r - N_t^r, \quad (16)$$

and it equals the change in the net foreign asset position of region r. Moreover, in this five region economy, $\sum_{r=1}^{5} CA_t^r = 0$.

3.3 A discussion of modelling choices

As mentioned above, most of the modelling choices we used are reasonably standard in this literature. However, an important issue, which deserves some discussion, is the existence of heterogeneity in taste and technology across the various regions. We tried to discipline our choices by minimising the use of arbitrary differences in preferences and technology to match the main differences across regions. However, the regions we consider are different and we need to model these differences in a parsimonious fashion. In our model, the differences across the five regions we consider stem from three different sources: (i) demographic trends and size of the labour force; (ii) productivity; (iii) discount factors. We discuss these in turn. Notice that given the nature of our model, we need also to take a stance on the path of these driving variables in the future.

Demographic trends and size of the labour force. We take the population size of the various regions and their demographic composition as an exogenous source of variation. We ca directly use UN data to specify these differences, although we do not try to model them in terms of fertility choices or relate them to other economic choices, such as labour supply. As for the future, we take UN projections of demographic trends and use them throughout our exercises. It should be stressed that the nature of our exercise implies that the relative size of regions (in terms of population and in particular labour efficiency units) matters substantially for the results we obtain. As we do not model explicitly labour supply or labour force participation, we extrapolate, as we discuss below, observed trends. These projections are, to an extent, arbitrary and we perform some robustness exercise to establish how our results change with changes in these projections.

Productivity trends. Differences in productivity among different regions are obvious and observables, so that, as we discuss below, we calibrate different levels of productivity in our model to match the differences we observe in the historical data. However, unlike demographic trends, it is not completely obvious how to forecast future trends in productivity and, in particular, differences among different regions. Differences in the relative size of labour efficiency units are key in the open economy exercises we perform to determine both equilibrium factor prices and capital flows. For this reason, we explore different alternative assumptions about the path of future productivity in different regions. Whilst it is probably reasonable to assume that in the very long run there will be convergence, the speed of convergence and the relative paths in different reasons will be very important. In our simulations we explore a few different alternatives.

Discount factors. As we mentioned above, whilst we try to keep differences in preference parameters at a minimum, historically, different regions have exhibited very different patterns of saving behaviour, which is difficult to explain within the standard model we use. In particular, two facts stand out: the extremely high saving, especially in the last 30 years, of China and the relatively low saving of Latin America. The observed saving behaviour of these regions is also reflected, to an extent, to relatively high and low levels of capital to output ratios. Probably the simplest way to replicate these differences within our model is to assume differences in the discount factor. In what follows, therefore, we assume that Chinese are considerably more patient than Latin Americans. These differences, of course, should not interpreted literally and could proxy for more complex and maybe more realistic differences. One model, for instance, that has been proposed to explain the relatively high saving rates observed in China over a period of very rapid economic growth is one of habits. One could interpret the high patient as a proxy for such effects. If that is the case, however, one would not want to maintain the substantial differences in discount factors as a permanent feature of our model. For this reason, in what follows we explore to alternatives. First, we assume that in the future the difference in patient will stay constant. We then explore the consequences of having discount factors converging (slowly) over time.

A final point on discount factor should be the observation that effective discount factors (that is the extent to which certain levels of future consumption are converted into utility) are also different across regions because of differences in mortality rates and adult equivalence scales, which, in turn, are affected by fertility patterns.

4 Calibration

Preliminaries: We calibrate parameters of the model using demographic and economic data that are available for periods between 1990 and 2010 in the five regions. We assume that all demographic and productivity parameters in the five regions converge to the same values by 2200, thus all regions converge to the same balanced growth path some time after 2200. We then let our world economy transit between the two steady-states, by imposing a gradually converging path of mortality, fertility and female participation rates as well as the level of aggregate and individual productivities. The model's period is set to 5 years.[2]

The Five Regions: The world in our model consists of five regions that differ in the timing of demographic transitions. *High Income region* includes United States, Canada, Europe, Japan, plus Australia and New Zealand. *Middle Income region* encompasses countries that recently experienced high economic growth and includes India, Russia, South Africa, South Korea, Taiwan, Thailand and Turkey. *Low Income region* includes countries in Africa (except for South Africa), other Asia and Oceania. The fourth region is China. *Latin America and Caribbean (LAC)* includes

[2] The calibration strategy matches a set of moments in the data with the model's counterparts in the *closed economy* equilibrium. The open economy equilibrium assumes the exact same parametrization and therefore have different levels of aggregate variables, such as output and capital stock.

countries in Central America, South America and the Caribbean.

Technological Parameters: We choose a Cobb-Douglas specification

$$F(Z_t^r, K_t^r, H_t^r) = Z_t^r (K_t^r)^{\alpha} (H_t^r)^{1-\alpha},$$

for the production function with capital share $\alpha = 0.30$ and its constant depreciation rate of 5% on an annual basis. The growth rate of TFP, λ_t^r in each region is set so that the region achieves the target average per-capita output growth rate, as computed from the World Bank's *World Development Indicators* (WDI) for the period of 1990-2010. We assume a constant growth rate until 2010 to match the historical average.

We set the initial value of TFP in High Income region Z_0^H in order to normalize income per capita to 1 in the first steady state. Based upon the WDI data, income per capita in High Income region was approximately three times larger than that of LAC region in 2010 and we set the value of Z_0^{LAC}, productivity in the initial steady state to match this ratio. Similarly, GDP per capita of Middle Income region, Low Income region and China were 0.19, 0.12 and 0.22 relative to that of High Income region, respectively. We set the TFP level of each region accordingly to match the relative size of GDP per capita. We assume that both the TFP level and the growth rate in the five regions converge to common values by 2150. We let the TFP growth rate of High Income region converge to the long-run value of 1.5% gradually by 2150. We assume that the TFP level of the other four regions will also converge to the level of High Income region by 2150 and thereafter all regions have the same TFP level and the long-run growth rate of 1.5%. Calibrated parameters are summarized in Table 1.

Table 1: Growth rate of TFP 1990-2010

Region	GDP per capita growth, WDI 1990-2010, data	TFP growth rate λ_t^r 1990-2010 calibrated	GDP per capita level, WDI 2010,data	Initial TFP level Z_0^r calibrated
1. High Income	1.3%	0.54%	1 (normalization)	1.372
2. Middle Income	3.4%	1.85%	0.19	0.407
3. Low Income	2.1%	1.08%	0.12	0.414
4. China	9.6%	6.62%	0.22	0.155
5. LAC	2.0%	0.49%	0.32	0.718

Demographic Parameters: Since each model-period corresponds to five years, we set $I^d = 3$ so that agents become adults and economically active at age 17 and we set $I = \bar{I} - I^d = 24 - 3 = 21$, so that households can live a maximum of 24 periods (120 years). We also set the retirement age $I^R = 11$ which corresponds to age 67. All these parameters are common in the five regions.

Age-specific fertility rates are based on the UN data and projections for 1990-2100. For the periods beyond 2100, we assume that fertility rates at each age converge by 2200 to those of High Income region projected for 2100.

Age-specific surviving probabilities in the five regions for the period 1950-2100 are computed based on the actual and projected data on population shares by age-group in the UN database. After 2100, we make the surviving rates smoothly converge to those of High Income region by 2200.

Another major demographic trend is the growth in female labor force participation rates. Our main data sources here come from historical labor market data of the International Labour Organization (ILO). In order to estimate the recent trend, we focus on the ILO data since 1970s, when we have more comprehensive coverage of the countries and population in each region. Figure 3 displays the trend in female labor force participation rates in the past five decades. Note that there are two data points available for China. In order to capture the long-run time trend in the female labor supply, separately from the time requirements and impact of dependent children on their labor supply, we estimate the following equation outside of the model for the participation rate of women $P^r_{i,t} \in (0,1)$ with an exponential trend for all regions except for China.

$$P^r_{i,t}(\mathbf{d}^r_{i,t}) = \psi^r_0 + (\overline{P} + \overline{T_i} - \psi^r_0)\{1 - \exp[-\psi^r_1 * (t-1)]\} + \sum_{j=1}^{I^d} \hat{\alpha}_j d^r_{i,j,t}, \tag{17}$$

where ψ^r_0 measures the participation rate for a female worker with no children in 1950.[3] $\overline{P} = 0.68$ is the long-run female participation rate, based on the projection of the Bureau of Labor Statistics (BLS) for the U.S. in 2020; $\overline{T}_i$ is the long-run value of time devoted by a woman of age i to child care (common across regions) computed from the final steady state value of the number of dependent children at age j, $d_{i,j,\infty}$ and the estimated time to take care of children $\hat{\alpha}_j$, i.e. $\overline{T_i} = -\sum_{j=1}^{I^d} \hat{\alpha}_j d^r_{i,j,\infty}$.; the parameter ψ^r_1 regulates the speed of convergence towards the long-run rate $\overline{P}$. The estimated parameters for High, Middle and Low Income and LAC regions are $(\psi^H_0, \psi^M_0, \psi^L_0, \psi^{LAC}_0) = (0.4191, 0.4276, 0.4248, 0.2349)$ and $(\psi^H_1, \psi^M_1, \psi^L_1, \psi^{LAC}_1) = (0.1686, 0.0527, 0.0810, 0.1294)$, respectively.

For China, female participation rates at available data points in the last few decades are high and remain stable at about 78% in 1980s and 90s and declines slightly to 76% in 2000s. Therefore we estimate the function (17) without a time trend until 2000 and make the female participation rates change only through the time-varying vector $\mathbf{d}^r_{i,t}$ that indicate the number of dependent children until 2000. Thereafter, we assume that the participation rates of women without children will linearly converge to the level so that the average participation rate will reach the same long-run value of $\overline{P} = 0.68$ in the final steady state.[4]

[3] Substituting $t = 1$ and $d^r_{i,j,t}$ in equation (17) yields $P^r_{i,t}(\mathbf{d}^r_{i,t}) = \psi^r_0$. Note that the model period starts in 1990 and the formula for the participation rates are adjusted accordingly.

