Macroeconomic Effects of the Demographic Transition in Brazil*

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December 2013

Abstract

Brazil is a prominent developing country with a still relatively young population that is undergoing what is expected to be a fast demographic transition. The dependency ratio – the size of the population that is economically inactive to the size of the labor force – should hit bottom within the next ten years, and start increasing fast thereafter. Hence, the so-called "first demographic dividend" – an increase in the size of the labor force relative to the overall population – will soon turn negative and subtract from per capita growth. However, a "second demographic dividend" is possible if, facing the prospects of an extended period of retirement, individuals decide to increase the pace of asset accumulation. We use an open economy, two country, overlapping generations model to study the possibility of a meaningful second dividend materializing in Brazil. Our conclusion is that this is an unlikely outcome. The main culprit is a generous social security system that considerably undermines households' incentives to save for retirement.

JEL classification codes: E13, E60, J11

Keywords: demographic transition, Brazil, capital flows, social security, demographic dividend

*This paper was commissioned by the CEDES-IDRC project "Demographic asymmetries and global financial governance." We thank Ramiro Albrieu, Jose Maria Fanelli, Marcelo R. Santos, Cassio M. Turra, and seminar participants at SBE 2013 and Insper for valuable comments and discussions. Felipe R. Mazin provided research assistance. Emails: ricardodob@insper.edu.br, cvianac@econ.puc-rio.br.

1 Introduction

Brazil is a relatively young, prominent developing country undergoing what is expected to be a fast demographic transition. Owing to a decline in the mortality rate, the Brazilian population increased significantly between 1940 and 1970. In the 1940s, the annual population growth rate was around 2.4%, rising to 3.0% in the 1950-1960s, as life expectancy rose from 44 to 54 years. According to Carvalho (2004), the so-called "demographic transition" in Brazil started in the 1970s, with a sudden fall in the fertility rate. The latter kept decreasing during the 1980s, 1990s, and 2000s, leading to important differences between the actual age distribution of the population and its so-called "stable-equivalent."[1] At the same time, longevity kept increasing. By 2010, population growth had fallen to only 1.0% per year, life expectancy had reached 74 years, and the economically active population had grown from 56% to 64% of the total population (between 1980 and 2010).

According to recent forecasts, population growth is expected to fall further, entering negative territory around 2050.[2] A useful summary of the population's age structure, the *total dependency ratio* – the size of the population that is economically inactive to the size of the labor force – has been falling continuously since the peak attained around 1965. That ratio is now expected to hit bottom within the next ten years, before increasing again to reach a level close to its historical peak by the end of this century.[3]

It is well known that demographic developments may have important macroeconomic consequences. In particular, increases in longevity and decreases in population growth – which are features of modern demographic transitions such as the one Brazil is undergoing – have important implications for savings decisions, capital accumulation, and, ultimately, economic growth and well-being. Such "aging processes" may also present important challenges for public finances, depending on social security arrangements. In turn, because such arrangements are important determinants of consumption-savings decisions, they also shape the way in which demographic developments influence the macroeconomy.[4]

In this chapter, we study the macroeconomic effects of the demographic transition in Brazil. A common way to analyze the potential effects of demographic developments on the economy is to focus on the possibility of so-called "demographic dividends" arising during a demographic

[1] The stable-equivalent population is the underlying population that would emerge if the fertility and mortality rates remained constant for a long period of time.

[2] United Nation's World Population Prospects: The 2012 Revision.

[3] United Nation's World Population Prospects: The 2012 Revision. The total dependency ratio is computed as the ratio of the sum of the population aged 0-14 and that aged 65+ to the population aged 15-64.

[4] It is also well known that economic developments may affect demographic trends. This is the subject of a literature in Economics that treats such trends as endogenous outcomes of an interaction between some exogenous determinants and some endogenous factors, such as individual's fertility choices (see, e.g., Galor 2011). In this paper we take demographic developments to be exogenous, and study their macroeconomic consequences.

transition. The *first demographic dividend* starts after a fall in fertility leads the labor force to grow relatively faster than the overall population, thus spurring per-capita income. At a later stage, lower fertility leads to lower labor force growth, while increases in longevity drive higher the population share of the elderly. As a result, the dependency ratio increases again and reverses the first dividend. As pointed out above, Brazil is close to the end of its first demographic dividend: The labor force should soon start growing less than the overall population. We thus focus on the possibility of a *second demographic dividend* arising during the remainder of Brazil's demographic transition. The second demographic dividend may arise if, facing the prospects of an extended period of retirement, individuals decide to increase the pace of asset accumulation (Mason and Lee 2007). This leads to either a larger domestic capital stock or larger foreign asset holdings. In either case, domestic income might end up being higher.

Whether or not a second dividend materializes during the aging process depends crucially on the extent to which individuals need to save for retirement, which in turn depends on social security and other institutional and cultural arrangements. At first pass, the current social security system does not bode well for the prospects of a meaningful second demographic dividend arising in Brazil. According to Turra, Queiroz, and Rios-Neto (2011), the Brazilian social security system is particularly generous toward the elderly. Because Brazil is a developing country with a (still) young population, large flows of public transfers could be expected to be directed to children. Instead, as in older, developed Western countries, social programs to the elderly dominate public transfers, while children's well-being depends largely on individual household efforts. This arrangement certainly affects households' incentives to save for retirement.

However, in an open economy, lack of domestic savings need not hold back the pace of capital accumulation, which can be financed with foreign savings. All else equal, the existence of differences in the intensity, pace, and timing of demographic transitions across countries should influence the direction and size of international capital flows. Whether or not capital will flow to Brazil during the remainder of its demographic transition thus depends, among many other things, on its demographic developments relative to those elsewhere in the global economy.

To study how public policies and differential demographic developments vis-a-vis the world might interact to produce or prevent a second demographic dividend in Brazil, we use a small-scale, two country, general equilibrium overlapping generations model, based on Gertler (1999) and Ferrero (2010) – with the "foreign country" representing the rest of the (more developed) world. We keep the open economy dimension of Ferrero (2010) and reintroduce social security systems, as in Gertler (1999). The framework allows us to model differential demographic trends, social security systems, fiscal policies, retirement ages etc., and to study the role of demographics and policies in shaping a second demographic dividend in Brazil. We also study the importance of international capital flows, by contrasting results for open- and closed-economy versions of the model.

To isolate the role of demographic developments in Brazil and abroad, those developments are the only forces driving the economies from one steady state to another. We study aggregate dynamics during the demographic transitions both under the assumption that the economies are closed to trade in goods and assets, and under the assumption that they are fully open (or that they suddenly open up) to trade in goods and assets.

Our results suggest that, given the current social security system, a small second demographic dividend would arise in Brazil if it remained relatively closed to trade in goods and assets. Opening up under current social security arrangements turns out to be a losing proposition in that respect. However, these scenarios produce incredible paths for some variables, such as expenditures with public pensions and taxes as a share of Gross Domestic Product (GDP). This is due to the fact that maintaining the very high replacement rates currently in place in Brazil becomes unsustainable as the country starts to age fast in the next couple of decades.

Motivated by those results we then entertain "reform scenarios," in which growth in expenditures with public pensions is contained. We first analyze a "bold" reform scenario in which taxes are frozen as a share of GDP, and expenditures with pensions have to adjust endogenously to balance the budget. This produces a more meaningful second demographic dividend in Brazil, irrespective of whether the economy is open or closed to trade. In fact, in that case becoming more integrated with the world economy arguably becomes a winning proposition.

The bold reform scenario is arguably unrealistic, however, since it involves defaulting on "contracts" that are currently in place. Hence we consider a more gradual reform scenario, in which the replacement rate in Brazil is lowered to the level that prevails in the OECD over a 25 year period. That brings us back to a situation in which a closed economy might arguably deliver a larger second dividend.

We conclude that a meaningful second dividend is unlikely to materialize in Brazil. The main culprit is a generous social security system that considerably undermines households' incentives to save for retirement. We grant that there exist reforms that would be able to spur a meaningful second dividend, but our results indicate that they would need to be too aggressive to appear feasible.

Our work is related to two intersecting literatures. The first uses large-scale overlapping generations models to study social security systems, evaluate policy reforms, and perform counterfactual analyses. Examples include Imrohoroglu et al. (1995), Attanasio et al. (2006, 2007), and Krueger and Ludwig (2007). In Brazil, Ellery Jr. and Bugarin (2003) build on Imrohoroglu et al. (1995) to compare the pay-as-you-go social security scheme with a fully savings-funded system, pointing the circumstances under which the former may result in a welfare gain relative to the latter.

The second literature studies the macroeconomic effects of demographic developments. Examples include Ferrero (2010), Mason and Lee (2007) and Albrieu and Fanelli (2013). Like the last to papers, we focus on the second demographic dividend. Relative to those two papers, our work differs in that we rely on a framework in which the consumption-savings decisions that are key to the second demographic dividend are *endogenous*. In other words, we emphasize what demographers call the *behavioral* dimension of the second dividend. We present a quantitative analysis of the effects of the demographic transition on households' consumption-saving decisions, and its implications for asset accumulation, current account dynamics, and capital flows. We also analyze the extent to which social security reforms and free capital flows may affect the gains from a second demographic dividend.

Our work is closest to Attanasio et al. (2006, 2007). They use a large-scale two country general equilibrium OLG model to study the effects of demographic developments on the macroeconomy, with a focus on social security. Both papers take a "North-South" perspective, and calibrate the model to data for the "More Developed Regions" and "Less Developed Regions" defined according to the UN's classification.[5] In particular, Attanasio et al. (2006) take the point of view of developing economies to study the macroeconomic implications of differential demographic transitions and social security systems in the North and in the South. However, Brazil does not fit their typical developing economy, which features relatively more favorable demographic trends going forward, and much lower replacement rates than in the North.

2 The analytical framework[6]

As in Gertler (1999) and Ferrero (2010), the economic actors in the model are households, firms, and the government. Individuals are born workers and supply inelastically one unit of labor while in the labor force.[7] Income is either consumed or saved using the available assets: physical capital, government bonds, and foreign assets (in the open-economy versions of the model). Retirees consume out of their wealth and social security benefits. Goods producing firms are perfectly competitive and produce the homogeneous consumption good. The government consists of a fiscal authority that, in the baseline model, takes government consumption and social security spending as given and relies on lump-sum taxes and one-period debt to satisfy

[5] According to the UN's classification, the group of "More Developed Regions" is composed of North America, Europe, Japan, Australia, and New Zealand. The group of "Less Developed Regions" includes Africa, Asia (except for Japan), Latin America and the Caribbeans, plus Melanesia, Micronesia, and Polynesia.

[6] We follow Gertler's (1999) and Ferrero's (2010) presentation closely, maintaining a social security system as in Gertler (1999) and analysing open economies as in Ferrero (2010). We then use the model to define demographic objects of interest – in particular the first and second demographic dividends, following Albrieu and Fanelli (2013), and Mason and Lee (2007).

[7] Our model thus abstracts from childhood, as in Gertler (1999) and Ferrero (2010). We return to this issue when we detail the calibration on which we base our quantitative analysis.

its budget constraint. In our quantitative analyses we also consider cases in which tax rates are exogenous and social security spending has to adjust to balance the budget.

We consider the effects of changes in demographic parameters in an otherwise perfect-foresight environment. The only source of uncertainty that may potentially affect agents' behavior stems from idiosyncratic retirement and death risk. This approach isolates the effects of demographics on the macroeconomic equilibrium, and is thus suitable for our goals. For brevity, below we present the structure of the domestic economy. The foreign economy is analogous. We then consider closed-economy versions of the model, and open-economy versions, in which the two economies can trade assets and goods.

2.1 Households and life-cycle structure

At any given point in time, individuals belong to one of two groups: workers (w) or retirees (r). At time $t-1$, workers have mass N_{t-1}^{w} and retirees have mass N_{t-1}^{r}. Between periods $t-1$ and t, a worker remains in the labor force with probability ω_{t-1}, and retires otherwise. If retired, an individual survives from period $t-1$ to period t with probability γ_{t-1}. In period t, $(1-\omega_{t-1}+n_{t-1})\, N_{t-1}^{w}$ new workers are ready to work. Consequently, the law of motion for the aggregate labor force is

$$N_{t}^{w} = (1-\omega_{t-1}+n_{t-1})\, N_{t-1}^{w} + \omega_{t-1} N_{t-1}^{w} = (1+n_{t-1})\, N_{t-1}^{w}, \tag{1}$$

so that n_{t-1} represents the growth rate of the labor force between periods $t-1$ and t. The number of retirees evolves over time according to

$$N_{t}^{r} = (1-\omega_{t-1})\, N_{t-1}^{w} + \gamma_{t-1} N_{t-1}^{r}. \tag{2}$$

From (1) and (2), we define the (elderly) dependency ratio ($\psi_t \equiv N_t^r / N_t^w$), which summarizes the relevant demographic dimension of the model, and evolves according to

$$(1+n_{t-1})\, \psi_t = (1-\omega_{t-1}) + \gamma_{t-1} \psi_{t-1}. \tag{3}$$

Workers supply one unit of labor inelastically, while retirees do not work. Preferences for an individual of group $z = \{w, r\}$ are a restricted version of the recursive non-expected utility family (Kreps and Porteus 1978, Epstein and Zin 1989) that assumes risk neutrality

$$V_t^z = \left\{ (C_t^z)^{\rho} + \beta_t^z \left[E_t \left(V_{t+1} \mid z \right) \right]^{\rho} \right\}^{\frac{1}{\rho}}, \tag{4}$$

where C_t^z denotes consumption and V_t^z stands for the value of utility in period t. Retirees and workers have different discount factors to account for the probability of death

$$\beta_t^z = \begin{cases} \beta\gamma_t & \text{if } z = r, \\ \beta & \text{if } z = w. \end{cases}$$

The expected continuation value in (4) differs across workers and retirees because of the different possibilities to transition between groups

$$E_t \left\{ V_{t+1} \mid z \right\} = \begin{cases} V_{t+1}^r & \text{if } z = r, \\ \omega_t V_{t+1}^w + (1 - \omega_t) V_{t+1}^r & \text{if } z = w. \end{cases}$$

This life-cycle model is analytically tractable because the transition probabilities ω and γ are independent of age and of the time since retirement. With standard risk-averse preferences, however, this assumption would imply too strong a precautionary savings motive for young agents. Risk-neutral preferences with respect to income fluctuations prevent a counterfactual excess of savings by young workers (Farmer 1990, Gertler 1999). We can still obtain a reasonable response of consumption and savings to changes in interest rates through suitable calibration of the coefficient of intertemporal substitution ($\sigma \equiv (1-\rho)^{-1}$).

