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Quantifying the Effects of the Demographic Transition in Developing Economies

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Quantifying the Effects of the Demographic Transition in Developing Economies*

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Abstract

This paper evaluates quantitatively the impact of the observed demographic transition on aggregate variables (factor prices, saving rate, output growth), and on inter-generational welfare in developing economies. It does so by developing a large-scale two-region equilibrium overlapping generations model calibrated to the North (more developed countries) and the South (less developed countries). The paper highlights that the effects of the demographic trends for less developed regions may depend on the degree of international capital mobility and on the extent to which the large Pay-As-You-Go systems in place in the more developed world will be reformed.

KEYWORDS: capital flows, demographic transition, developing economies, growth, social security, welfare

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1 Introduction

Many regions of the world are currently in the midst of a demographic transition. The main qualitative elements characterizing this transition, namely a reduction in fertility rates and an increase in life expectancy, are common across all regions. However, the magnitude, pace and timing of these changes are not, and different regions of the world are going through various stages of the demographic change.

Most of the developed world, and in particular Europe and Japan, have already reached very high levels of old-age dependency ratios (around 25%), measured by the fraction of the total population aged over 60 and display fertility rates below replacement value.¹ Thanks mainly to the larger immigration flow, the U.S. display a higher population growth rate than Europe and Japan.

In contrast, among developing countries, Latin America has only recently experienced a dramatic drop in the fertility rate: in the last 30 years, the birth-rate has declined from over five children per woman to less than three.² In spite of this sharp reduction, fertility is still 1.5 children per woman above the levels of the U.S. and Europe. Its life expectancy at birth is still over 10 years shorter than in the U.S. and Europe, but it has been growing steadily. East Asia has passed two decades ago through the phase Latin America is undergoing now, while most of Africa is still experiencing remarkably high population growth rates.³ The Middle East and South Asia are at intermediate points between Latin America and Africa. Overall, population growth is much higher in developing countries: the share of the world population living in the developed world (North America, Europe, Oceania and Japan), currently 20%, is expected to decline to less than 14% by 2050 (United

¹Replacement fertility is estimated to be 2.1 in developed countries and 2.4 in developing countries, due to the larger infant mortality rate.

²Also China witnessed a dramatic decline in fertility rate in the past two decades, mostly due to coercive family planning government policies, such as the “one-child” policy implemented in the late 70’s.

³Recently, though, in some African countries, population growth has considerably slowed down due to the HIV/AIDS epidemics. In South Africa, for example, life expectancy at birth has declined by 10 years (from 61 to 51) in the 1990s.

Nations, 2003).

Another important economic trend is the rise in female labor force participation. In the U.S., the fraction of women at work increased from 35% to over 65% in the postwar period. Part of this upward tendency for women to work more hours is due to the decline in birth rates. However, other factors, such as the development of the service sectors, the introduction of female contraceptives, the cultural impact of WWII and the 1960s, the reduction in child-care costs, and technological progress in the household are those credited to explain the bulk of changes in female participation. Interestingly, the South is catching up quickly with the North: for example, if we consider the average between Brazil, India, Mexico and Korea, female participation rates were below 20% in 1950 and climbed to 40% in 2000.

There is a long tradition in macroeconomics, going back to the seminal work of Malthus, that studies the causes of the secular decline in fertility and the other demographic trends described above. In this paper, we are interested in the macroeconomic and welfare implications of demographic trends, so we model the trends as occurring *exogenously*. We refer the reader to Greenwood and Seshandri (2005) for a recent survey of the literature on the economic sources of the demographic transition.

A vast literature has studied the economic implications of these massive demographic changes for the *developed* world. Perhaps surprisingly, the economic consequences of the demographic transition on *developing* economies have received much less attention. Since the demographic change is still largely ongoing, the dominant view is that the next decades will deliver a big “demographic bonus” on the speed of development. The reason is that the demographic structure that will prevail in the next decades in the South of the world—featuring a large fraction of working-age population—will be associated to high saving rates, faster capital accumulation and sustained growth. Moreover, in the policy debate it is often argued that, thanks to faster growth, the next decades constitute a major *window of opportunity* for these countries to implement structural reforms that in less favorable times may have less political support (e.g.,

IADB, 2000).

Several authors have uncovered a strong empirical nexus between changes in the demographic structure and aggregate macroeconomic variables. Recent contributions include Taylor (1995) and Behrman et al. (1999) on Latin America; Higgins and Williamson (1997) and Bloom and Williamson (1998) on South-East Asia (see Bloom, Canning and Sevilla, 2001, for a survey). Methodologically, the results in this literature are based upon estimation of time-series regressions of aggregate saving and output on several demographic indicators. The findings vary substantially by country and period, but a fair summary seems to be that the demographic changes of the past 30 years are associated to an acceleration in income per capita around 1% per year (Bloom, Canning and Sevilla, 2001) in developing regions.

Even though this empirical approach has yielded useful insights on the statistical association between demographic dynamics and macroeconomic outcomes, it has a number of limitations. Notably, it cannot take into account the general equilibrium interactions between factor prices and capital accumulation, and it is unable to quantify the intergenerational welfare consequences of demographic trends, which is ultimately a crucial question.