[4] Although we do not have the decomposition of the participation rates by occupations or regions, it is possible that high female workers' involvement in the farming sector contributed to the high female labor force participation in earlier data, which may shift in future as a result of urbanization and a change in the Chinese industrial structure. Therefore, we assumed that the labor force participation rate will decline and converge to that of the other regions in the long-run, rather than assuming it to remain high at around 80%.

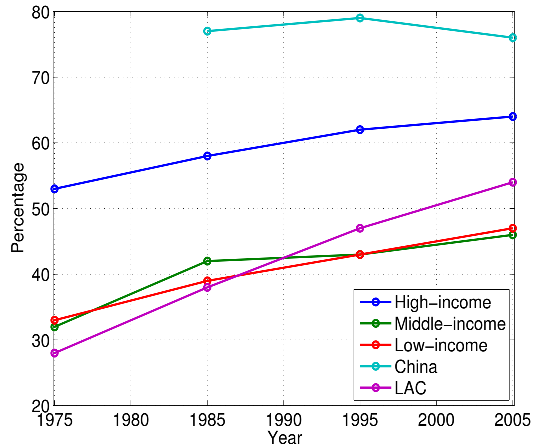


Figure 3: Female labor force participation rate in five regions: ILO data

Once the female participation rates $P^r_{i,t}(\mathbf{d}^r_{i,t})$ are computed for each region, we can derive $\Lambda^r_{i,t}(\mathbf{d}^r_{i,t})$, the fraction of the time endowment (normalized to one) worked by the household of spouses, i.e. $\Lambda^r_{i,t}(\mathbf{d}^r_{i,t}) = 0.5[1 + P^r_{i,t}(\mathbf{d}^r_{i,t})]$, where the husband is assumed to work full time.

As in Attanasio, et al (2006), the data from the Consumer Expenditure Survey (CEX) are used to estimate the marginal effects α_j of the presence of a pair of dependent children at age j (0-4, 5-9 and 10-14 years old) on women's probability of participation. The Probit regression, which controls for several individual characteristics including age, race and education, yields $\alpha_{0-4} = -0.146$, $\alpha_{5-9} = -0.0960$, $\alpha_{10-14} = -0.0464$. The coefficients are negative and significant and younger children have stronger impact on the probability of female participation. Figure 4 displays the estimated participation rates of female from 1950 to 2200 in each region as well as the contribution of the fertility trend, relative to the value in 1950 which is set at zero.

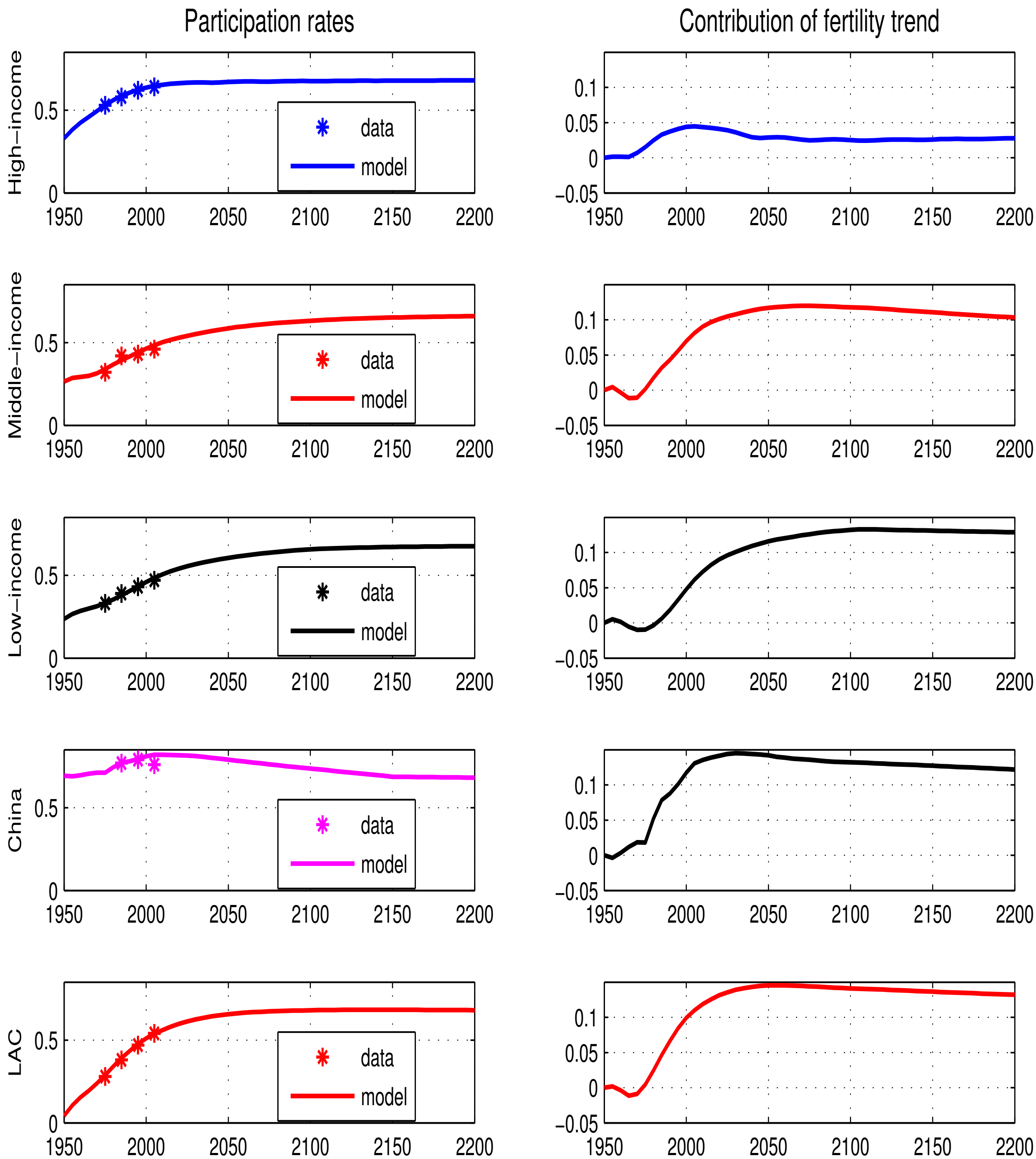


Figure 4: Estimated female labor force participation rate in five regions

We normalize the total population in High Income region in 1990 to one and set the initial population size for the other four regions to 1.2024, 1.4425, 1.0967 and 0.4267 respectively, based on the UN population data in 1990. During the transition away from the initial steady-state, the population size in the five regions is determined by the evolution of age-specific fertility rates $\phi^r_{i,t}$ and survival rates $s^r_{i,t}$.

Preferences and Endowments Parameters: Following the bulk of the literature on consumption (for a survey, see Attanasio, 1999), we set $\theta = 2$. The weight parameter of children in the utility of adult parents is set to match the commonly used consumption adult-equivalent scales. The micro-evidence on equivalence scales summarized in Fernandez-Villaverde and Krueger (2006, Table 3.2.1) points at a ratio between the consumption of a household with 1, 2 and 3 children compared to a household without children of 1.231, 1.470, and 1.694, respectively. Using equation (2), it is easy to see that our function $\omega\left(d^r_{i,t}\right)$ should satisfy the three moment conditions

$$\begin{aligned}
\omega\,(0.5)^{\frac{1}{\theta}} &= (1.231 - 1)\,/0.5, \\
\omega\,(1)^{\frac{1}{\theta}} &= (1.470 - 1)\,, \\
\omega\,(1.5)^{\frac{1}{\theta}} &= (1.694 - 1)\,/1.5.
\end{aligned}$$

Note that we need to make an adjustment for the fact that in our model children come in pairs. Given $\theta = 2$, setting $\omega = 0.216$ independently of the number of children yields an excellent fit.

We set β^r to match the target capital-output ratio in each region in 2010. The annual discount factors are $\{1.0260, 1.0292, 1.0315, 1.1059, 1.0123\}$ for each of the five regions (High Income, Middle Income, Low Income, China and LAC), which are set to match the target capital-output ratio of $\{3.7, 2.8, 3.1, 3.3, 3.3\}$, respectively.[5]

We chose to use a region-specific discount factor since the model is able to approximate better heterogeneity in saving intensity across regions by assuming heterogeneous degree of impatience across regions. The region-specific discount rates implicitly capture various factors that lead to different saving behaviors such as the stage of development in the financial market or policies that encourage or discourage saving which are not explicitly modeled in our framework. We assume that the

[5]The capital-output ratio is based on the data from Penn World Table in 2010. For China, we use the average in 2000-2010, as the capital-output ratio has grown from less than 2.8 to 4.1 from 2000 to 2010 and it is difficult to find an equilibrium of the model if we assume that an extremely high discount factor that would match the ratio of 4.1 lasts indefinitely.

subjective discount factor in each region remains constant over time in the baseline simulations, but conduct sensitivity analysis in section 5.2, where we assume they will converge to a common value in the long run.

The calibration of the age profile of efficiency units is done separately for each region. The age-efficiency profile for LAC region is estimated using Mexican micro data, *Encuesta Nacional de Ingreso y Gasto de los Hogares* (ENIGH), which is the equivalent of the U.S. CEX, using the 1989, 1992, 1994, 1996, 1998, and 2000 waves.[6] The sample, across both surveys, is the universe of married couples headed by males and aged 17-69 and the derived "household wage" is an average of male and female wage weighted by hours worked. For High-Income region, we use weekly wage data from the U.S. *Consumer Expenditure Survey* (CEX) for the period 1982-1999. For Middle Income region, we assume the same profile as LAC region. For Low Income region, we use the age-efficiency profile in Bangladesh, estimated by Kapsos (2008), who uses a national occupational wage survey conducted by the Bangladesh Bureau of Statistics (BBS) in 2007 with the support of the ILO. We use the estimated coefficients of the hourly wage regression, that controls for age and education levels. Finally for China, we use Chinese Household Income Project (CHIP), a survey of Chinese households in urban and rural areas. We use individual data from the urban income, consumption and employment questionnaire and estimate the wage profile using a sample of household heads aged 20-65 in the 1995 and 2002 waves of the survey. The regression includes the age and education of an individual and we take the weighted average of spouses' wages to derive a household wage.