Households consume a homogeneous final good C_t and allocate their wealth among investment in physical capital K_t, bonds issued by the government B_t, and foreign assets F_t. Households rent the capital stock to goods producers at a world real rate $R_{W,t}$ plus the cost of depreciation $\delta \in (0, 1)$. Government bonds B_t also pay a gross nominal return $R_{W,t}$.

2.1.1 Retirees

An individual born in period j and retired in period τ chooses consumption $C_t^r(j, \tau)$ and assets $A_t^r(j, \tau) \equiv K_t^r(j, \tau) + B_t^r(j, \tau) + F_t^r(j, \tau)$, for $t \geq \tau$ to solve

$$V_t^r(j, \tau) = \max \left\{ (C_t^r(j, \tau))^\rho + \beta\gamma_t \left[V_{t+1}^r(j, \tau) \right]^\rho \right\}^{\frac{1}{\rho}} \tag{5}$$

subject to

$$C_t^r(j, \tau) + A_t^r(j, \tau) = \frac{R_{W,t-1}}{\gamma_{t-1}} A_{t-1}^r(j, \tau) + D_t(j, \tau), \tag{6}$$

where $D_t(j, \tau)$ is the retiree social security benefit.

At the beginning of each period, retirees turn their wealth over to a representative mutual fund which invests the proceeds on physical capital $K_t^r(j, \tau)$, government bonds $B_t^r(j, \tau)$ and foreign assets $F_t^r(j, \tau)$ and pays back a fair premium over the market return equal to $1/\gamma_{t-1}$ to compensate for the probability of death (Blanchard 1985, Yaari 1965). A retiree who survives between periods $t-1$ and t then makes investment decisions right at the end of the period.

The consumption Euler equation for the retiree yields that consumption is a fraction $\epsilon_t \pi_t$ of total wealth

$$C_t^r(j,\tau) = \epsilon_t \pi_t \left(\frac{R_{W,t-1} A_{t-1}^r(j,\tau)}{\gamma_{t-1}} + S_t(j,\tau) \right), \tag{7}$$

where $S_t(j,\tau)$ is the total present value of the retiree's future social security benefits $(D_{t+v}(j,\tau))$:

$$S_t(j,\tau) = \sum_{v=0}^{\infty} \frac{D_{t+v}(j,\tau)}{\prod_{s=1}^{v} R_{W,t+s-1}/\gamma_{t+s-1}} = D_t(j,\tau) + \frac{S_{t+1}(j,\tau)}{R_{W,t}/\gamma_t}, \tag{8}$$

and the marginal propensity to consume satisfies a first-order non-linear difference equation:

$$\frac{1}{\epsilon_t \pi_t} = 1 + \gamma_t \beta^{\sigma} R_{W,t}^{\sigma-1} \frac{1}{\epsilon_{t+1}\pi_{t+1}}. \tag{9}$$

From (6) and (7), asset holdings evolve according to

$$A_t^r(j,\tau) + \frac{\gamma_t S_{t+1}(j,\tau)}{R_{W,t}} = (1 - \epsilon_t \pi_t) \left(\frac{R_{W,t-1} A_{t-1}^r(j,\tau)}{\gamma_{t-1}} + S_t(j,\tau) \right).$$

Finally, we can also show that the value function for a retiree is linear in consumption

$$V_t^r(j,\tau) = (\epsilon_t \pi_t)^{\frac{\sigma}{1-\sigma}} C_t^r(j,\tau). \tag{10}$$

2.1.2 Workers

Workers start their life with zero assets. We write the optimization problem for a representative worker born in period j in terms of total assets $A_t^w(j) \equiv K_t^w(j) + B_t^w(j) + F_t^w(j)$. Specifically, such worker chooses consumption $C_t^w(j)$ and assets $A_t^w(j)$ for $t \geq j$ to solve

$$V_t^w(j) = \max \ \left\{ (C_t^w(j))^{\rho} + \beta \left[\omega_t V_{t+1}^w(j) + (1-\omega_t) V_{t+1}^r(j,t+1) \right]^{\rho} \right\}^{\frac{1}{\rho}} \tag{11}$$

subject to

$$C_t^w(j) + A_t^w(j) = R_{W,t-1} A_{t-1}^w(j) + W_t N_t^w(j) - T_t(j), \tag{12}$$

and $A_j^w(j) = 0$, where W_t is the real wage, $N_t^w(j)$ is the measure of cohort j, and $T_t(j)$ is the total amount of taxes paid by workers in that cohort. Workers cannot turn their wealth over to the mutual fund, and hence do not receive the additional return that compensates for the probability of retirement.[8] The value function $V_{t+1}^r(j,t+1)$ is the solution of the problem (5) − (6) above and enters the continuation value in the dynamic program, since workers have

[8] Allowing workers access to the mutual fund industry would provide complete insurance against the probability of retirement, hence shutting down most of the interesting life-cycle dimensions of the model.

to take into account the possibility that retirement occurs between periods t and $t+1$.

The complete solution to a worker's optimization problem is described in detail in Gertler (1999) and Ferrero (2010). Workers' consumption is a fraction of total wealth, defined as the sum of financial and non-financial ("human") wealth

$$C_t^w(j) = \pi_t \left(R_{W,t-1} A_{t-1}^w(j) + H_t(j) + S_t^w(j) \right), \tag{13}$$

where $H_t(j)$ represents the present discounted value of current and future real wages net of taxation:

$$H_t(j) \equiv \sum_{v=0}^{\infty} \frac{W_{t+v}(j) N_{t+v}^w(j) - T_{t+v}(j)}{\prod_{s=1}^{v} \Omega_{t+s} R_{W,t+s-1}/\omega_{t+s-1}} = W_t(j) N_t^w(j) - T_t(j) + \frac{\omega_t H_{t+1}(j)}{\Omega_{t+1} R_{W,t}}, \tag{14}$$

and $S_t^w(j)$ is the total present value of the future social security benefits the worker can expect during retirement:

$$S_t^w(j) = (1-\omega_t)\, \epsilon_{t+1}^{\frac{\sigma}{1-\sigma}} \frac{S_{t+1}(j, t+1)}{\Omega_{t+1} R_{W,t}} + \omega_t \frac{S_{t+1}^w(j)}{\Omega_{t+1} R_{W,t}}, \tag{15}$$

where $S_{t+1}(j, t+1) = \frac{S_{t+1}}{\psi_{t+1} N_{t+1}}$ and S_{t+1} denotes the present value of future social security benefits of all retirees alive at time $t+1$.

As for retirees, workers' marginal propensity to consume π_t also evolves according to a first-order non-linear difference equation

$$\frac{1}{\pi_t} = 1 + \beta^\sigma \left(\Omega_{t+1} R_{W,t} \right)^{\sigma-1} \frac{1}{\pi_{t+1}}. \tag{16}$$

The adjustment term Ω_{t+1} that appears in (14)-(16) corresponds to

$$\Omega_{t+1} \equiv \omega_t + (1-\omega_t) \left(\epsilon_{t+1} \right)^{\frac{1}{1-\sigma}},$$

and augments the discount rate $R_{W,t}$ relative to the infinite-horizon case.

In the definition of non-financial wealth (14), the term $\Omega_{t+1} R_{W,t}/\omega_t$ constitutes the real effective discount rate for a worker. The first component of the (higher) discounting captures the effect of the finite lifetime horizon (less value attached to the future). The term ω_t augments the actual discount factor because workers need to finance consumption during the retirement period (positive probability of retiring).

The dynamics of asset holdings can then be obtained from the worker's budget constraint and the consumption function (13)

$$A_t^w(j) + \frac{\omega_t \left(H_{t+1}(j) + S_{t+1}^w(j)\right)}{\Omega_{t+1} R_{W,t}} = (1-\pi_t)\left(R_{W,t-1} A_{t-1}^w(j) + H_t(j) + S_t^w(j)\right).$$

Finally, as for retirees, workers' value function is also linear in their consumption

$$V_t^w(j) = (\pi_t)^{\frac{\sigma}{1-\sigma}} C_t^w(j). \tag{17}$$

2.1.3 Aggregation

The marginal propensities to consume of workers and retirees are independent of individual characteristics. Hence, given the linearity of the consumption functions, aggregate consumption of workers (C_t^w) and retirees (C_t^r) have the same form as (7) and (13) [9]

$$C_t^w = \pi_t \left(R_{W,t-1} A_{t-1}^w + H_t + S_t^w\right), \tag{18}$$

$$C_t^r = \epsilon_t \pi_t \left(R_{W,t-1} A_{t-1}^r + S_t\right), \tag{19}$$

where A_{t-1}^z is the total financial wealth that members of group $z = \{w, r\}$ carry from period $t-1$ into period t; H_t is the aggregate value of human wealth, evolving according to

$$H_t = W_t N_t^w - T_t + \frac{\omega_t H_{t+1}}{(1+n_t)\,\Omega_{t+1} R_{W,t}}, \tag{20}$$

S_t is the present value of future social security benefits of all retirees alive at time t:

$$S_t = D_t + \frac{\widehat{S}_{t+1} N_t^r}{R_{W,t}/\gamma_t} = D_t + \frac{S_{t+1}\psi_t}{(1+n_t)\,\psi_{t+1} R_{W,t}/\gamma_t}, \tag{21}$$

where D_t are total social security payments for retirees in period t, and $\widehat{S}_{t+1} = \frac{S_{t+1}}{N_{t+1}^r} = \frac{S_{t+1}}{\psi_{t+1} N_{t+1}^w}$ is the value of social security at $t+1$ per beneficiary; and S_t^w is the present value of future

[9] Note the algebra for the aggregate variables: $A_{t-1}^r = \sum_{j,\tau} A_{t-1}^r(j,\tau)$, $A_{t-1}^w = \sum_j A_{t-1}^w(j)$, $T_t = \sum_j T_t(j)$, $\sum_{j,\tau} D_t(j,\tau) = D_t$, $H_t = \sum_j H_t(j)$, $S_t^w = \sum_j S_t^w(j)$ and $S_t = \sum_{j,\tau} S_t(j,\tau)$. And, provided $W_t(j)$ is independent of individual-specific characteristics (i.e. equal to $W_t \; \forall \; j$): $\sum_j W_t(j) = N_t^w W_t$.

social security benefits that all workers alive at time t can expect during retirement:

$$S_t^w = (1-\omega_t)\,\epsilon_{t+1}^{\frac{1}{1-\sigma}} \frac{\widehat{S}_{t+1} N_t^w}{\Omega_{t+1} R_{W,t}} + \omega_t \frac{\widehat{S}_{t+1}^w N_t^w}{\Omega_{t+1} R_{W,t}} \quad (22)$$

$$= (1-\omega_t)\,\epsilon_{t+1}^{\frac{1}{1-\sigma}} \frac{S_{t+1}}{(1+n_t)\,\psi_{t+1}\Omega_{t+1} R_{W,t}} + \omega_t \frac{S_{t+1}^w}{(1+n_t)\,\Omega_{t+1} R_{W,t}}, \quad (23)$$

where $\widehat{S}_{t+1}^w = \frac{S_{t+1}^w}{N_{t+1}^w}$ is the value of future social security that workers alive at $t+1$ can expect during retirement per beneficiary.

The aggregate consumption function C_t is the weighted sum of (19) and (18). If $\lambda_t \equiv A_t^r / A_t$ denotes the share of total financial wealth A_t held by retirees, the aggregate consumption function is

$$C_t = \pi_t \left[(1-\lambda_{t-1})\, R_{W,t-1} A_{t-1} + H_t + S_t^w\right] + \epsilon_t \pi_t \left(\lambda_{t-1} R_{W,t-1} A_{t-1} + S_t\right). \quad (24)$$

Relative to the standard neoclassical growth model, the distribution of assets across cohorts is an additional state variable that keeps track of the heterogeneity in wealth accumulation due to the life-cycle structure.

Aggregate assets for retirees depend on the total savings of those who are retired in period t as well as on the total savings of the fraction of workers who retire between periods t and $t+1$:

$$A_t^r = R_{W,t-1} A_{t-1}^r + D_t - C_t^r + (1-\omega_t)\left(R_{W,t-1} A_{t-1}^w + W_t N_t^w - T_t - C_t^w\right). \quad (25)$$

Aggregate assets for workers depend only on the savings of the fraction of workers who remain in the labor force:

$$A_t^w = \omega_t \left(R_{W,t-1} A_{t-1}^w + W_t N_t^w - T_t - C_t^w\right). \quad (26)$$

The law of motion for the distribution of financial wealth across groups obtains from substituting expressions (18) and (26) into (25):

$$(\lambda_t - 1 + \omega_t)\frac{A_t}{\omega_t} = (1-\epsilon_t \pi_t)\, R_{W,t-1} \lambda_{t-1} A_{t-1} + D_t - \epsilon_t \pi_t S_t. \quad (27)$$

Expression (27) relates the evolution of the distribution of wealth λ_t to the aggregate asset position A_t.