Figure 5 shows estimated profiles for the five regions, where the wage at age 17 is normalized to 1 in each region. High Income region has the steepest slope, followed by Middle Income region, China and Low Income region. The peak of the wage is at around 45-50 years old in High and Middle Income regions, while the profile is much flatter and a mild peak arrives at age above 50 in the other two regions. We assume that the age-wage profiles will remain as in Figure 5 until 2010, when they start to gradually converge to the profile of High Income region by 2200.

[6]See Attanasio and Szekely (1999) for a detailed description of the Mexican survey data.

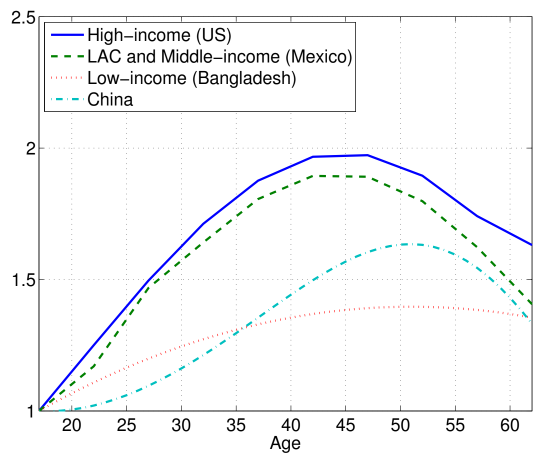


Figure 5: Wages over the life-cycle

Government Policy Parameters: We obtain the ratio of the government debt B_t^r as a fraction of GDP from the IMF's World Economic Outlook Database (WEO). We use the net debt variable that represents the gross debt net of financial assets. In LAC region, the average over the period 1990-2010 was 34% of GDP. The net debt level was 48%, 39% and 51% in High, Middle and Low Income regions. For China, only gross debt data is available, which is 13.8% of GDP. Since we do not have the data for the government's financial assets, we assume the net debt of 10% of GDP in the baseline calibration.

The total government expenditures as a fraction of GDP are also obtained from the WEO, available since 1980s. The average over 1980-2000 was 24% in LAC region and 39%, 24%, 22% and 20% of GDP in High, Middle and Low Income regions and China, respectively. Since these figures represent general public expenditures, which include spendings for social security and interest payment, we compute the ratio of the government expenditures G_t^r to GDP so that the total expenditures match the ratios from the WEO database as reported above. The ratios of G_t^r to GDP was 26.4% for LAC and 30.0%, 24.5%, 23.7% and 18.3% for each of the other four regions.

Based on the study of OECD, the replacement rate of pensions to the average earnings is set at $\kappa_t^r = 58.0\%$ in High Income region.[7] Unfortunately, similar systematic studies on the replacement rates for other regions are not available. The

[7]OECD, Pension at a Glance, 2013.

average replacement rate is likely to be much lower than in High Income region due to two factors. First, the disproportionate role of self-employment and informal production means that a vast part of the working population is not covered by a public pension system. Second, the involvement of governments in the pension sphere is limited: in Asia, only Korea and Taiwan operate a defined benefits PAYG scheme with universal coverage; Latin America is the region with the largest number of pension system already reformed towards substantial privatization (see Mohan, 2004, for the Asian experience; see Corbo, 2004, for the Latin American experience). We set the replacement rate κ_t^r in other four regions at 10%, which is also the value used in Attanasio, Kitao and Violante (2006 and 2007) for the area that encompasses the countries in the four regions.

We estimate effective tax rates following the method of Mendoza, et al (1994), using data in 2000-2010, for all regions except for China, for which necessary data are not available from the same database. Consumption tax rate τ_c^r is set at 9.7%, 15.6%, 6.3% and 16.4% for High Income, Middle Income and Low Income region and LAC, respectively. Capital income tax rate τ_a^r is 35.7%, 18.4%, 13.5% and 11.5%. For China, we use estimates of Cui, et al (2011) and set consumption tax at 7.7% and capital income tax at 25.7%.

In the benchmark experiment, the labor income tax $\tau_{w,t}^r$ in each region adjusts along the equilibrium path of the model to balance the government budget.

5 Numerical results

In this section, we present results for a number of simulations where we compare transition dynamics under two scenarios: open and closed economies. We study the evolution of key economic variables in the five regions of the world we have described above: High Income, Middle Income, Low Income, China and LAC. The economic variables we look at include capital, output, saving, saving rates, interest rates, wage rates, equilibrium tax rates, current account and external wealth. We will first carefully examine features of the baseline scenario and second conduct several additional exercises to understand the driving force of saving dynamics over the transition periods and sensitivity of our results to alternative assumptions of the model.

5.1 Baseline scenario

Figure 6 shows the paths of the interest rate in the five regions when the economy is closed without capital mobility, together with the path of the world interest rate when there is full capital mobility. We focus on and display results for the time period of 2010-2100. In the closed economy scenario, LAC, Low Income and Middle Income regions start with higher interest rates than in High Income region and China. In the former three regions, capital is more scarce relative to labor than in the latter two and therefore interest rates are higher. The interest rate will start to decline after 2010 in all five regions because of the demographic trends we saw in section 1. A rise in longevity increases saving to cover consumption expenditures for a longer retirement period. Lower fertility rates and fewer dependent children in a household imply a larger fraction of disposable income allocated to savings. As the demographic transition stabilizes and fertility rates increase, interest rate starts to rise in mid-2020s in High Income region, but the decline continues until much later in other regions of the world.

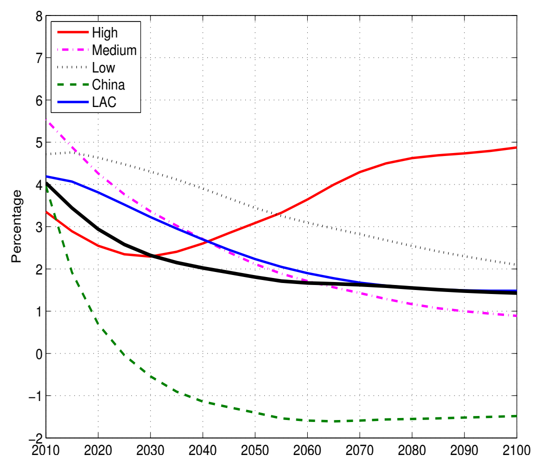


Figure 6: Baseline scenario: interest rates of the world. The thick solid line (black) represents open economy.

Figure 7 extracts from Figure 6 the closed and open economy interest rate in LAC. Our model projects the interest rates to decline throughout the century in LAC and fall from above 4% in 2010 to almost 1.5% in the closed economy. The trend is driven by a decline in the fertility rates that will continue until the middle of the century and a rise in life expectancy. In our model, the open economy interest rates decline as well but the path always lies below that of the closed economy, implying that the capital will flow into LAC from other regions of the world in the open economy and capital becomes more abundant relative to labor.

Figure 8 shows the path of the equilibrium wage rate in LAC generated by our model, in closed and open economies. The inflow of capital into LAC makes labor more scarce and capital more abundant and therefore the wage rates are higher in the open economy, just the opposite of the path of interest rate.

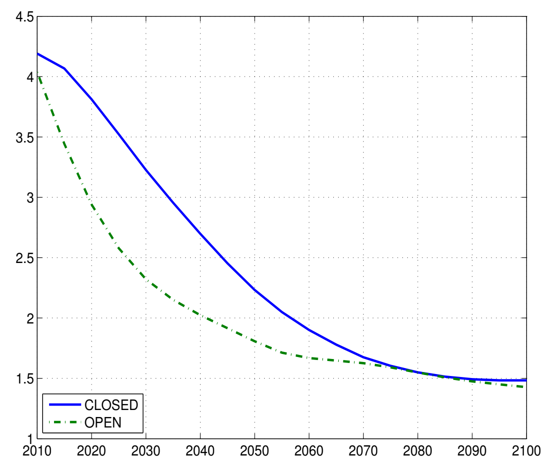


Figure 7: Baseline scenario: interest rates in LAC

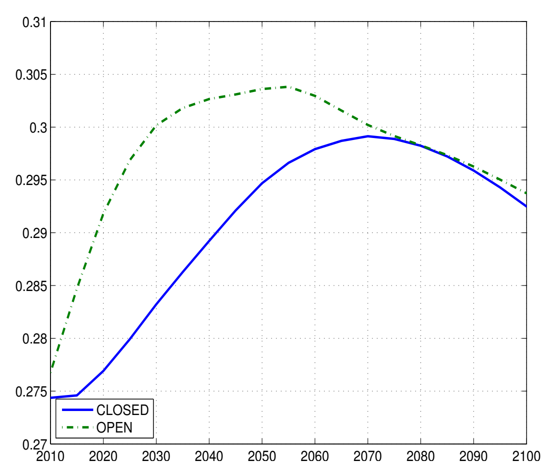


Figure 8: Baseline scenario: wage rates in LAC

Figure 9 presents our simulation results for the equilibrium tax rates in LAC, in closed and open economies. Tax rates are derived in equilibrium so that the consolidated government budget constraint is satisfied in each period. Tax rates rise gradually in both closed and open economies as the old-age dependency ratio rises and the expenditures for social security payment increase. The change, however, is not very large, rising from about 26% to 30% in the closed economy and from 25% to 30% in the open economy, since we assume that the replacement rate is and remains relatively low at 10%. In section 5.2, we will conduct an experiment in which the social security replacement rate is higher and assess the effect on equilibrium labor income taxes.

The tax rates in the open economy are lower than in the closed economy until about 2060, though the difference is not very significant, at less than 2% at most. In LAC, the main tax revenues come from labor taxes. Although the interest rate is lower and the capital tax revenue is smaller in the open economy, the wage is higher as we saw in Figure 8, which makes the budget balancing labor tax rate lower in the open economy.

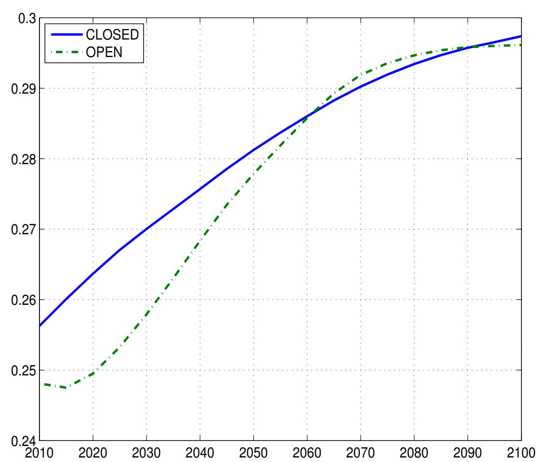


Figure 9: Baseline scenario: labor income tax rates in LAC

Since, in our model, there will be more capital in the open economy due to the capital inflow from other regions, capital used in the production is higher in the open economy as shown in Figure 10. Figure 11 shows the paths of output per capita, which shows the similar difference between closed and open economies as in the path of capital.

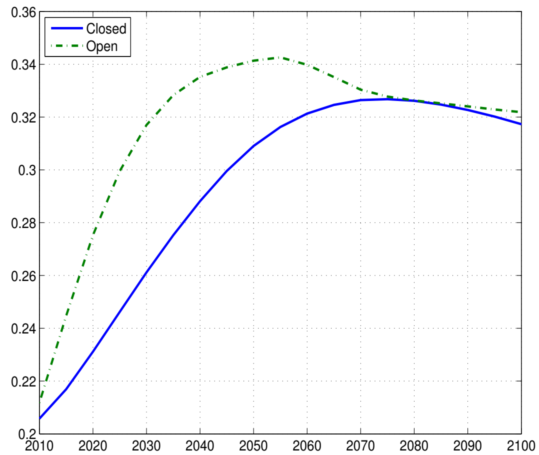


Figure 10: Baseline scenario: capital per capita in LAC

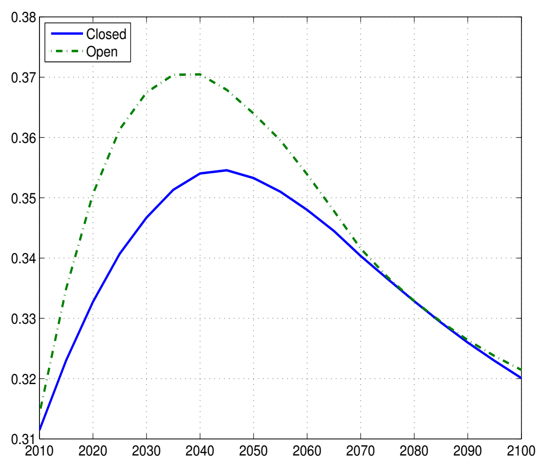


Figure 11: Baseline scenario: output per capita in LAC

Figure 12 displays how the current account evolves in LAC under the open economy scenario. The current account is defined as the difference between aggregate domestic savings and aggregate gross investments in the region. A surplus indicates a net capital outflow from the region and an increase in the external wealth held by the region. Our model simulations predict that LAC will run a deficit during the initial two decades of the transition, before it turns to a surplus in late 2020s. The current account will remain positive for several decades until the region starts to run a deficit in around 2080. The underlying stocks of external wealth are shown in Figure 13, where it is shown as a percentage of GDP in LAC.

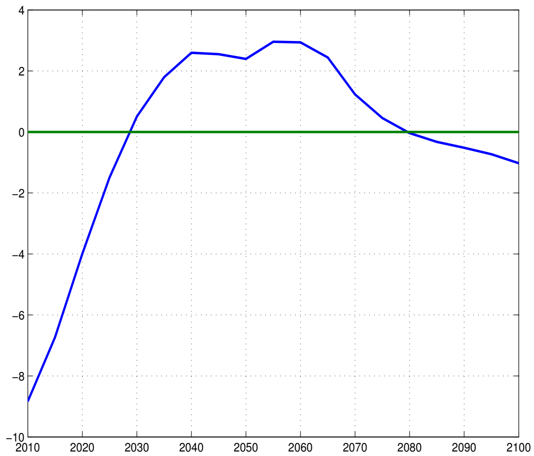


Figure 12: Baseline scenario: current account as percentage of GDP in LAC

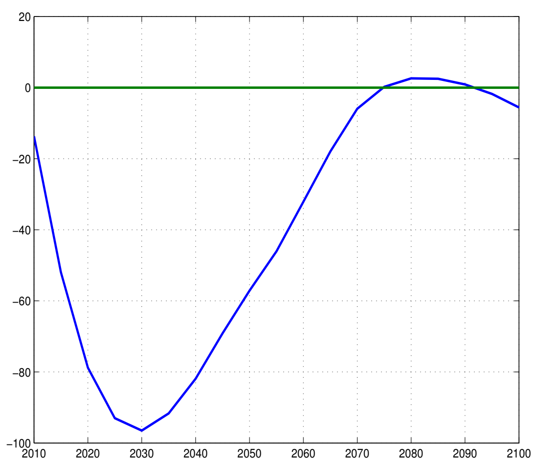
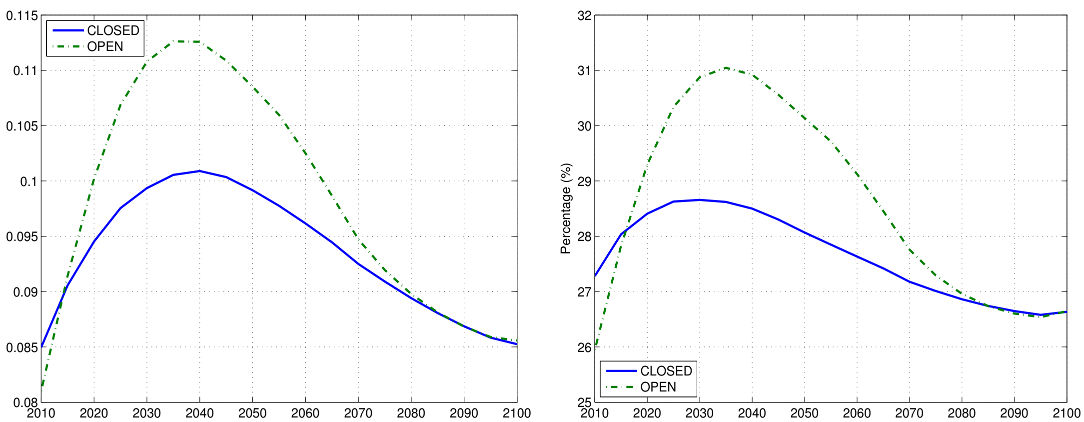


Figure 13: Baseline scenario: external wealth as percentage of GDP in LAC

Figure 14 shows the paths of the saving per capita and saving rates. The saving is defined as $Y_t - C_t - G_t$ in the closed economy and $Y_t - C_t - G_t + r_t N_t$ in the open economy. Saving rates are computed as the ratio of the saving to the total income, that is, Y_t and $Y_t + r_t N_t$ in the closed and open economies, respectively.

As the fraction of old-age individuals, who are consumers rather than savers, rises, the saving rates in our model tend to decline. The effect is offset by an increase in savings associated with a decline in fertility rates and stronger saving motives for retirement with a longer life-expectancy. The fertility rates decline in the first half of the century but stabilize and increase slowly thereafter. The model predicts a rise in saving rates in the next few decades, which is followed by a moderate decline in the close economy. In the open economy, the saving rates rise more rapidly since there will be more capital used in the production in the region because of the capital inflow and output is higher than in the closed economy.



(a) Saving per capita (b) Saving rate

Figure 14: Baseline scenario: saving in LAC.

Figures15 to 18 show the path of four variables in closed and open economies in other four regions. Both High Income region and China will have capital outflow initially and as shown in Figure 15, the wage rate is lower in the closed economy as labor becomes more abundant relative to capital in the open economy. The open economy wage rate will be higher after 2030s in High Income region as the capital starts to flow into the region. China continue to be a capital exporter and the wage rate will remain below the level in the closed economy throughout the century. Labor income tax rates will rise rapidly in High Income region, as it becomes increasingly more costly to finance its generous social security system, as shown in Figure 16. The tax will be lower in the open economy as the wages are higher than in the closed economy.

Figure 17 shows the path of capital per capita in the four regions. The economy will possess more capital in Middle Income and Low Income regions initially, thanks to the investment from abroad. Middle Income region will switch to a capital exporter in about 2060 and start to earn capital income from investment in other regions of the world. Figure 18 shows the dynamics of current account, changes in the external wealth of the four regions.

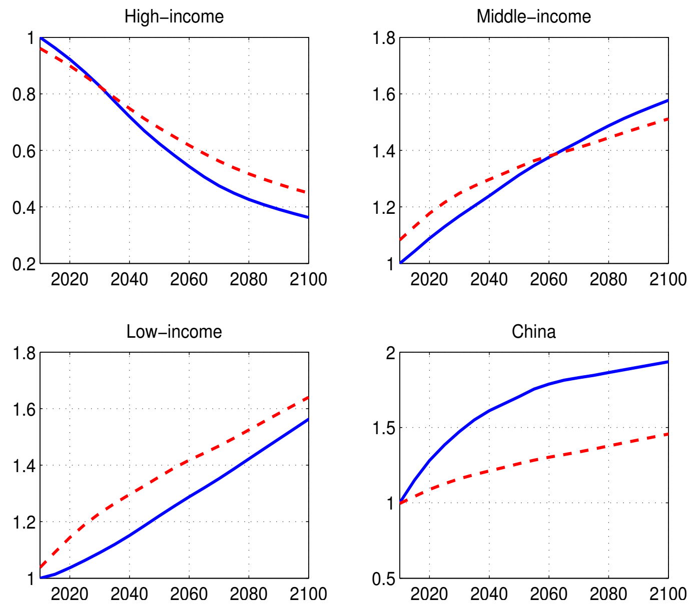


Figure 15: Baseline scenario: wage rates in other four regions. Solid lines represent closed economy and dashed lines represent open economy.