2.2 Production

The economy is competitive and producers combine labor and capital rented from both workers and retirees to produce according to a standard Cobb-Douglas labor-augmenting technology

$$Y_t = (X_t N_t^w)^\alpha K_{t-1}^{1-\alpha}, \tag{28}$$

where $\alpha \in (0,1)$ is the labor share and the technology factor X_t grows exogenously at rate x_{t-1} between $t-1$ and t:

$$X_t = (1 + x_{t-1}) X_{t-1}.$$

Adjustment costs make the firm's problem dynamic and firms choose N_t^w, I_t to solve

$$V(I_{t-1}, K_{t-1}) = \max_{I_t, K_t} \left[(X_t N_t^w)^\alpha K_{t-1}^{1-\alpha} - W_t N_t^w - I_t + \frac{V(I_t, K_t)}{R_{W,t}} \right] \tag{29}$$

subject to

$$K_t = (1-\delta) K_{t-1} + \left[1 - \frac{\phi}{2} \left(\frac{I_t}{I_{t-1}} - \mu_t \right)^2 \right] I_t. \tag{30}$$

The first-order conditions for labor, capital and investment are

$$W_t = \frac{\alpha Y_t}{N_t^w} = \alpha X_t^\alpha \left(\frac{K_{t-1}}{N_t^w} \right)^{1-\alpha}, \tag{31}$$

$$q_t R_{W,t} = (1-\alpha) \frac{Y_{t+1}}{K_t} + (1-\delta) q_{t+1}, \tag{32}$$

and

$$q_t \left[1 - \frac{\phi}{2} \left(\frac{I_t}{I_{t-1}} - \mu_t \right)^2 - \phi \left(\frac{I_t}{I_{t-1}} - \mu_t \right) \frac{I_t}{I_{t-1}} \right] = 1 - \frac{\phi q_{t+1}}{R_{W,t}} \left(\frac{I_{t+1}}{I_t} - \mu_{t+1} \right) \left(\frac{I_{t+1}}{I_t} \right)^2. \tag{33}$$

Trivially, if $\phi = 0$, $q_t = 1$, and $(R_{W,t} - 1) = (1-\alpha) \frac{Y_{t+1}}{K_t} - \delta$.

2.3 Social security and fiscal policy

The government runs a social security system that makes total pension payments D_t to the population of retirees, determined by a replacement rate d_t applied to an estimate of the average wage that retirees alive at t received when they were active workers:

$$D_t = N_t^r \cdot d_t \cdot \overline{W_t^r}, \tag{34}$$

where $\overline{W_t^r} = \frac{W_t}{(1+x_{t-1})^{(1-\gamma_{t-1})^{-1}}}$ and $\left(1-\gamma_{t-1}\right)^{-1}$ is the average retirement period when the survival probability is γ_{t-1}.[10]

In order to finance the aforementioned social security payments and a given stream of consumption G_t, the government issues debt B_t and levies lump-sum taxes. The flow government budget constraint is

$$B_t = R_{W,t-1}B_{t-1} + (G_t + D_t - T_t). \tag{35}$$

Iterating equation (35) forward and imposing a no-Ponzi condition yields the following intertemporal budget constraint:

$$R_{W,t-1}B_{t-1} = \sum_{v=0}^{\infty} \frac{T_{t+v}}{\prod_{s=1}^{v} R_{t+s-1}} - \sum_{v=0}^{\infty} \frac{G_{t+v}}{\prod_{s=1}^{v} R_{t+s-1}} - \sum_{v=0}^{\infty} \frac{D_{t+v}}{\prod_{s=1}^{v} R_{t+s-1}}. \tag{36}$$

In most of our analyses we assume that the ratio between government spending and GDP is kept constant ($G_t = gY_t$). We also impose a fiscal rule that requires the government to keep debt constant as a fraction of GDP ($B_t = bY_t$). Hence, taxes adjust endogenously to satisfy the government's budget constraint. Later we consider alternative policy configurations.

2.4 Asset markets and international capital flows

The structure of the foreign economy, whose variables are denoted with an asterisk, is analogous to the one described above. Total assets for the domestic economy are the sum of the capital stock K_t, government bonds B_t, and the net foreign asset position F_t:

$$A_t = K_t + B_t + F_t. \tag{37}$$

In addition, the trade balance (NX_t) is given by:

$$NX_t = Y_t - (C_t + I_t + G_t). \tag{38}$$

International capital flows equalize asset returns across countries ($R_{W,t}$), and thus net foreign assets evolve according to:

$$F_t = R_{W,t-1}F_{t-1} + NX_t. \tag{39}$$

where $R_{W,t-1}$ is the world interest rate between $t-1$ and t that clears the international capital

[10] Of course this formula does not correspond exactly to the actual average wage that retirees alive at t earned as workers. This would require taking a weighted average of past wages that is complicated by the fact that productivity growth and the survival probability are time varying. We thus use the aforementioned approximation as a way to apply a tractable adjustment for productivity growth to current wages.

market:

$$F_t + F_t^* = 0. \tag{40}$$

2.5 Equilibrium

Given the dynamics for the demographic processes $\{n_{t-1}, n_{t-1}^*, \gamma_{t-1}, \gamma_{t-1}^*\}$; the targets of government consumptions g, g^*; the retirement probabilities $\{\omega_{t-1}, \omega_{t-1}^*\}$ and replacement rates $\{d_t, d_t^*\}$; and the growth rates of productivity $\{x_{t-1}, x_{t-1}^*\}$, a competitive two-open-economy equilibrium is a sequence of quantities $\{C_t^r, C_t^w, C_t, A_t^r, A_t^w, A_t, \lambda_t, H_t, S_t, S_t^w, Y_t, K_t, I_t, F_t, B_t, T_t\}$, $\{C_t^{r*}, C_t^{w*}, C_t^*, A_t^{r*}, A_t^{w*}, A_t^*, \lambda_t^*, H_t^*, S_t^*, S_t^{w*}, Y_t^*, K_t^*, I_t^*, F_t^*, B_t^*, T_t^*\}$, marginal propensities to consume $\{\pi_t, \epsilon\}$, $\{\pi_t^*, \epsilon_t^*\}$ and prices $\{R_{W,t}, \Omega_t, \Omega_t^*, W_t, W_t^*\}$, such that:

1. Retirees and workers maximize utility subject to their budget constraints, taking the interest rate and wages as given, as outlined in subsections 2.1.1 and 2.1.2.

2. Goods producers maximize profits subject to their production possibilities, taking the interest rate and wages as given, as outlined in subsection 2.2.

3. Given the policy choices of g, g^*, ω_t, ω_t^*, d_t, d_t^*, policy makers choose taxes and debt issuance to satisfy their budget constraints, as in subsection 2.3.

4. The markets for labor, capital and goods clear. In particular, the worldwide resource constraint is

$$Y_t + Y_t^* = C_t + I_t + G_t + C_t^* + I_t^* + G_t^*. \tag{41}$$

   In the closed economies configuration, the two regions are completely independent and, instead of one (world) interest rate, there are two different interest rates $\{R_t, R_t^*\}$. When solving the model, we rewrite it in terms of normalized variables that assure stationarity (i.e., $z_t \equiv Z_t/(X_t N_t^w)$ for any variable Z_t that grows with technology and the labor force).

2.6 Demographic dividends in the model

We use the framework described above to define a series of demographic variables of interest – especially the first and second demographic dividends. We do so by mapping objects in the model to the variables defined in Albrieu and Fanelli (2013) and Mason and Lee (2006, 2007).

The *support ratio* is given by the ratio of the "effective number of producers" to the "effective number of consumers":

$$SR_t = \frac{EN_t^w}{EN_t} = \frac{W_T N_t^w}{\frac{C_T^w}{N_T^w} N_t^w + \frac{C_T^r}{N_T^r} N_t^r + \frac{G_T}{N_T} N_t}, \tag{42}$$

where we have included government consumption in computing the effective number of consumers. In (42), T is a base period, which we retain to facilitate comparisons of our simulations with studies that followed the National Transfers Account (NTA) methodology (e.g., Albrieu and Fanelli 2013). For practical purposes, T will be the first year in our simulations.

The first demographic dividend corresponds to the period during the demographic transition in which SR_t is increasing – i.e., the period in which the number of effective producers increases faster than the number of effective consumers. Given that W_T, $\frac{C_T^w}{N_T^w}$, $\frac{C_T^r}{N_T^r}$, and $\frac{G_T}{N_T}$ are fixed in a base period, the first demographic dividend thus defined only depends on the evolution of the composition of the population. In our model, this is summarized by the (elderly) dependency ratio ($\psi_t \equiv N_t^r/N_t^w$):

$$SR_t = \frac{W_T}{\frac{C_T^w}{N_T^w} + \frac{C_T^r}{N_T^r}\psi_t + \frac{G_T}{N_T}(1+\psi_t)}.$$

Thus, in some sense the first demographic dividend is somewhat “mechanical” – strictly so if demographic developments are exogenous.

As argued by Mason and Lee (2007), a second demographic dividend is also possible if the aging population increases the pace of asset accumulation to face an extended retirement period. While the first dividend is transitory, the second dividend can lead to a permanently higher level of consumption. However, the second dividend is far from automatic, given that households may not have the incentives to increase savings – in particular, whether or not a second dividend arises might depend on the public policies in place.

Following Albrieu and Fanelli (2013), we also compute the so-called *adjusted support ratio*:

$$ASR_t = SR_t \frac{HI_t}{HC_t}, \tag{43}$$

where $HI_t = \frac{W_t}{W_T}$ and $HC_t = \frac{(C_t^w + C_t^r + G_t)/N_t}{\left(C_T^w + C_T^r + G_T\right)/N_T}$ are, respectively, the proportional increase of real wages and of per capita consumption. Loosely speaking, the second dividend amounts to consumption increasing more than labor income – i.e., HC_t increasing faster than HI_t.

To formalize the concept of the second demographic dividend, Mason and Lee (2007) suggest the use of a measure of total consumption per effective consumer:

$$\frac{TC_t}{EN_t} = \frac{TC_t}{EN_t^w} SR_t = c_t \frac{W_t}{W_T} SR_t, \tag{44}$$

where total consumption is $TC_t = (C_t^w + C_t^r + G_t)$ and $c_t = \frac{TC_t}{W_t N_t^w}$ is what the authors refer to as the “consumption ratio” – the ratio of total consumption to labor income. That is, total consumption per effective consumer can be decomposed as (i) the product of the total consumption per effective worker and the support ratio, or (ii) the product of the consumption ratio, the wage index and the support ratio.

According to Mason and Lee's (2007) definition, the second demographic dividend *in a small open economy* is the rate of growth of consumption relative to labor income – i.e., the rate of growth of c_t in the second equality of equation (44) (Mason and Lee 2007, page 14). However, as the authors point out, this definition does not take into account possible general equilibrium effects on wages and interest rates.

Mason and Lee (2007) suggest that a more comprehensive measure of the second demographic dividend is the growth rate of consumption per effective consumer in excess of the growth rate of the support ratio – i.e., the rate of growth of $\frac{C_t}{EN_t^w}$ in the first equality of equation (44).[11]

Given that our model accounts for the general equilibrium effects of the demographic transition on wages and interest rates, we define the second demographic dividend as the growth rate of consumption per effective worker, $\left[d\left(\frac{C_t}{EN_t^w}\right)/dt\right]/\frac{C_t}{EN_t^w}$ – which equals the growth rate of consumption per effective consumer in excess of the growth rate of the support ratio. This measure differs from Mason and Lee's (2007) definition of the second dividend in a small open economy precisely because it accounts for the changes in real wages induced by the demographic transition.

3 Quantitative analysis

We are interested in the macroeconomic implications of demographic developments in Brazil relative to those in the global economy (which we proxy with aggregates for OECD countries). We treat such developments as exogenous, and calibrate time-varying parameters to simulate the demographic transitions implied by recent demographic projections. In our scenarios, demography is the only exogenous force driving the economies from one steady state to another. The only other factors that can affect the transition path are changes to public policies.

3.1 Calibration

We take 2010 to be the initial steady state. In Table 1 we report demographic projections of the United Nations (2011) that we use in our simulations. Recall that the relevant population growth rates in our model are the growth rates of the labor force. We assume that workers join the labor force at age 20, and proxy labor force growth with population growth 20 years earlier. The UN provides projections for four different fertility variants (i.e., for high-, medium-, low-

[11]For example, they write (Mason and Lee 2007, page 5): "Suppose the consumption ratio $c(t)$ and labor productivity $Y(t)/L(t)$ were unaffected by demography. Per capita consumption would vary directly with the support ratio." Another hint at the implicit definition of the second dividend comes a few pages later (Mason and Lee 2007, page 13): "In the absence of the second demographic dividend, the consumption index $(\bar{c}/\bar{y})$ would track the support ratio exactly."