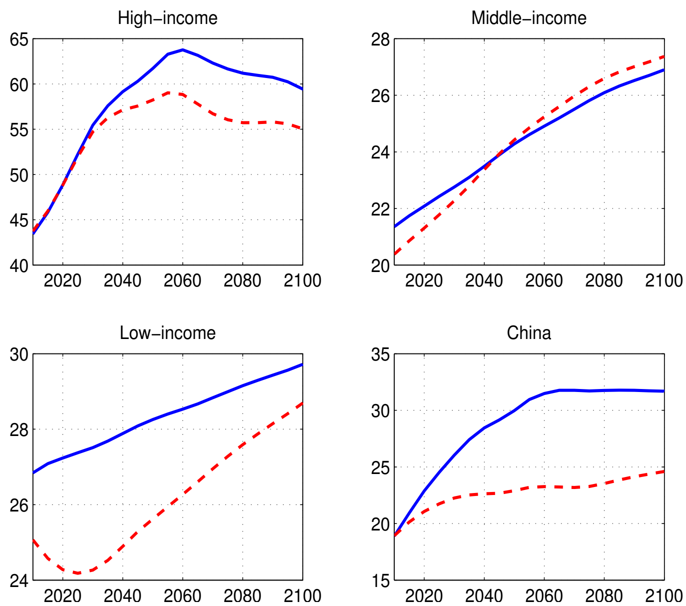


Figure 16: Baseline scenario: labor income tax rates in other four regions. Solid lines represent closed economy and dashed lines represent open economy.

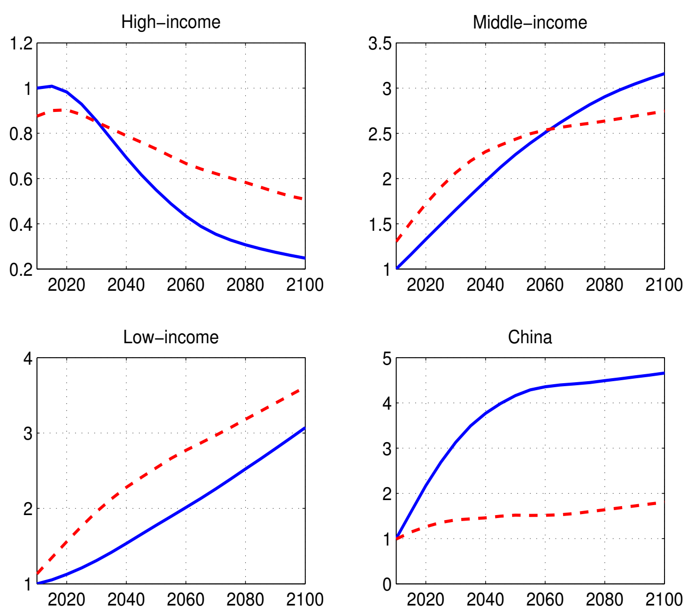


Figure 17: Baseline scenario: capital per capita in other four regions. Solid lines represent closed economy and dashed lines represent open economy.

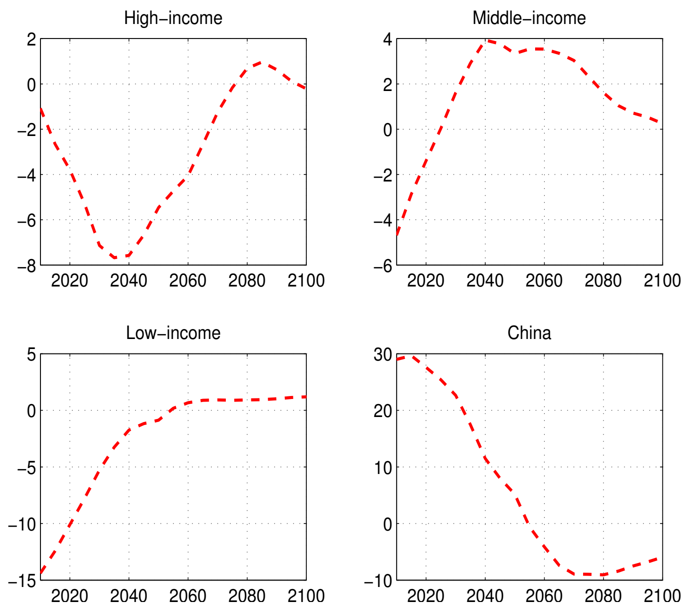


Figure 18: Baseline scenario: current account in other four regions. Solid lines represent closed economy and dashed lines represent open economy.

5.2 Experiments

In this section we will simulate our model under alternative assumptions about calibrated parameters and the path of demographic variables in order to understand better the determinants of key economic variables.

5.2.1 Convergence of the discount factor β_t^r

In the baseline model, we calibrated the subjective discount factor β_t^r in each region so that the model matches the capital output ratio as in the data and assumed that the discount factor will stay constant over time. In this section, we simulate the model assuming that the discount factor will converge to a common value, the calibrated discount factor of High Income region. We let the convergence take place gradually so that they will all reach the common value by 2150.

Given the calibrated discount factors of $\{1.0260, 1.0292, 1.0315, 1.1059, 1.0123\}$ in the five regions (High, Middle, Low Income, China and LAC), the convergence implies a slight decline in the discount factor for Middle and Low Income regions, a major decrease for China and a moderate increase for LAC. As shown in Figure19, the interest rate in the closed economy will be higher in LAC than in the baseline scenario of a constant discount factor since households are more patient and try to increase saving to consume more in future, to which they place a higher preference weight. The interest rate will be lower in China when we assume that the discount factors converge, as they will become less patient over time and saving will decline.

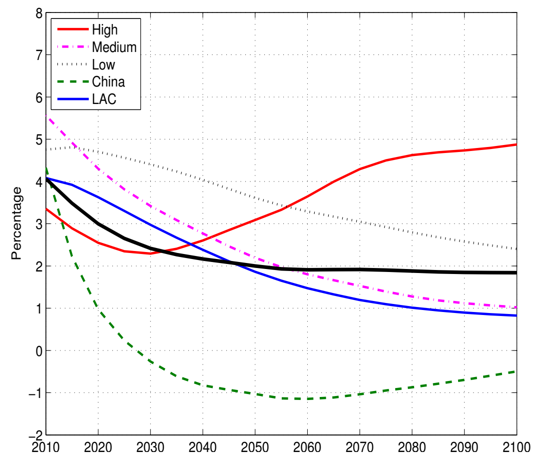


Figure 19: Convergence in discount factor: interest rates of the world. The thick solid line (black) represents open economy.

Figure 20 shows that the interest rate in the closed economy in LAC is much lower than in the open economy interest rate, which is due to a stronger saving incentives and a greater amount of capital, as shown in Figure 21. Households in LAC will invest more in other regions of the world in the open economy and as shown in Figure 22, LAC will start to run a current account surplus in 2025, several years earlier than in the benchmark and the balance remains positive until early 2090s, much later than 2070s in the benchmark.

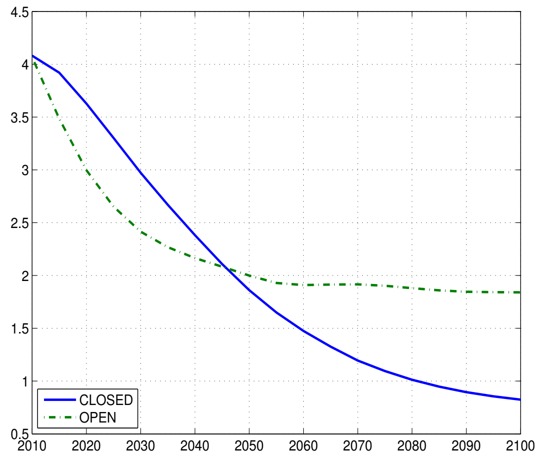


Figure 20: Convergence in discount factor: interest rates in LAC

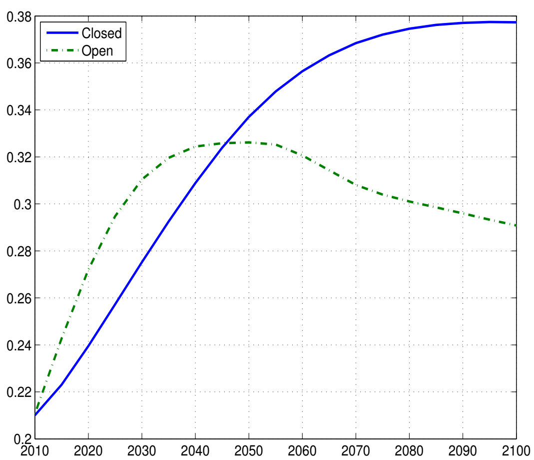


Figure 21: Convergence in discount factor: capital per capita in LAC

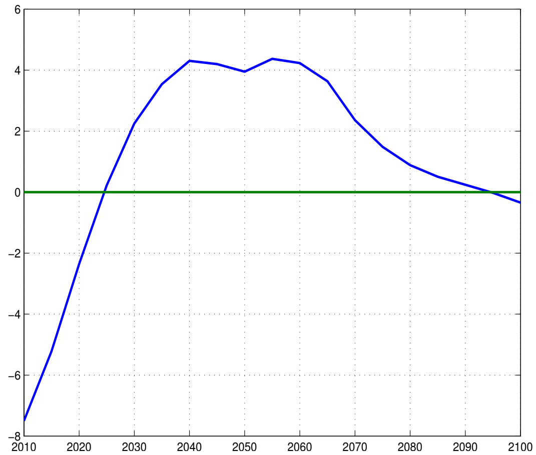
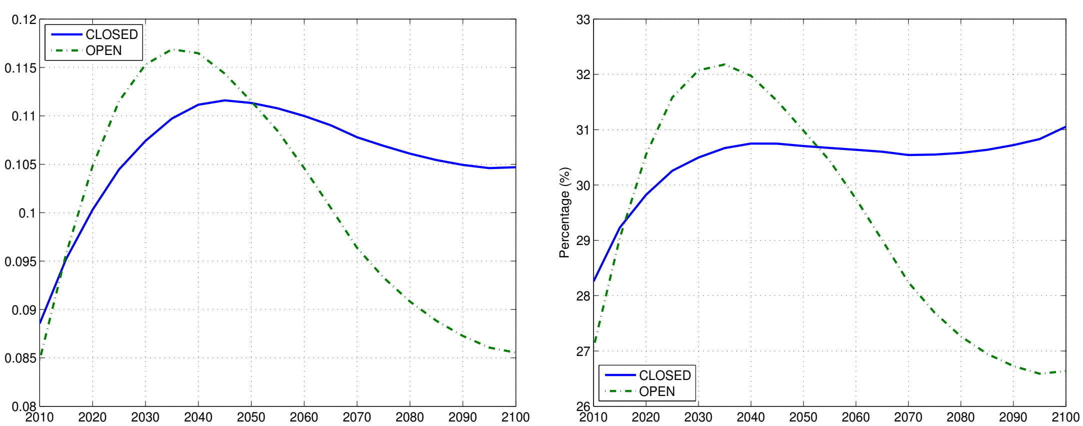


Figure 22: Convergence in discount factor: current account as percentage of GDP in LAC

Figure 23 shows that the saving is much higher in the closed economy when the discount factor converges to a higher level, about 10% above the level in the benchmark at the peak. The saving rate is also higher, by 2 to 4 percentage points throughout the transition.



(a) Saving per capita

(b) Saving rate

Figure 23: Convergence in discount factor: saving in LAC.

5.2.2 Effects of demographic transition

In order to understand the roles played by the changes in the demographic parameters, we compute transition dynamics under two alternative assumptions about demographic variables. In the first, we assume that the survival rates are fixed at the level of 2010 in all five regions of the world throughout the transition. In the second, we fix fertility rates at the initial steady state level. The exercise will help quantify the roles of each factor and decompose the changes in key macroeconomic variables including saving rates.

Roles of rising survival rates: Figures 24 and 25 show the paths of the interest rate and capital per capita in LAC, respectively, when we fix the survival rates unchanged throughout the transition. The saving will be much lower without the increase in longevity and it is about 10% lower at the peak of the closed economy compared to the benchmark economy. The interest rate does not decline as sharply as in the benchmark and the lowest interest rate is about 2.6% reached in 2080s, rather than 1.5% in the benchmark.

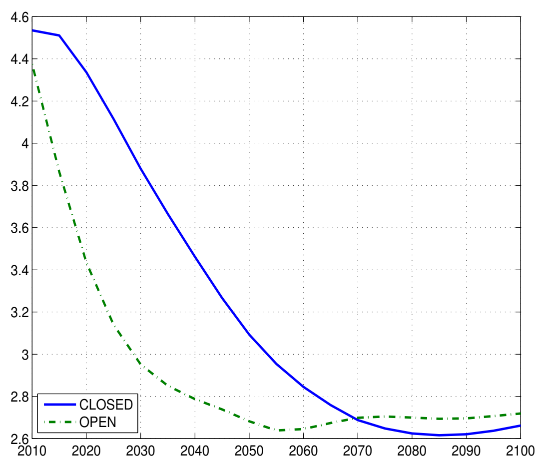


Figure 24: Constant survival rates: interest rates in LAC

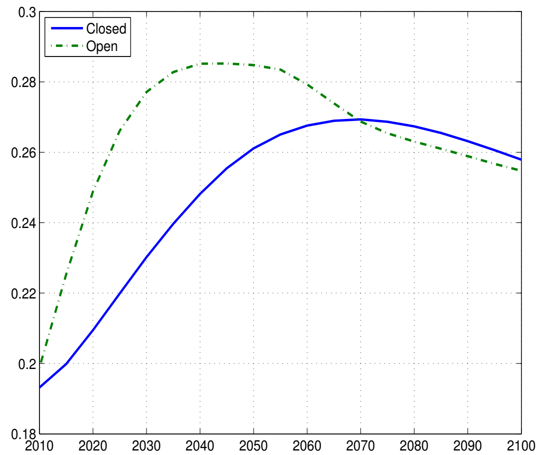
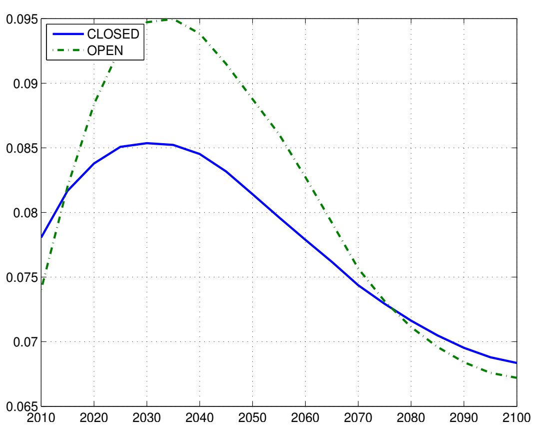
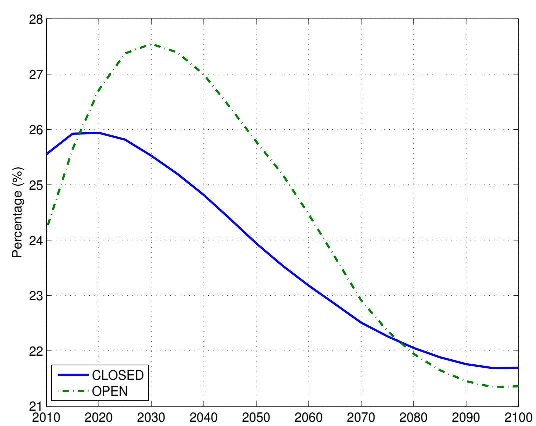


Figure 25: Constant survival rates: capital per capita in LAC

As a result of fewer incentives to save for retirement because of the shorter life-expectancy than in the benchmark, the saving rates are lower, at about 26% at the peak and declining sharply thereafter to fall below 22% by the end of the century in the closed economy, while the saving rate in the benchmark economy stay in the range of 26 to 29% throughout the transition.



(a) Saving per capita



(b) Saving rate

Figure 26: Constant survival rates: saving in LAC.

A case of low "subjective" survival rates: What if households in LAC underestimate the survival rates and make life-cycle decisions accordingly? We simulate a model assuming that households underestimate their life-expectancy and continue to hold the belief even if they see the distribution of mortality risks that deviates from their belief. More precisely, we assume that households think the survival rates are lower by 1% than actual rates at each age, which implies that the life-expectancy at the end of the century will be about 7 years shorter than in the benchmark.

Such underestimation will have qualitatively similar effects as the scenario of constant survival rates we studied above. Figure 27 shows the path of capital per capita, which is lower than in the benchmark. We are assuming that only households in LAC underestimate the longevity in this experiment and the capital in the open economy is not very different from that in the benchmark. As shown in Figure 28, the saving is also lower than in the benchmark closed economy, as they mistakenly think that their life-expectancy is low and face fewer incentives to save for retirement.

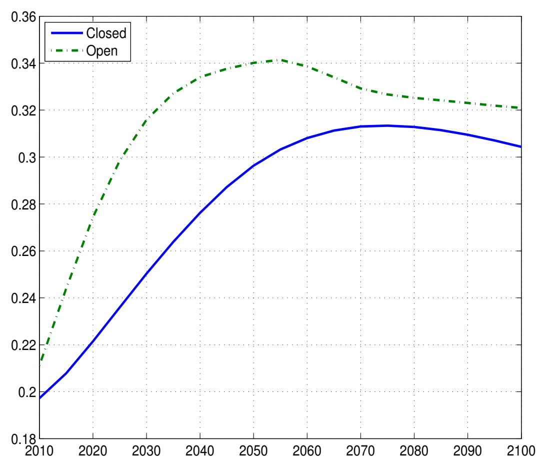
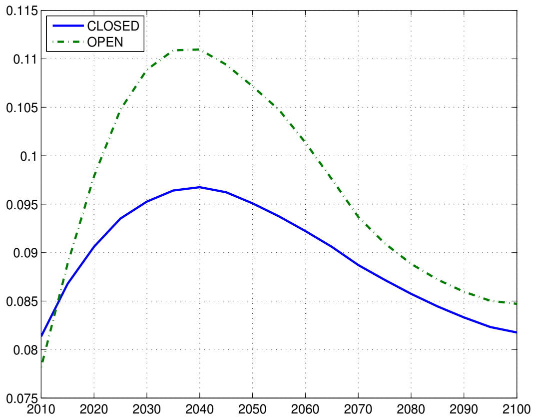
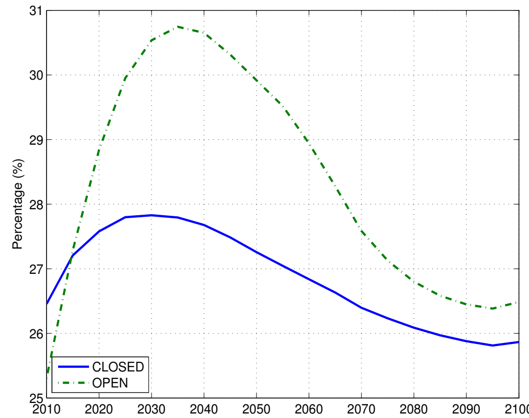


Figure 27: Underestimated survival rates: capital per capita in LAC



(a) Saving per capita



(b) Saving rate

Figure 28: Underestimated survival rates: saving in LAC.

Roles of changing fertility rates: As we saw in Figure 1, total fertility rate is projected to decline further from about 2.2 in 2010 to less than 1.8 in 2040 in LAC, when it starts to rise gradually towards the end of the century, though it only recovers to about 1.9, much lower than the initial level in 2010. In this section, we simulate our model assuming that fertility rates will remain constant and fixed at a high level of 2010 throughout the transition, in order to assess the roles of the fertility rate dynamics.

As shown in Figure 29, in the closed economy the capital will be lower throughout the century with a constant and high fertility rate. Households need allocate more of their disposable income for consumption to support a larger number of children in a family.

In China and High Income regions, where the fertility rates are projected to rise, the experiment will hold the fertility rates at a lower level than the projected level. In these regions, capital will be higher and the interest rates are even lower than in the benchmark economy. As a result, there will be a greater divergence of the interest rates between the closed and economies and a large capital inflow from the regions of low interest rate to LAC is observed. The capital and saving in the open economy will be much higher than in the benchmark economy as shown in Figure 29, an opposite result from what we observe in the closed economy.