Table 1 - Demographic prospects, 1990-2100

Major group or country	1990-2010	2010-2035	2035-2060	2060-2085	2085-2100
Panel 1.A: Annual rate of population change (percentage - medium-fertility variant)					
WORLD	1.31	0.89	0.44	0.16	0.07
More developed regions	0.38	0.21	0.02	0.02	0.08
Brazil	1.32	0.54	-0.11	-0.49	-0.52
Panel 1.B: Life expectancy at birth (both genders combined)					
WORLD	66.0	71.4	75.5	78.6	80.6
More developed regions	75.3	79.5	82.7	85.6	87.7
Brazil	69.9	75.9	79.3	81.8	83.6

Source *: United Nations, Department of Economic and Social Affairs, Population Division (2011). World Population Prospects: The 2010 Revision. Files 20 and 5-1.*

and constant-fertilities). Among them, we choose to use the medium fertility scenario.[12] Panels 1.A and 1.B show the United Nations' (2011) projections until 2100 for population growth (assuming medium fertility) and life expectancy. Notice the negative population growth rates projected for Brazil after 2040 (Panel 1.A). Those projections imply that after growing from 195 million people in 2010 to close to 225 million in 2040, the Brazilian population will decrease by almost 0.5% per year, reaching 180 million by the end of the 21st century. Because our simulations extend into 2200 for steady-state calculation purposes, we assume that population growth rates converge to zero from 2100 to 2150, and stay at zero from then on.[13]

Panel 1.B shows that life expectancy should increase both in Brazil and in more developed countries, without considerably narrowing the gap between the two. From 2100 to 2150, we assume that life expectancy increases annually by half of what is expected in the 2090-2100 period; and increases by one-quarter of what is expected in the 2090-2100 period from 2150 to 2200.

Given the population growth and life expectancy prospects just described, Brazil in 2010 is a country that is getting to the end of its first demographic dividend, when the support ratio reaches its peak, to enter a phase where a second dividend is possible if the population accumulates enough assets while aging (see, e.g., Giambiagi and Tafner 2010).

Table 2 reports parameter values and initial demographic conditions used in the model simulations of our scenarios. Given the assumption that workers are born at age 20, the initial non-retirement and survival probabilities ("ω_{2010}" and "γ_{2010}") target the current average

[12] Among the four scenarios, the high fertility variant is the only one that does not predict a significant decrease in the Brazilian population in the second half of this century.

[13] Besides the uncertainty associated with the UN's demographic projections towards the end of its horizon (2100), the reader should keep in mind that the results for our simulations at very long horizons are likely to depend on those terminal assumptions. They should thus be taken with more grains of salt than usual.

Table 2: Parameter values and initial conditions - demographics and technology

		Brazil	OECD
Average retirement age	$20 + 1/(1-\omega)$	63.00	63.00
Non-retirement probability	ω	0.9767	0.9767
Average Longevity	$20 + 1/(1-\omega) + 1/(1-\gamma)$	74.00	78.00
Survival probability	γ	0.9091	0.9329
Population growth rate	n	1.57%	0.43%
Dependency ratio	$\psi = (1-\omega)/(1+n-\gamma)$	0.22	0.33
Relative population size	N	0.1894	1
Technology growth rate	x	0.00%	0.00%
Relative productivity	X	0.4683	1

retirement age of 63 in both Brazil and the OECD, and average longevities of 74 (Brazil) and 78 (OECD). For the relative size of the populations in the initial steady state we rely on United Nations (2011) "World Population Prospects: The 2010 Revision". To calibrate the relative productivities in the steady state we resort to OECD (2012) "Looking to 2060: Long-term global growth prospects", which estimates that Brazil's multifactor productivity level was 46.8% of the OECD group level average in 2010.

Finally, Table 3 presents preference, technology, and policy parameters. Preference and technology parameters are taken from Gertler (1999) and Ferrero (2010). With respect to government consumption, we assume it to be a steady 20% of the GDP for both economies. The government debt to GDP ratio is also fixed, at 60% for the OECD Economies and 40% for Brazil, in accordance with 2010 levels. In most of our analyses we assume that such levels for government consumption and debt/GDP remain constant. Together with public pension replacement rates of 70% and 42%, those values result in current public pension spending to GDP ratio of approximately 10.2% in Brazil and 9.2% in the OECD in 2010 – not too far from IMF (2011) estimates, which place public pension expenditures in that year at 9.5% of GDP in Brazil and 8.7% of GDP in the OECD.[14] Our policy assumptions in the *Baseline* scenarios imply that taxes are endogenous and vary to satisfy the government's budget constraint. We entertain alternative specifications when we study policy reforms.

[14] Given the simplified nature of the social security system in the model, it is no surprise that the values do not match the data exactly. One way to eliminate the existing discrepancies would be to allow freedom in picking replacement rates to match the data on expenditures with public pensions.

Table 3: Preference, technology, and policy parameters - baseline scenarios

		Brazil	OECD
Discount factor	β	0.98	0.98
Elast. intertemp. substitution	σ	0.5	0.5
Labor share	α	2/3	2/3
Depreciation rate	δ	10%	10%
Govern. consum. (% GDP)	g	20%	20%
Govern. debt (% GDP)	b	40%	60%
Replacement rate	d	70.00%	42.10%

Before we turn to our quantitative results, it is worth recalling that our model abstracts from the childhood period. Hence, strictly speaking, the demographic developments that we model can be summarized by the evolution of the (elderly) dependency ratio. This is a reasonable simplifying assumption given our focus on Brazil, where the increase in the elderly dependency ratio in the medium-fertility scenario is projected to account for more than 100% of the increase in the total dependency ratio until 2100. However, one may worry that this simplification would overstate the effects of the demographic transition relative to a model that could capture the evolution of both the elderly and the child dependency ratios. It turns out that in our calibrated model, the increase in the dependency ratio from 2010 to 2100 – of roughly 36 percentage points – comes very close to matching the increase in the total dependency ratio projected by the UN for the same period – of 39 percentage points. Hence we think the simple model with only workers and retirees should allow for a sensible analysis of our research question.

3.2 Results

We present our analyses in the form of alternative scenarios, which combine different assumptions about the economic environment, and different policy specifications.[15] Relative to the economic environment, the key issue is whether we treat the economies as open or close. We entertain three alternatives: closed economies, open economies, and initially closed economies that open up for trade in goods and assets. Finally, in terms of policies, we focus on different "social security reforms". In particular, we analyze policies that involve an exogenous declining path for the replacement rate as well as scenarios in which expenditures with public pensions

[15] Recall that the results for our simulations at very long horizons are likely to depend on the "terminal assumptions" that are needed for steady state calculation purposes. This is in addition to the uncertainty associated with the UN's demographic projections towards the end of its forecast horizon. The reader should thus keep in mind that results for very long horizons should be taken with more grains of salt than usual. Nevertheless, for completeness we report results until 2200.

are effectively "frozen" as a share of GDP, and the replacement rate must adjust endogenously to the new policy.

Our use of "demographics only" scenarios is similar in spirit to that of Albrieu and Fanelli (2013). The main difference is that they assume that per-capita consumption and GDP growth observed between 2000 and 2010 will repeat (exogenously) in the future, whereas in our analyses those variables are endogenous and consistent with each scenario entertained. In that sense our approach is closer to Attanasio et al. (2006, 2007).

3.2.1 Demographics

In our scenarios the dynamics are driven only by the demographic transitions in the two economies, and by changes in public policies. Figure 1 presents the paths for population growth and "aging" that we feed into the model (first column). Those paths imply the two diagrams in the second column. We present the alternative policy scenarios in subsequent sections.

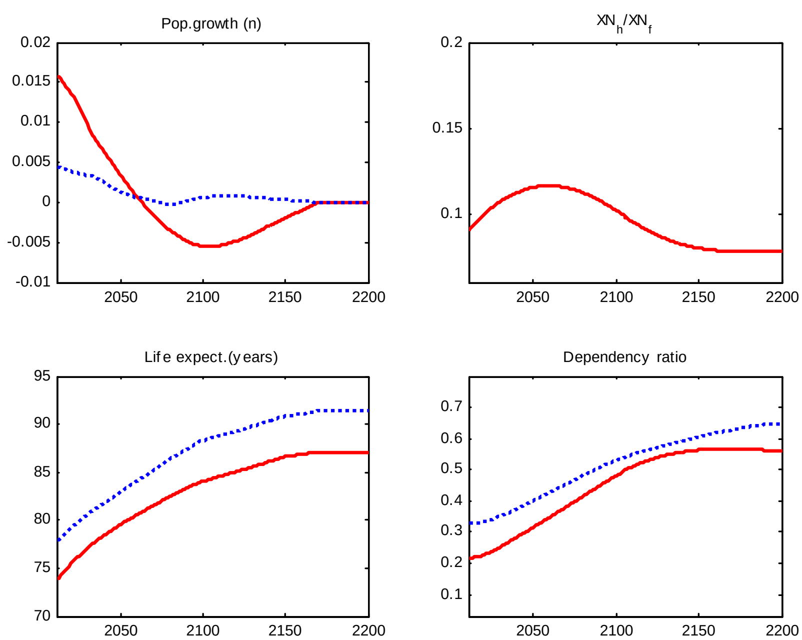

Figure 1: Demographic trends in Brazil (solid red line) and OECD (dotted blue line)

3.2.2 Baseline scenario: Closed economies

Figure 2.1 presents the dynamic paths for various variables in the two economies under the assumption of no trade in goods nor assets. This *Baseline closed-economy* scenario is our benchmark in this chapter, and henceforth we use *Baseline* to refer to all scenarios in which the current social security systems remain in place. This is in contrast with subsequent scenarios in which we entertain social security reforms.

In the absence of productivity growth and keeping the social security incentives unchanged, aging implies declining paths for GDP and consumption per capita in both economies. The generous public pension system in Brazil drives the associated public expenditures above 25% of GDP in the new steady state, and the required financing leads to a dramatic increase in tax revenues, of almost 20% of GDP. Interest rates in Brazil are much higher than in the OECD, in accordance with the different levels of capital per worker.

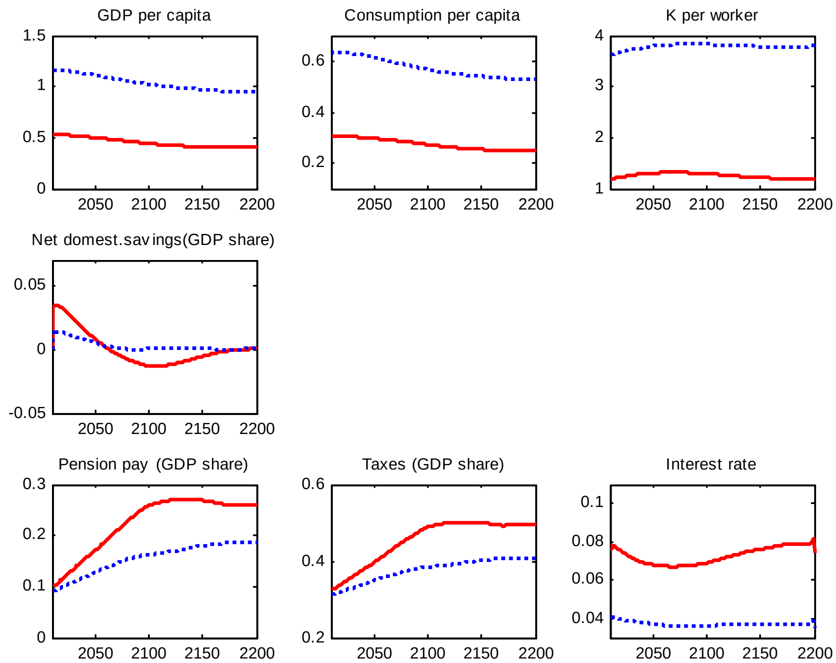

Figure 2.1: *Baseline* closed scenario - Brazil (solid red line) and OECD (dotted blue line)

In Figures 2.2 and 2.3 we present the paths for the first and second demographic dividends, as well as a few other variables that are helpful in understanding the composition effects in the former and the behavioral effects in the latter. Whenever we present separate paths for workers and retirees, solid and dashed red lines correspond to, respectively, Brazilian workers and retirees, while dotted and dash-dot blue lines correspond to, respectively, OECD workers and retirees.

The adverse dynamics of the first demographic dividend (Figure 2.2, chart (3,1)) are directly implied by the composition effect of demographic developments (Figure 1, chart (2,2)). In terms of the second demographic dividend, prospects are essentially neutral for the OECD, and alternate from slightly positive for many decades (reaching at most 0.20%, for a short time period) to slightly negative in the subsequent decades for Brazil (Figure 2.2, chart (3,2)). This yields a slightly upward hump-shaped profile for total consumption per (effective) worker (Figure 2.2, chart (2,2)). But even in the positive phase, the second dividend is not enough to offset the negative effect of the first dividend, and total consumption per (effective) consumer falls (Figure 2.2, chart (2,1)).