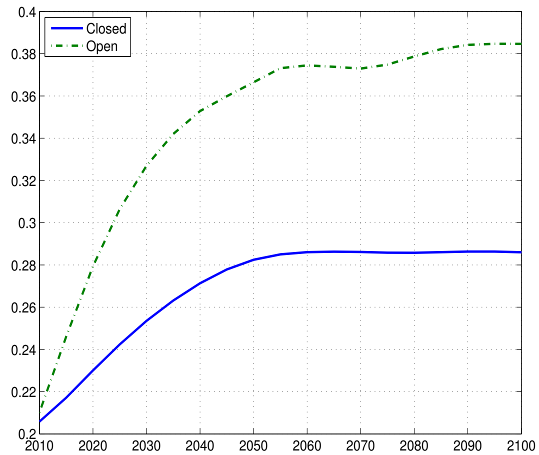
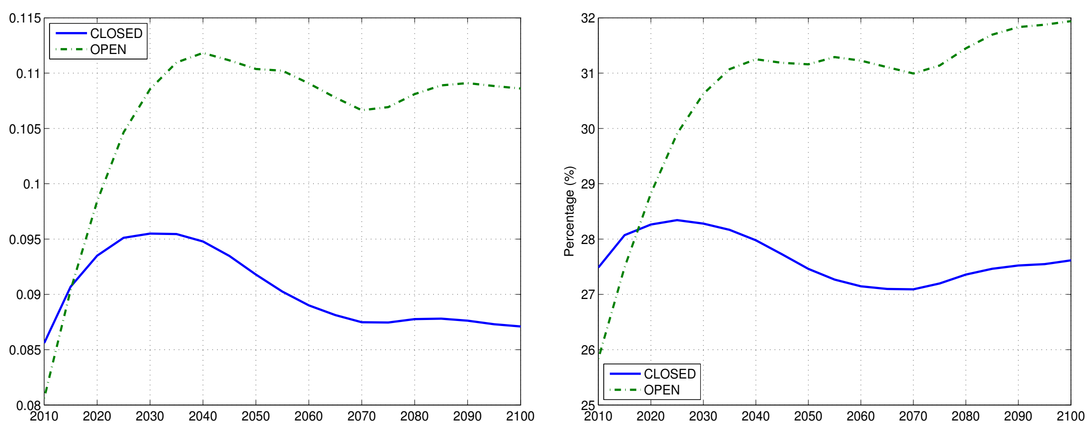


Figure 29: Fixed fertility rates: capital per capita in LAC



(a) Saving per capita

(b) Saving rate

Figure 30: Fixed fertility rates: saving in LAC.

5.2.3 Pension replacement rate

In this section we compute an equilibrium transition path assuming that the LAC has more generous public social security system. We set the pension replacement rate of LAC at 30%, instead of 10% in the benchmark economy. This experiment also approximates the scenario in which the government can comprehend earnings of individuals better for the purpose of providing public pension benefits.

With a rise in pension benefits, equilibrium tax rates will be higher as shown in Figure 31. The tax keeps rising throughout the century and reaches about 37% in 2100, while it was less than 30% in the benchmark economy.

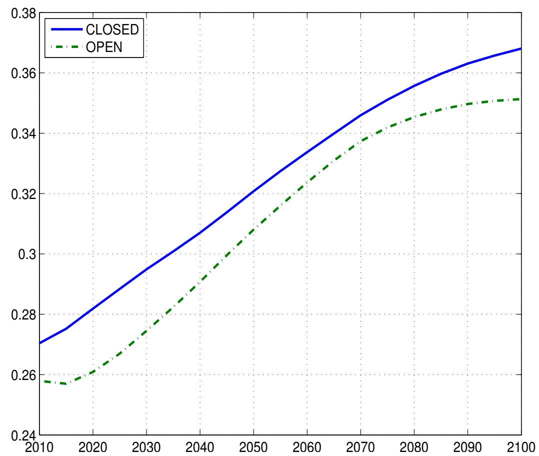


Figure 31: More generous social security: labor income tax rate in LAC

As shown in Figure 32, capital per capita is much lower than in the benchmark closed economy. In 2060, for example, capital per capita is 17% lower when the pension replacement rate is higher at 30%. As households expect to receive more generous retirement benefit from the government, they have fewer incentives to save on their own for retirement. As a result, aggregate capital declines and so does output of the economy. Figure 33 shows the effects on saving. The saving rate in the closed economy is much lower than in the benchmark, reaching below 22% by 2100 while it was above 26% in the benchmark.

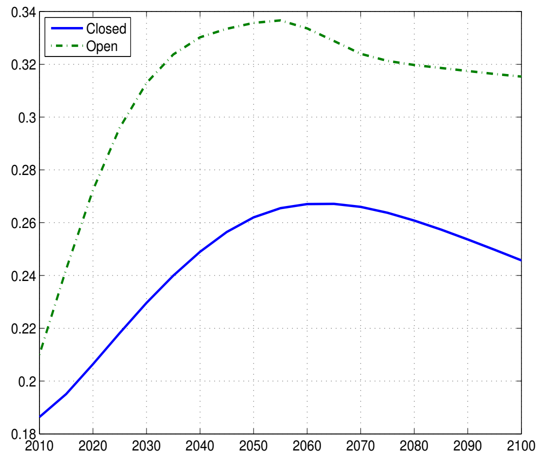
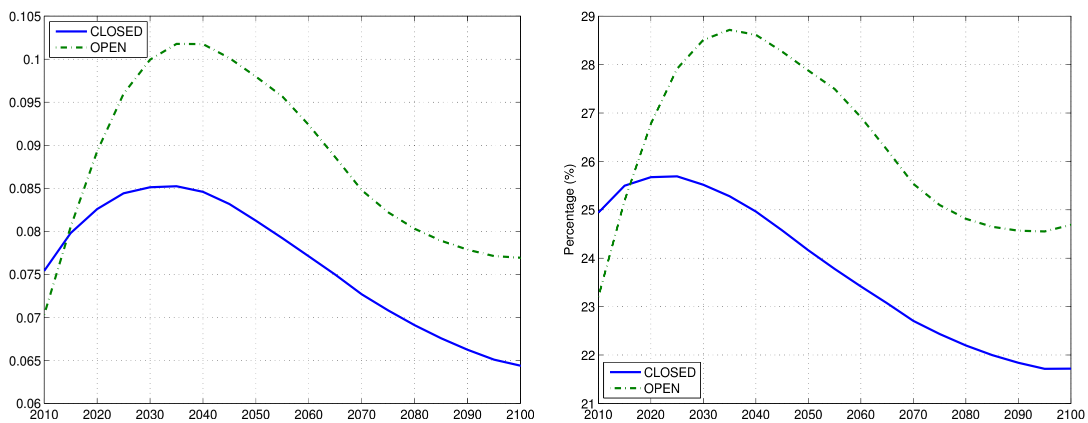


Figure 32: More generous social security: capital per capita in LAC



(a) Saving per capita

(b) Saving rate

Figure 33: More generous social security: saving in LAC.

5.2.4 Alternative fiscal adjustment

In the baseline simulations, we adjusted labor income tax in each period of the transition so that the government budget is satisfied. In this section we consider alternative scenarios of financing the demographic transition.

In the first, we use consumption tax instead of labor income tax to achieve the fiscal balance. Figure 34 shows the path of equilibrium consumption tax rates in the closed and open economies in LAC. The consumption tax rate would have to rise from about 17% in 2010 to 24% in 2100, with an increase of 8 percentage points in the closed economy. A rise of a similar magnitude is needed in the open economy as well. Compared to the transition financed by labor income tax, capital is slightly higher during the transition but the difference is small. Rising consumption taxes will make the tax-inclusive cost of consumption higher in future and induce households to consume more upfront and save less for future, but at the same time, they face incentives to save more to smooth the consumption over the time periods, which offsets the first negative effects on savings. As shown in Figure 35, the savings are slightly higher than in the baseline case, but the difference is small.

Note that in our model labor supply is exogenously set over the life-cycle and there may be more actions in response to a change in labor income taxes if a model endogenizes labor supply.

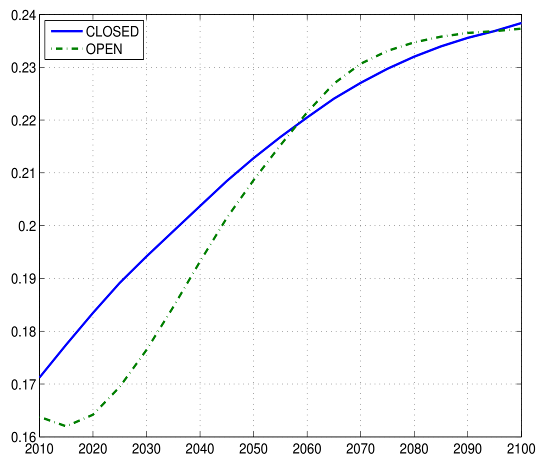
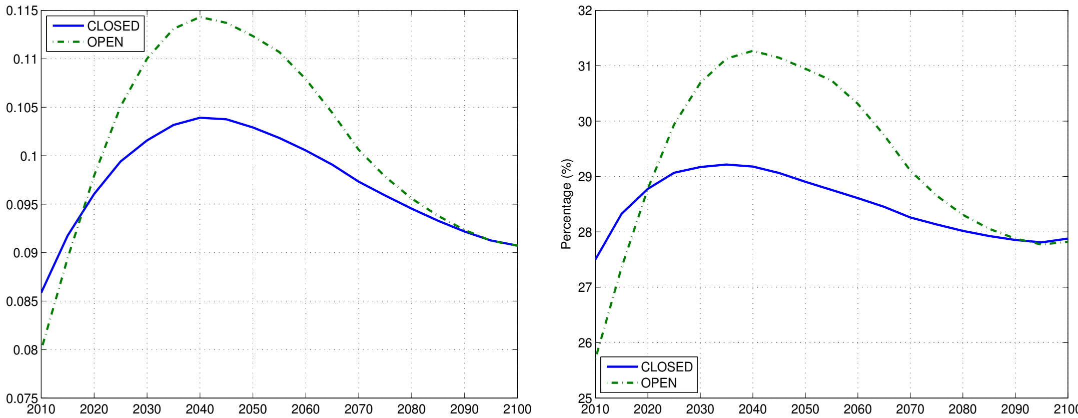


Figure 34: Transition financed by consumption tax: consumption tax rate in LAC



(a) Saving per capita

(b) Saving rate

Figure 35: Transition financed by consumption tax: saving in LAC.