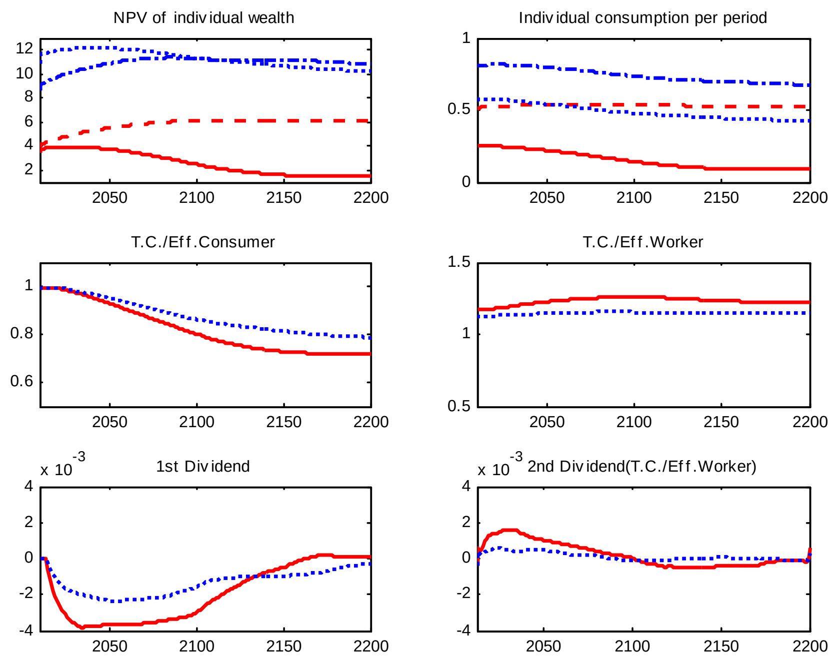

Figure 2.2: *Baseline* closed scenario - Brazil (solid and dashed red lines) and OECD (dotted and dash-dot blue lines) – demographic dividends

The two top diagrams of Figure 2.2 shed light on the behavioral effects underlying the second dividend. While in the OECD the net present value (NPV) of workers' wealth overtakes retirees' over time (dotted and dash-dot blue lines, respectively, in Figure 2.2, chart (1,1)), in Brazil retirees' wealth increases and workers' wealth decreases (solid and dashed red lines, respectively). In the long run, Brazilian workers own essentially zero assets (Figure 2.3, chart(3,1)), and retirees are the only asset owners (Figure 2.3, chart(3,2)). Retirees consume more than workers in both regions, but over time this difference widens in Brazil (Figure 2.2, chart (1,2)).

3.2.3 Closed vs. open economies

To understand the role of the "closed economy" assumption, in Figures 3.1 and 3.2 we compare the results for Brazil presented in the previous section (dotted black line) with results obtained under the assumption of free trade in goods and services, and fully integrated capital markets (solid red line). Due to the relative size of the two economies, the OECD dynamics are much more similar in the two scenarios (closed and open economies). The reason is that trade and

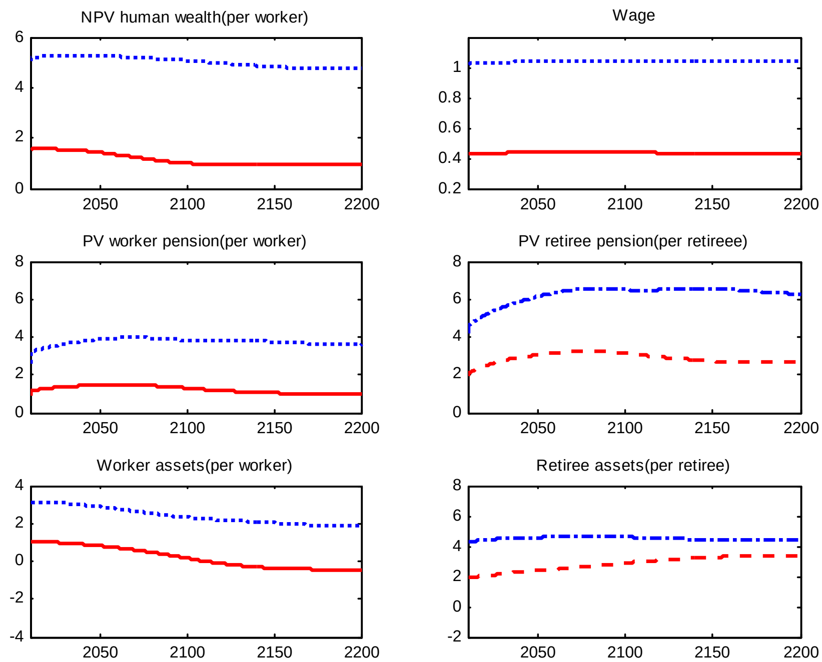

Figure 2.3: *Baseline* closed scenario - Brazil (solid and dashed red lines) and OECD (dotted and dash-dot blue lines) – wealth decomposition

capital flows to and from Brazil are small relative to the size of the OECD block. Hence we only present results for Brazil. Whenever we present separate results for workers and retirees, solid and dashed red lines correspond to, respectively, workers and retirees under the open economy assumption, while dotted and dash-dot black lines correspond to, respectively, workers and retirees under the closed economy assumption.

The most important difference relative to the closed economy results is the much lower (global) interest rate that Brazil faces (Figure 3.1, chart (3,3)), which results from the availability of external resources. Lower interest rates and higher wages (Figure 3.3, chart (1,2)) imply a redistribution of income from capital owners to workers, increasing the NPV of human wealth (Figure 3.3, chart (1,1)).[16] Given the generous current social security system, the much lower interest rate also increases the present value of pensions (Figure 3.3, charts (2,1) and (2,2)) and discourages savings (Figure 3.1, chart (3,1)), to the point that both workers and retirees end up not holding any assets (Figure 3.3, charts (3,1) and (3,2)). The net effects on the present value of agents' wealth imply that workers are richer and retirees are poorer in the closed economy (Figure 3.2, chart (1,1)). Because the marginal propensities to consume are lower in the open economy, workers' consumption does not change much, but retirees' consumption is definitely lower in the open economy.

[16] Wages are intrinsically linked to capital per worker, as indicated by equation (31).

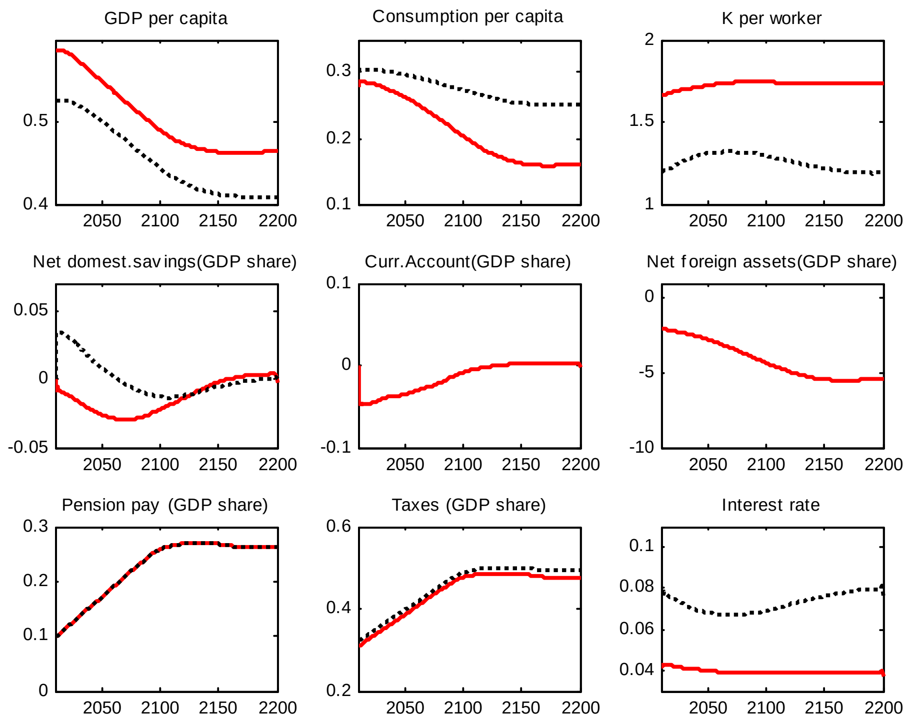

Figure 3.1: Brazil *Baseline* - Open (solid red line) x closed (dotted black line)

Although GDP per capita is higher in the open economy, it is still declining over time, and consumption per capita is lower than in the closed economy. The latter result stems from lower marginal propensities to consume and the negative net foreign asset position (Figure 3.1, chart (2,3)). The behavioral effects described previously underlie the negative second demographic dividend.

The open-economy assumption implies sizeable and persistent current account deficits (Figure 3.1, chart (2,2)). As a result, Brazil's net foreign asset position, equal to -2.5 times GDP in the initial steady state (2010), declines to around -5 times GDP over time. These results are highly counterfactual. According to Lane and Milesi-Ferretti (2007), from 1970 to 2011, Brazil's NFA/GDP has varied in the range of -58% and -15%. In 2010, it was estimated to be -39.8%. It thus appears that the closed economy assumption is a better approximation of the degree of openness of the Brazilian economy – that is why it is our baseline assumption.

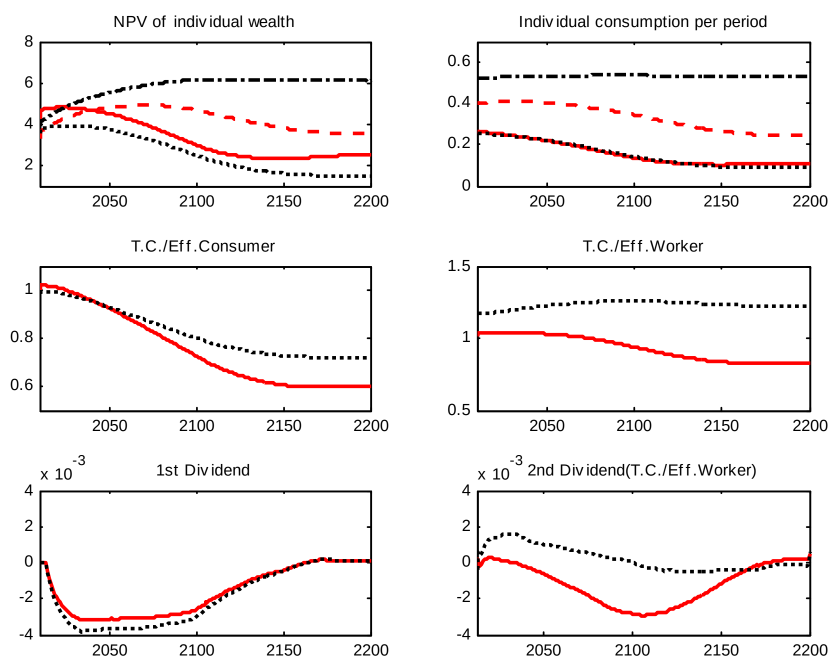

Figure 3.2: Comparison of *Baseline* scenarios, Brazil open (solid and dashed red lines) x Brazil closed (dotted and dash-dot black lines) - demographic dividends

Our results allow us to study the importance of the small open economy assumption in the definition of the second demographic dividend in Mason and Lee (2007). Recall that our measure of the second dividend differs from Mason and Lee's (2007) precisely because it accounts for the general equilibrium effects of the demographic transition on wages. In the scenarios entertained so far, changes in wages over time are somewhat small. Hence our measure of the second dividend turns out to be very close to Mason and Lee's (2007) definition. However, this will cease to be the case when we entertain scenarios in which the Brazilian social security system is reformed (see section 3.2.4).

Although the open- versus closed-economy comparison is useful, an important caveat to this comparative analysis is that open and closed economies depart from different initial steady states. This is also apparent in the results for the first dividend, which only differ because of the different levels of consumption and wages in the "base year" (see equation (42)).

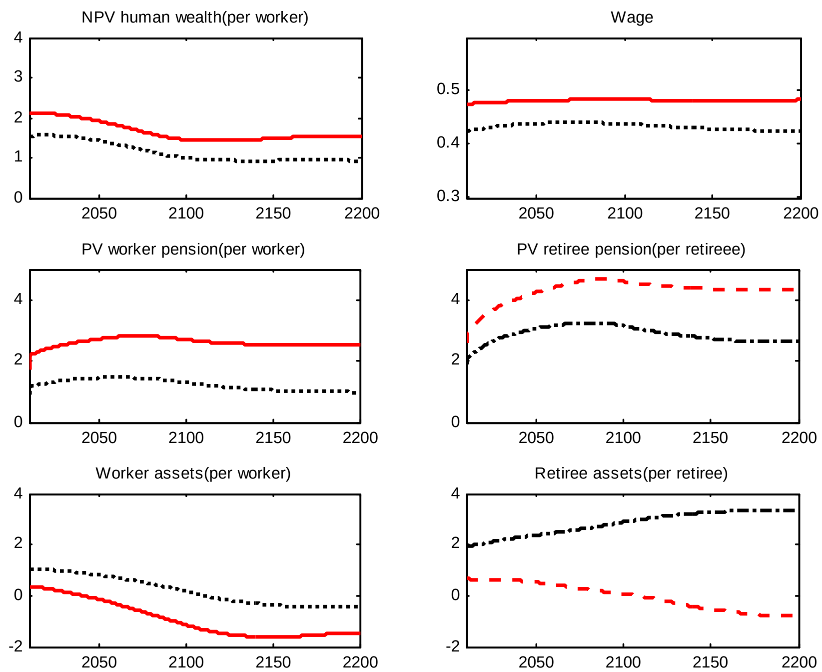

Figure 3.3: Brazil *Baseline* - Open (solid and dashed red lines) x closed (dotted and dash-dot black lines) - wealth decomposition

An alternative way to study the effects of the open- and closed-economy assumptions is to compare the scenario that assumes closed economies with a scenario in which the economies suddenly open up to trade in goods and assets at time zero (i.e., in 2010). Results are reported in Figures 4.1 and 4.2, again for Brazil only.

Opening up the economy leads to an immediate drop in interest rates in Brazil to international levels as foreign capital flows massively into the country. Consumption per capita spikes and domestic savings plummet. Brazil starts to run sizeable current account deficits, which, once again, eventually bring the country's net foreign asset position to a staggering -5 times GDP.

Except for differences in the initial periods, caused by the sudden opening of the economies to trade, the conclusions are similar to the ones obtained under the open-economy assumption. In particular, under the current social security systems, the second demographic dividend in Brazil

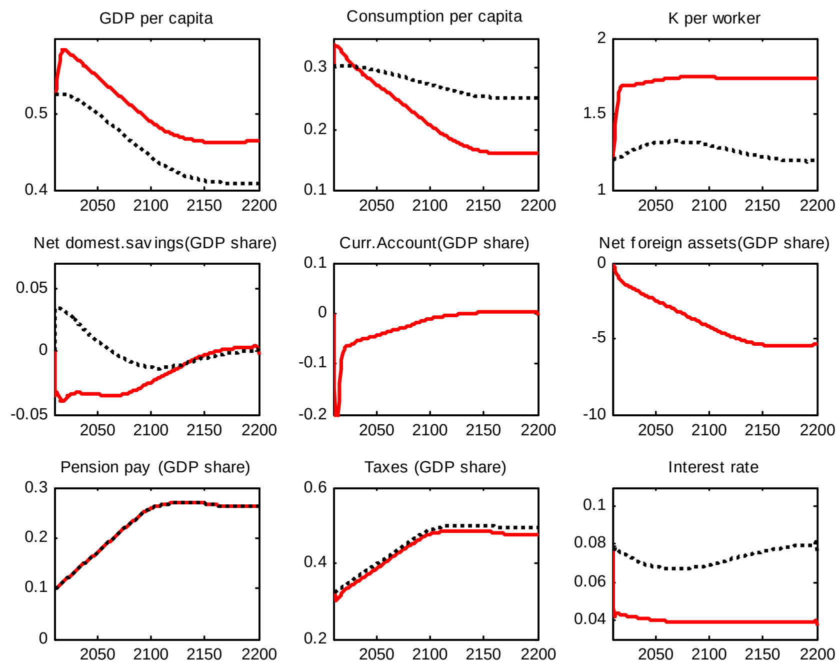

Figure 4.1: Brazil *Baseline* - sudden opening (solid red line) x Brazil closed (dotted black line)

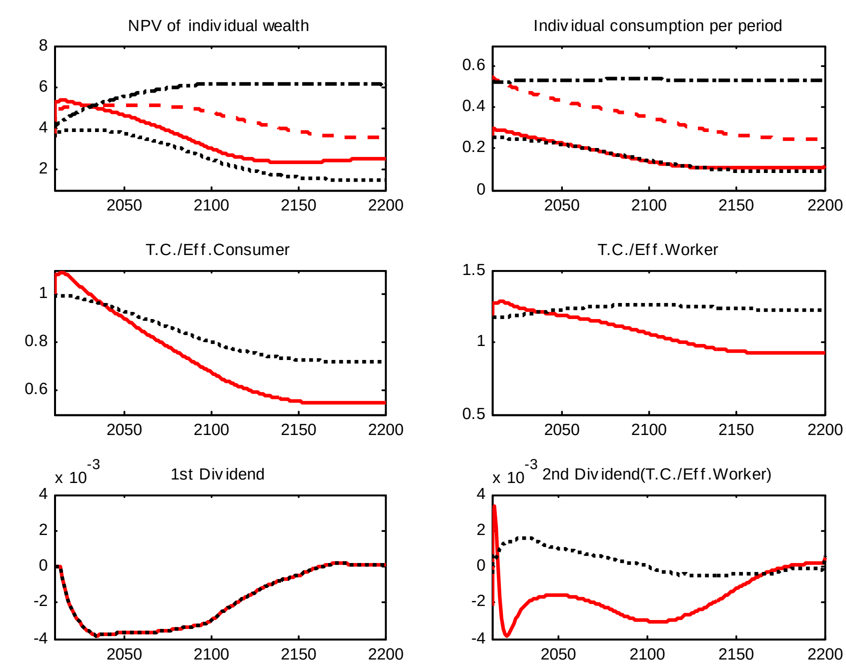

Figure 4.2: Brazil *Baseline* - sudden opening (solid and dashed red lines) x Brazil closed (dotted and dash-dot black lines) – demographic dividends

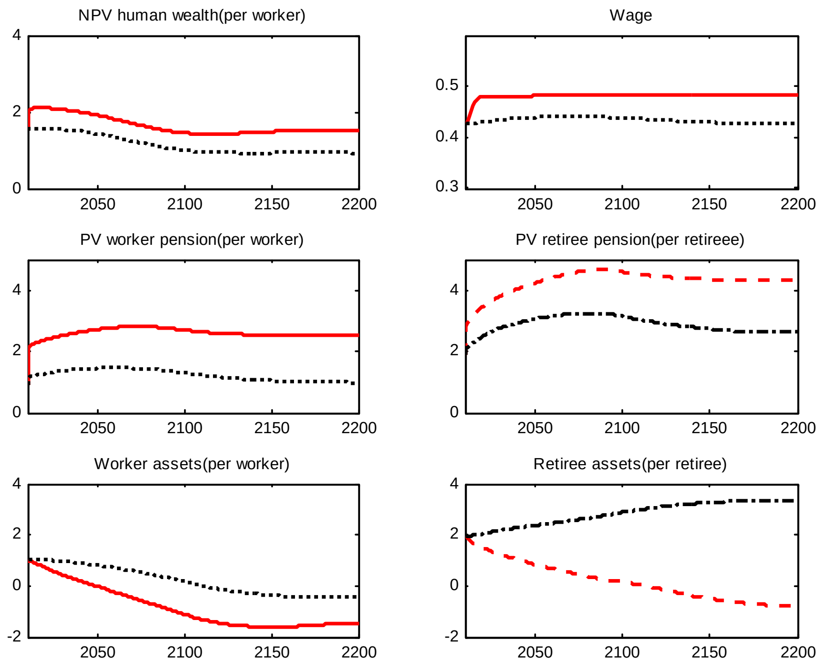

Figure 4.3: Brazil *Baseline* - sudden opening (solid and dashed red lines) x closed (dotted and dash-dot black lines) – wealth decomposition

is more favorable if the economy is relatively closed. A high replacement rate disincentivizes savings. Low interest rates in the case of open economies reinforce this effect. Counting on generous future pensions provided by the government and facing lower interest rates that increase the present value of pensions and human capital, Brazilians consume an even higher share of their income and accumulate fewer assets. The net foreign asset position becomes extremely negative, leading to a huge external imbalance against the OECD. Finally, taxes have to increase dramatically to afford high pensions to a fast-aging population.

Many of the results implied by the *Baseline* scenarios are highly implausible. Some of them have to do with assumptions about the environment, such as the economies being completely open to trade and capital flows. Both the "already open" scenario and the scenario in which closed economies open up create very large capital flows. Perhaps most important, all scenarios generate paths for the tax burden and net foreign asset position that are incredible. Although this argument is outside the model, an increase in taxes of 20% of GDP would most likely be politically infeasible and create huge incentives for tax evasion through "deformalization" of production activities. Likewise, negative net foreign asset positions of multiple times GDP would almost certainly not materialize, due to the risks of expropriation and default.

The implausible results that emerge from our analysis of the *Baseline* scenarios are likely also by-products of the assumption that the current social security systems will continue to run as they are. In particular, that the extremely generous replacement rate of the Brazilian system will remain constant even though the population will soon start aging fast. The extreme nature of some of the outcomes of the *Baseline* scenarios motivate our analyses of "reform scenarios", to which we turn next.

3.2.4 Reform scenarios

We start by looking at the effects of a social security reform that changes the rules governing public pensions in a quite radical way. Specifically, we study scenarios in which the government announces that taxes will no longer increase as a fraction of GDP, and that expenditures with pensions will have to adjust automatically to balance the budget. We name this a *Bold* reform. This is, of course, an extreme reform assumption. In particular, it would entail defaulting on "contracts" currently in place. Nevertheless, we believe that this exercise is useful because it highlights the potential effects of social security reforms in a stark way. Subsequently we entertain a more realistic, gradual social security reform.

***Bold* reform** We present results for Brazil only, starting with closed economies in Figures 5.1-5.3. Relative to the Baseline closed-economy scenario, in the *Bold* reform scenario GDP per capita and capital per worker increase significantly. Savings are higher and interest rates drop dramatically – eventually reaching levels that are lower than in the global economy (compare charts (3,3) in Figures 2.1 and 3.1). Pension expenditures are essentially capped at their initial level of 10% of the GDP and, as the population ages, the replacement rate falls, reaching 26% in 2200.

The reform entails an important shift in the paths of the present value of wealth of workers versus that of retirees (Figure 5.2, chart (1,1), solid red line versus dotted black line for workers, and dashed red line versus dash-dot black line for retirees). This arises mainly from the increase in the net present value of human wealth (Figure 5.3, chart (1,1)), but also because of workers' increased desire to save for retirement (Figure 5.3, chart (3,1)).

The second demographic dividend is sizeable in the *Bold* reform scenario, reaching approximately 0.20% per year for almost fifty years, and remaining above the *Baseline* closed-economy scenario into the next century. In this comparison it becomes clear that behavioral and general equilibrium effects matter for the magnitude of the second dividend. The increase in the NPV of workers' wealth more than compensates the reduction in the present value of retirees' wealth, and total consumption per effective consumer is also higher. In the long run, workers and retirees end up with approximately the same per capita consumption (Figure 5.2, chart (1,2)).

Next, in Figures 6.1-6.3, we compare the effects of reforming social security and suddenly opening up the economy at the same time (in solid and dashed red lines) against the Baseline

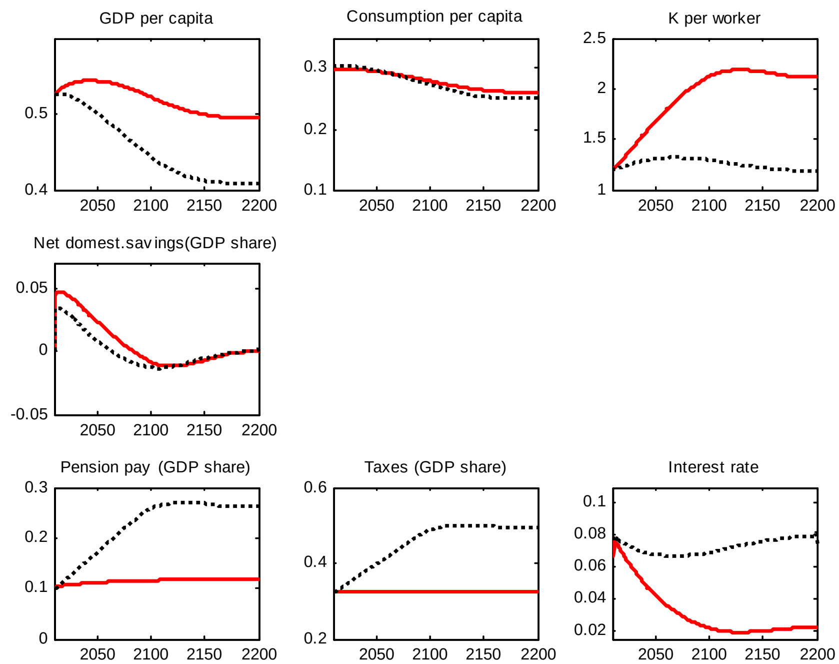

Figure 5.1: Brazil closed - *Bold* reform (solid red line) x *Baseline* (dotted black line)

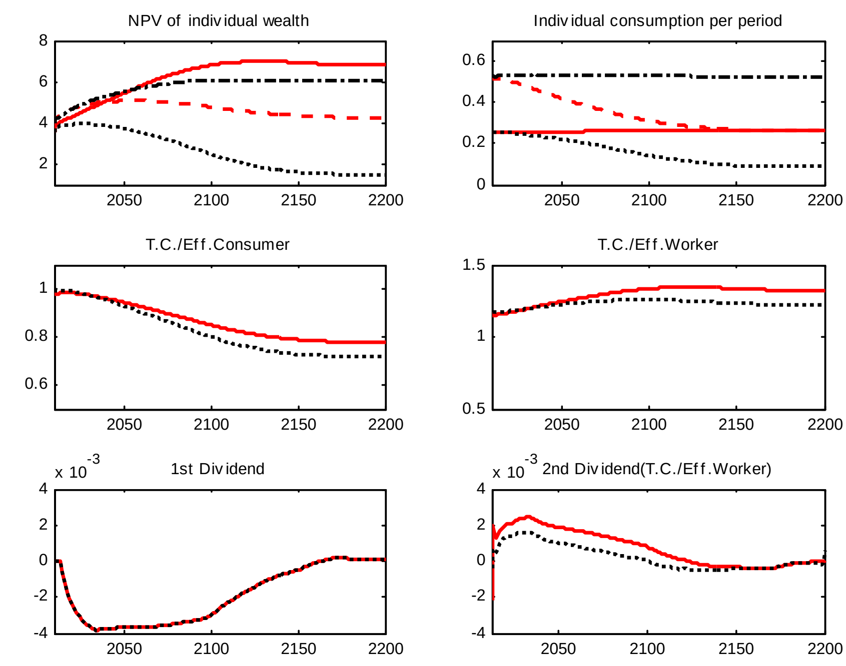

Figure 5.2: Brazil closed - *Bold* reform (solid and dashed red lines) x Baseline (dotted and dash-dot black lines) – demographic dividends