Next, we consider an increase in debt to GDP ratio during the transition. Given a rapid rise in expenditures with aging demographics, we find that debt alone cannot cover the rising imbalance of the government budget. Therefore, we exogenously set the path of debt to GDP ratio and use labor income tax to absorb the residual expenditures of the government, in the same way as in the benchmark simulations. We assume that the debt will triple and rise gradually from 34% of GDP in 2010 to 102% of GDP by 2150.

As shown in Figure 36, the labor income tax rate is lower than in the benchmark as a larger amount of newly issued debt will absorb part of the rising public expenditures. At the same time, however, the cost of servicing the debt will increase and the difference in the labor income tax turns out to be very small, about 1 percentage point at the end of the century. As the debt will absorb more of households' savings in the closed economy, capital used in production is lower than in the benchmark economy, as shown in Figure 37.

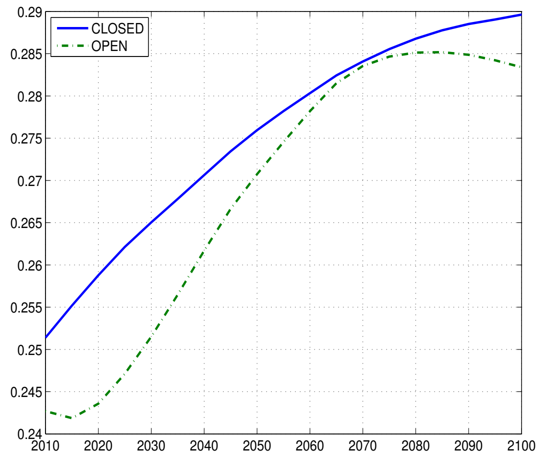


Figure 36: Higher debt during the transition: labor income tax rate in LAC

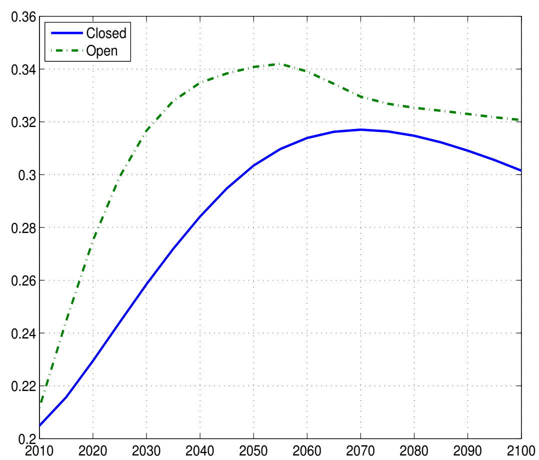


Figure 37: Higher debt during the transition: capital per capita in LAC

5.3 Discussion

The main purpose of this paper was to explore the effects of the dramatic demographic trends on saving and other economic variables, including interest rates and wages, in a general equilibrium model of Latin America and different regions of the world. Obviously our exercise abstracts from a large number of important issues, such as endogenous labour supply, migration and so on. However, our results are illuminating about the important role that the demographic transition could play in the coming decades. Some of the effects we stress might be counter balanced by other forces. However, it is clear that the dramatic demographic transition should imply a strong tendency towards higher saving rates in the coming decades in Latin America. In the open economy case, this implies a progressive improvement in the current account that, starting from a large deficit at the beginning of the period, becomes a surplus in 2030. This is true even in the baseline scenario when discount factors are kept at a low level for Latin America. If we assume convergence in discount factors, so that Latinos become progressively more patient, this trend is faster and more marked as saving and saving rates increase faster in LAC countries.

Obviously these results should be taken with a grain of salt and could be changed by a variety of other factors. However, it is clear that the demographic trends (and in particular the increase in longevity) should push saving rates up.

An interesting exercise we performed is that of increasing the generosity of the social security system. The way we modelled it in our model, this change could proxy for an increase in the coverage of pay as you go schemes or the complementing of funded schemes with basic social pension. In recent years, many countries in the region, such as Chile, Mexico and Peru, have been experimenting with increases in the unfunded component of their pension system. This type of changes will limit the increase in saving observed in the baseline experiment.

Figures 38 and 39 summarize the paths of the saving rates in the benchmark model and under various alternative assumptions about the demographics, preference and fiscal policies that we examined in the paper, in closed economy and open economy, respectively.

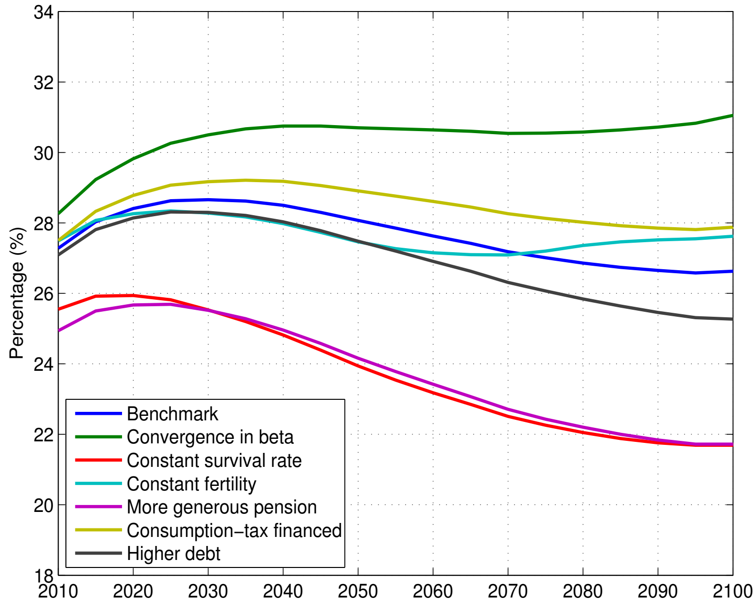


Figure 38: Saving rates in closed economy

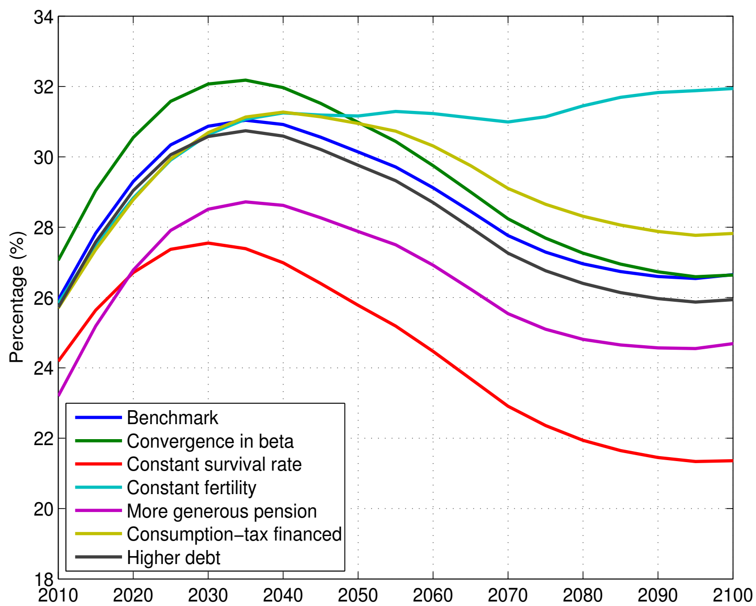


Figure 39: Saving rates in open economy

6 Conclusion

In this paper we build a large-scale full-blown overlapping generation model of households with five different regions of the world. We calibrated the model to match key macro and microeconomic features of each region, as well as the projections of demographic variables including the age-specific survival rates and fertility rates. With a rise in longevity and a decline in fertility rates over the next few decades, LAC will experience a rise in savings. In the open economy, the saving will rise even more rapidly because higher interest rate in LAC attracts capital inflow from other regions of the world that have lower interest rate. As the life-expectancy starts to stabilize and fertility rates begin to recover and increase, the saving rates will start to decline.

In order to understand determinants of the saving and key factors of the model that derives the dynamics of saving in LAC, we conduct a number of experiments. If the discount factor of LAC will converge to that of High Income region, the saving rate will be much higher and the region will run a current account surplus for a much longer period in the open economy. We also simulate the model hypothetically assuming that the survival rates and fertility rates are fixed constant to decompose the contribution of the demographic variables. We also simulate a few policy experiments. If, for example, LAC implements more generous pension system, saving will be significantly reduced as households will rely more on public transfers to finance old-age consumption than through their own savings. Using consumption tax instead of labor income tax to finance the transition and absorb the rising government expenditures, capital will be higher but the difference is small. Issuing more debt to partially cover the rising cost of aging demographics will help lower the labor income tax but the effect is small since there will be additional expenditures to service the debt.

The model we have constructed and presented in this paper constitutes a useful tool for the analysis of the impact of large changes in demographics and has allowed us to perform interesting policy experiments. However, it should be stressed that the model is not without limitations, despite our efforts to calibrate it to match some of the observed facts. Its results should therefore taken with some caution. We note, in particular, the necessity to calibrate a relatively high discount rate (or low discount factor) for LAC in order to account for the historically low level of the capital output ratio in the region. Probably the best interpretation of our results is the identification of some basic economic forces that, given the demographic forecasts should push towards increases in aggregate saving in the LAC region. There might be, however, other factors that might prevent the source of impact that we have discussed in this paper. Some of the demographic transition that generates the increase in saving that we have discussed has already occurred and yet LAC saving rates have not increased much. Future research should focus on why saving rates in the region have been so much lower than what would be predicted by a standard general equilibrium model.

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