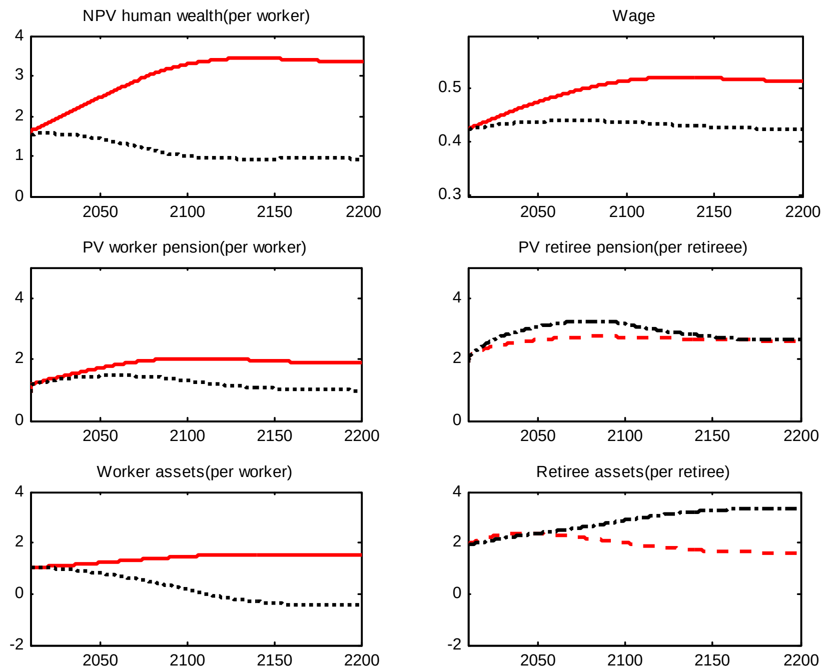

Figure 5.3: Brazil closed - *Bold* reform (solid and dashed red lines) x *Baseline* (dotted and dash-dot black lines) – wealth decomposition

closed-economy scenario (in dotted and dash-dot black lines). When the economy opens up and social security is reformed, interest rates drop and capital builds up dramatically. In this scenario, Brazilians eventually face a lower replacement rate than OECD citizens, and have stronger incentives to save for retirement. As Brazil moves into current account surpluses – after a period of extremely large current account deficits – Brazilians accumulate around 2.8 times the country's GDP in net foreign assets.

The initial sudden fall in the propensities to consume is more than compensated by the increase in the present value of wealth of both workers and retirees, who end up consuming more in the very short run. But as soon as retirees' consumption drops, the second dividend falls below the closed-economy case for a couple of decades, to become (and remain) higher after 2050. Except for a period of high savings between 2030 and 2080, total consumption per effective consumer is significantly higher than when the economy remains closed (including the case in which the social security is reformed).

Gradual reform The *Bold* reform scenarios analyzed previously are useful to illustrate the fact that a meaningful second demographic dividend might be possible in Brazil, especially if the economy opens up as social security is reformed. But that is too extreme a reform, as it essentially amounts to capping pensions as a share of GDP in an economy that will soon

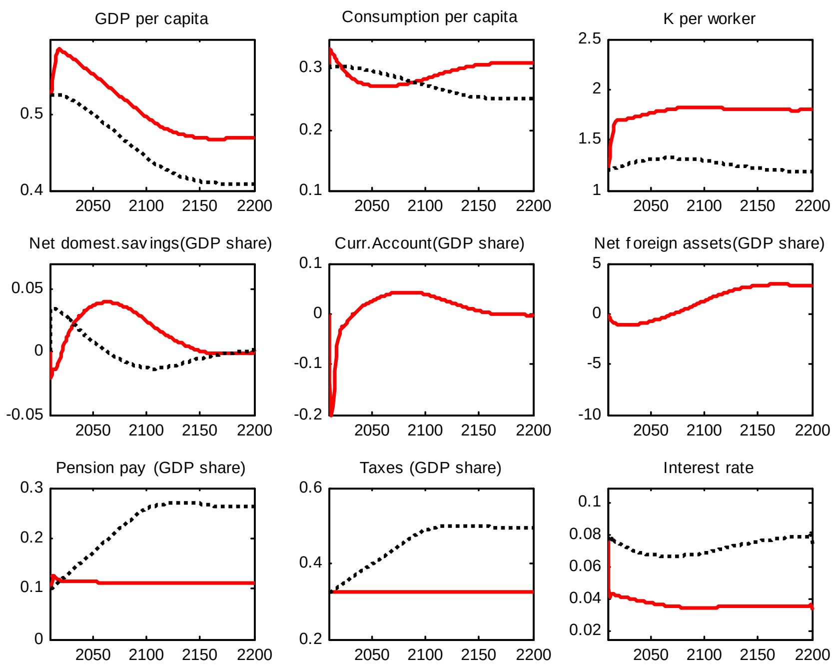

Figure 6.1: Brazil - *Bold* reform with sudden opening (solid red line) x *Baseline* closed (dotted black line)

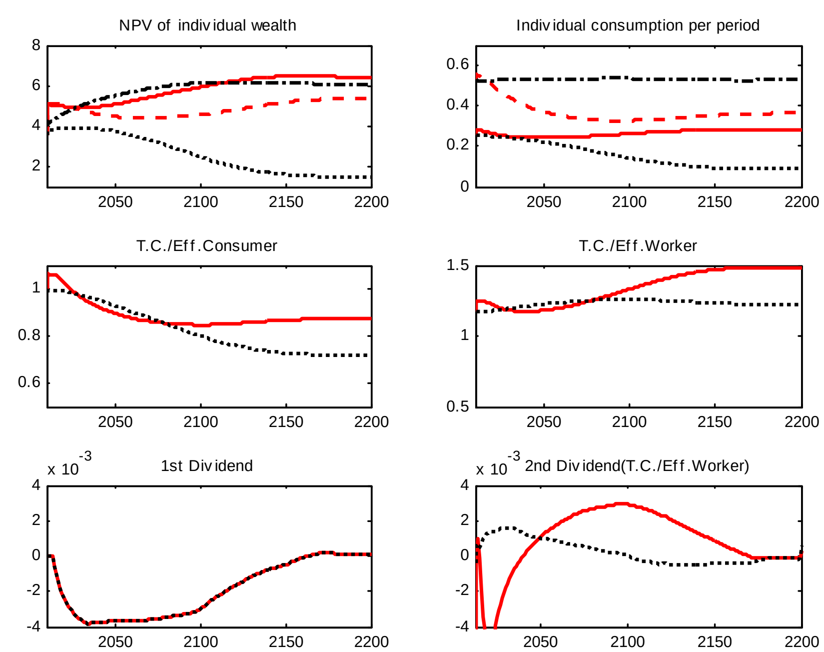

Figure 6.2: Brazil - *Bold* reform with sudden opening (solid and dashed red lines) x *Baseline* closed (dotted and dash-dot black lines) – demographic dividends

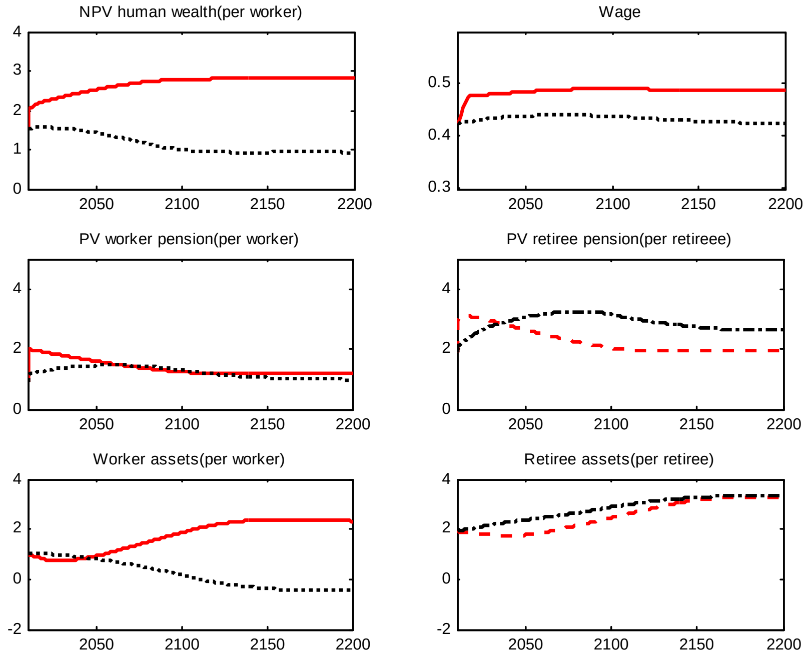

Figure 6.3: Brazil - *Bold* reform with sudden opening (solid and dashed red lines) x *Baseline* closed (dotted and dash-dot black lines) – wealth decomposition

embark on a fast aging process. In this section we entertain a more plausible, gradual reform.

What stands out in the *Baseline* scenarios with no reform is not as much the current level of expenditures with public pensions, but their projection as the Brazilian population starts to age fast going forward. Given the extremely high replacement rate of 70%, expenditures with pensions will eventually skyrocket to north of 25% of GDP (e.g. chart (3,2) in Figures 2.1, 3.1, and 4.1). Hence, we consider scenarios in which the current replacement rate is reduced gradually over a period of 25 years to reach the OECD level of 42% by 2035. We name this the *Gradual* reform scenario.

As before, we start with a comparison of the *Baseline* scenario with the *Gradual* reform scenario under the assumption of closed economies (Figures 7.1 and 7.2), followed by a comparison of the former scenario with a situation in which Brazil implements the gradual reform and opens up to trade in goods and assets (Figures 8.1 and 8.2).

Although there are some differences relative to the *Bold* reform case, overall the results are similar. The perspective of declining replacement rates going forward creates a strong incentive to save. Even in a closed-economy scenario, interest rates in Brazil decline to essentially international levels. Pensions and taxes as a share of GDP initially decline because of the decreasing replacement rate, and then increase again after 2035 because of the increasing dependency ratio. They stabilize, respectively, around 16% and 37% of GDP.

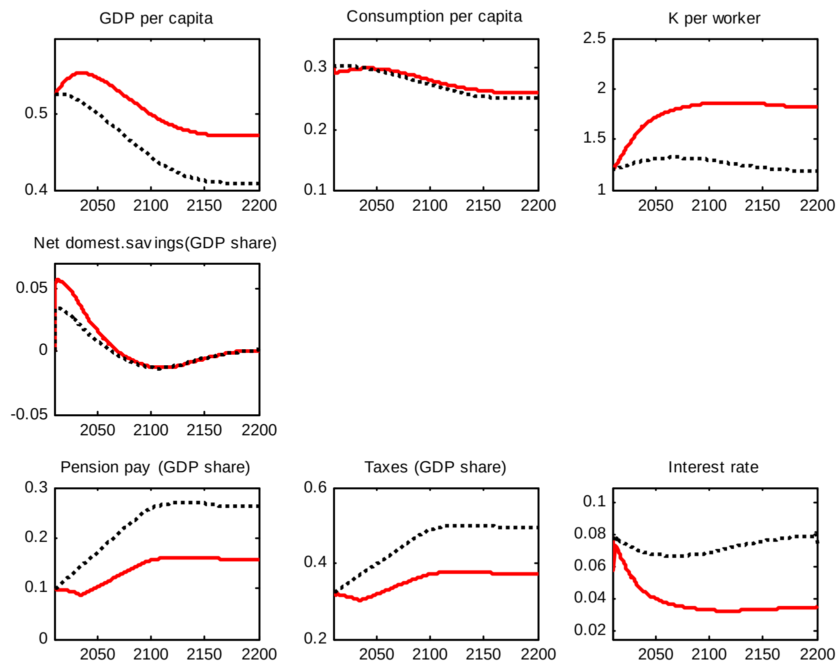

Figure 7.1: Brazil closed - *Gradual* reform (solid red line) x *Baseline* (dotted black line)

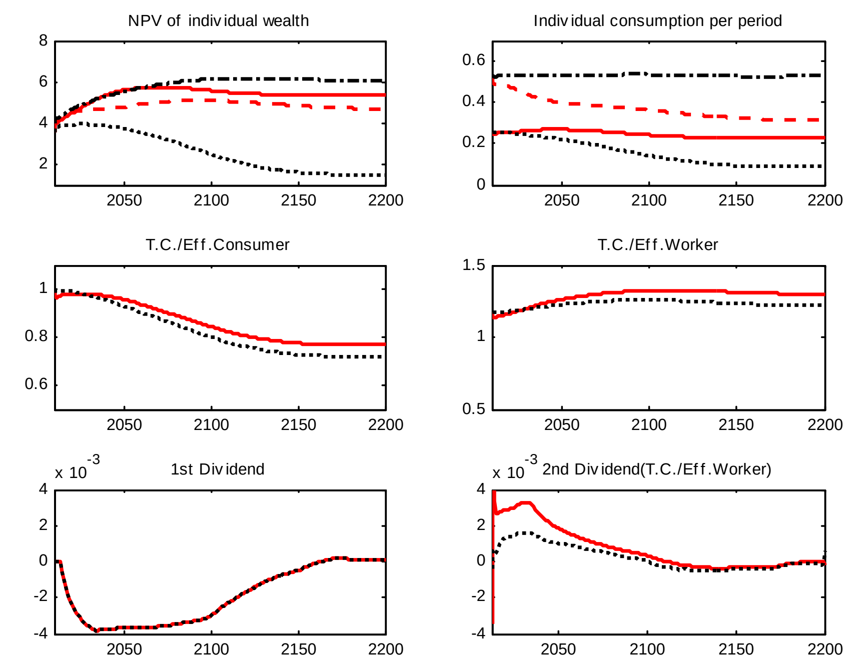

Figure 7.2: Brazil closed - *Gradual* reform (solid and dashed red lines) x *Baseline* (dotted dash-dot black lines) – demographic dividends

The reform increases the NPV of human wealth and reduces the present value of retirees' pensions relative to the *Baseline* scenario. The increase in the NPV of workers' wealth more than compensates the effects on retirees' wealth, and total consumption per effective consumer ends up higher. Overall, relative to the *Bold* reform, this scenario certainly appears more palatable for retirees.

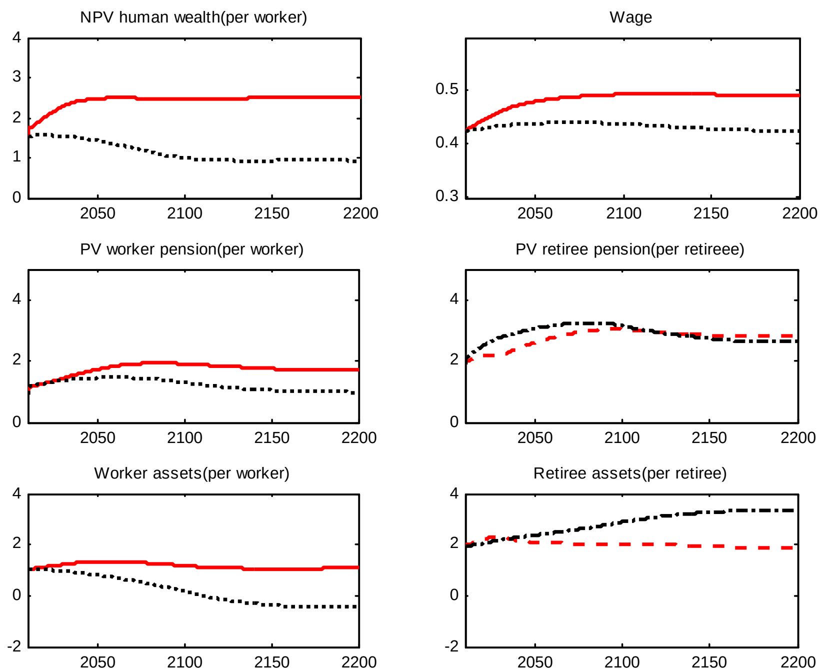

Figure 7.3: Brazil closed - *Gradual* reform (solid and dashed red lines) x *Baseline* (dotted and dash-dot black lines) – wealth decomposition

If the gradual reform starts at the same time as the economy opens up for trade (Figures 8.1-8.3), interest rates go down and capital accumulates faster in the beginning. After a brief period of large current account deficits, Brazil eventually moves into mild current account surpluses and Brazilians accumulate the equivalent of 50% of their GDP in net foreign assets. The second dividend, highly positive in the first few years, is lower than in the *Baseline* closed-economy scenario after a while. It then becomes higher again sometime before 2050, and remains higher thereafter. The general equilibrium effects on wages are also significant. This confirms that taking into account such effects might be important in scenarios in which social security is reformed.

Overall, it appears that the gains from opening up the economy at the onset of the gradual social security reform are not as obvious as in the *Bold* reform scenario. Perhaps this is not too surprising. Previously, we highlighted that without reforms the second dividend is likely to be larger if the economy is more closed. In contrast, the *Bold* scenarios show that opening might

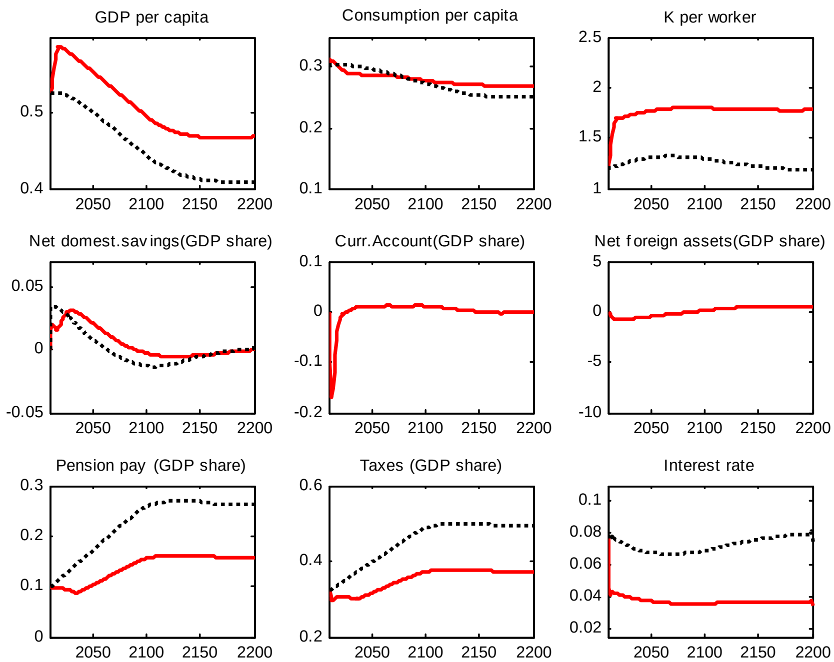

Figure 8.1: Brazil - *Gradual* reform with sudden opening (solid red line) x *Baseline* closed (dotted black line)

be positive for the prospects of a second demographic dividend if social security is revamped aggressively. Loosely speaking, the Gradual reform scenarios fall in between. Hence opening does not look as attractive a proposition as under an aggressive social security reform.

4 Conclusions

We use a small-scale, two country, general equilibrium overlapping generations model to study how public policies and differential demographic developments in Brazil vis-a-vis the developed world might interact to produce or prevent a second demographic dividend in Brazil. Our results suggest that, given the current social security system, a small second demographic dividend might arise if Brazil remains relatively closed to trade in goods and assets. Opening up under current social security arrangements turns out to be a losing proposition in that respect.

However, scenarios in which the current social security system remains in place produce incredible paths for expenditures with public pensions and taxes as a share of GDP. This is due to the fact that maintaining the very high replacement rates currently in place in Brazil becomes unsustainable as the country starts to age fast in the next couple of decades. To some extent, the average replacement rate in Brazil is high because average income is relatively low.

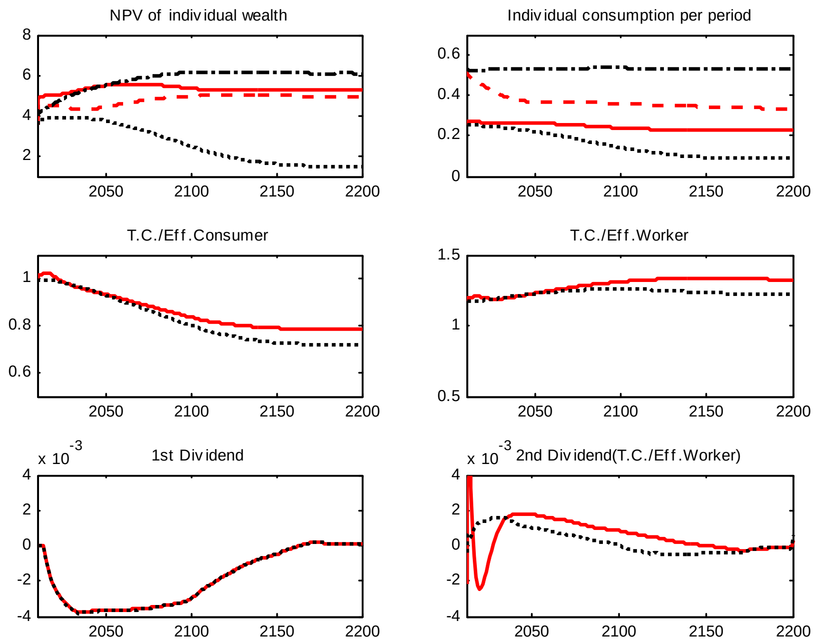

Figure 8.2: Brazil - *Gradual* reform with sudden opening (solid and dashed red lines) x *Baseline* closed (dotted and dash-dot black lines) – demographic dividends

What is granted by design given current social security rules is at least one minimum wage to every retired citizen above sixty five, or a certain pension (also indexed to the minimum wage) determined as a function of former contributions to the social security system. To the extent that the average income in Brazil increases (due to factors not included in our model), the replacement rate will fall somewhat. But along this transition – even if it happens eventually – the disincentives to save will be in place, reducing the scope for a meaningful second demographic dividend. Moreover, given current rules, it appears more likely that expenditures with pensions will become unsustainable, than that Brazil will grow its way out of this liability.

Motivated by those results, we entertain reform scenarios, in which growth in expenditures with public pensions is contained. We consider a *Bold* reform scenario in which taxes are frozen as a share of GDP, and expenditures with pensions have to adjust endogenously to balance the budget, and a more gradual reform scenario, in which the replacement rate in Brazil is lowered to the level that prevails in the OECD over a 25 year period. We also interact these reforms with liberalizations that open up the economy to trade in goods and assets. The *Bold* reform produces a meaningful second demographic dividend in Brazil, irrespective of whether the economy is open or closed to trade. In fact, in that case becoming more integrated with the world economy arguably becomes a winning proposition. That reform scenario is arguably unrealistic, however, since it involves defaulting on “contracts” that are currently in place,

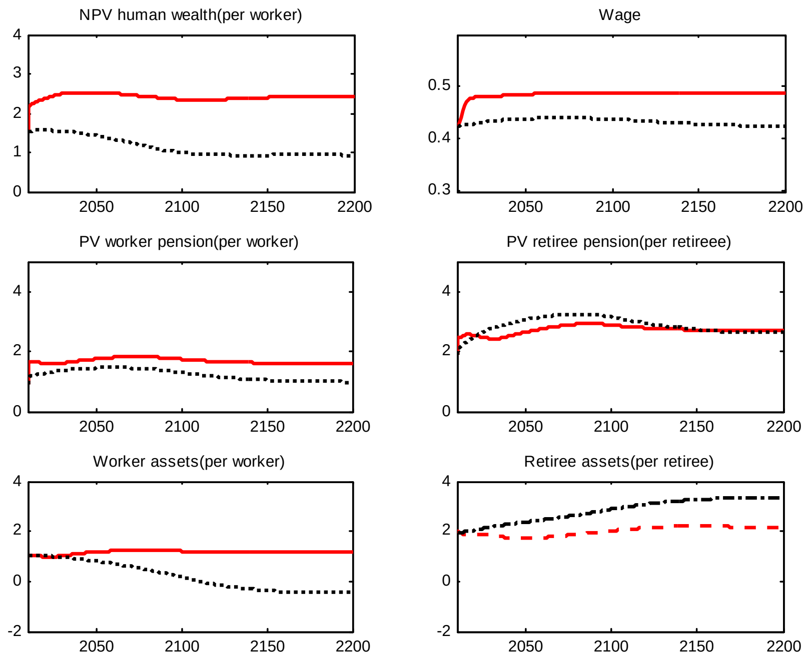

Figure 8.3: Brazil - *Gradual* reform with sudden opening (solid and dashed red lines) x *Baseline* closed (dotted and dash-dot black lines) – wealth decomposition

given social security rules. Unfortunately, under a more gradual reform keeping the economy relatively closed might arguably deliver a larger second dividend.

While our model brings discipline to a quantitative analysis of some of the macroeconomic effects of the demographic transition in Brazil, it is of course highly stylized. Hence it should only be seen as a guide to richer discussions – and possibly quantitative analyses – that factor in important dimensions that were left out of our framework and policy exercises. Nevertheless, we can always step outside the model to discuss a few important issues and relate our analysis to other contributions in this volume.

As Cooper (2013) points out, the Brazilian case does not quite fit the stereotype of other developing economies where demographic developments appear to be much more favorable, and where social security systems are less generous than in richer, more developed economies (see, e.g., Attanasio et al. 2006). In those cases, opening up to trade in goods and assets would appear to be beneficial in that it would allow those countries (and the developed world as well) to benefit from the trading opportunities brought about by the differential demographic developments. Younger, poorer countries can benefit from capital deepening, whereas older, richer countries can benefit from a higher return on capital, and sustain higher future consumption. In those cases, the issue of whether the countries attracting substantial amounts of capital have the financial infrastructure and the institutions to deal with them becomes important (see, e.g., Albrieu and Fanelli 2012 and Ocampo 2013). Here, again, Brazil does not quite fit the stereotype. In comparison with many other developing economies, Brazil has relatively deep financial and capital markets (see, for example, De Mello and Garcia 2012).

Relative to the issues discussed in the previous paragraph, our analysis suggests that in the case of Brazil other challenges might be more important. For example, our results suggest that opening up with an eye on the gains from trade due to differential demographic developments only makes sense if the country reforms its social security system. In that context, our model abstracts from important challenges that are likely to arise in practice. One important such challenge has to do with the political economy dimension of reform. Almost inevitably, retirees lose, while workers gain. Thus, reform proposals should face stronger opposition as the dependency ratio increases. This reasoning should be informative of reform strategies that have a higher likelihood of success. They should obviously try to be as bold as possible – if they are to spur a meaningful second dividend – but at the same time they have to be gradual to the extent necessary to make reforming feasible. A possible reform satisfying both criteria would be to announce a change in rules to a new "bold regime," while preserving current rules for those alive (or already participating in the labor market). A quantitative analysis of such a reform is certainly feasible, and appears worth undertaking in future research. In any case, one can ascertain that the political economy reasoning certainly calls for reforming sooner rather than later.

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