In this paper we contribute to the ongoing debate on the measurement of the economic and welfare implications of the demographic transition for developing countries. To overcome the above shortcomings, we carry out a quantitative analysis within a rich equilibrium model. Our main contribution is to emphasize an aspect that has been neglected by the literature: in a world with integrated capital markets, *the impact of the demographic transition in developing economies (the South) depends on the demographic trends in the developed world (the North)*. This is true for two reasons.

First, the different global demographic trends across regions induce diverging dynamics of the implicit rates of returns in the North and the South of the world. Thus, in an open economy with capital mobility, these interest rates differentials will command large capital flows. There-

fore, the impact of the demographic trends for the developing economies can be very different according to the degree of factor mobility. For example, if the unsynchronized demographic changes push capital toward the South, output in developing economies will grow faster. Second, the magnitude and the direction of capital movements depend on the extent to which the large Pay-As-You-Go (PAYG) systems of the North will be reformed as a response to demographic pressures. For example, in the event of a full privatization, life cycle savings will grow in the North and large capital flows (hence, faster growth) in the South become more likely.

We divide all countries in the world in two macro-regions called North and South and corresponding, respectively, to the “more developed regions” and “less developed regions” in the United Nation’s (UN) standard classification. We calibrate a large scale two-region general equilibrium overlapping-generations model to reproduce some basic facts of both developed and developing economies, in terms of the key demographic trends and of equilibrium steady-state values of macroeconomic aggregates.

Next, we simulate the global demographic transition in our model economy under three benchmarks. The first is a closed economy with no capital mobility. The remaining two are open economies with full capital mobility, where we assume two alternative scenarios for social security reform in the North. In one we keep pension benefits unchanged and let the payroll tax rise to balance the government budget; in the other, we fix the tax and we let the social security benefits decline to maintain the budget balanced. These latter two experiments represent two extremes: on the one hand, the survival of the PAYG and, on the other hand, a partial transition towards a fully-funded pension system in the North.

The objective of the analysis is quantifying the effects of the demographic change on some important macroeconomic aggregates in the South, like saving rate, factor prices, and income per capita growth. To make the mechanisms at work more transparent, before studying the impact of the full demographic transition, we run three counterfactuals

to report, separately, the impact of changes in fertility, longevity, and female participation.

Ultimately, we are interested in the impact of the demographic shifts on the welfare of the cohorts alive during the transition. We highlight that these welfare calculations pose a conceptual challenge because households' preferences change as longevity increases and fertility falls, making standard comparisons of lifetime utility flawed. We propose a consistent way to compute the welfare implications of the changes in equilibrium prices (interest and wage rate) and taxes (or benefits, depending on the policy scenario) induced by the demographic trends.

Our main findings are four. First, even though the income per capita “growth dividend” from the demographic transition was highest during the past 30 years—around 1.35% per year—it will still average 0.80% per year in the next five decades; thus the “window of opportunity” is still open. Second, when we decompose the demographic transition into changes in fertility, longevity, and participation rates we find that fertility has the strongest impact because it shifts the composition of the population toward age groups that are net savers and more productive providers of labor services. Third, the degree of openness of the economy, and the extent to which the North will privatize its PAYG system will have a small impact on future income growth. However, these factors will affect the distribution of income between labor and capital. For example, under a social security privatization scenario, wages would grow faster and rates of return to capital would fall more rapidly in the South, compared to a no-reform scenario. Fourth, households alive during the transition, especially the latest born cohorts, judge unfavorably the changes in the equilibrium prices and taxes induced by the demographic trends. The presence of unrestricted international capital flows can mitigate significantly these adverse welfare implications.

There are several studies in the literature related to ours. Auerbach and Kotlikoff (1987) pioneered the use of OLG models for computational experiments and Obstfeld and Rogoff (1996) extended them to a multi-region setting. Building on Lee (1974), Rios-Rull (2001) has developed a

useful set of tools to model in detail shocks to the demographic structure in overlapping generations models. Our methodology borrows heavily from these articles.

There is a vast literature, based on OLG models, on the sustainability of defined-contributions social security schemes financed on a pay-as-you-go (PAYG) basis.⁴ Some recent examples of quantitative analyses of this issue for the U.S., in closed economy models, are Conesa and Krueger (1998), Huggett and Ventura (1999), DeNardi, Imrohoroglu and Sargent (1999, 2001), and Kotlikoff, Smetters and Walliser (1999). Examples of multi-region models are Fehr, Jokisch and Kotlikoff (2005) and Attanasio, Kitao and Violante (2005). Miles (1999) and Miles and Timmermann (1999) have applied similar models to European countries. Storesletten (2000) has quantified the effect that migration flows into the U.S. can have on the welfare of the baby-boom generations.

Henriksen (2002), Brooks (2003), Feroli (2003), Borsch-Supan et al. (2004), and Domeij and Floden (2005) have all solved multi-region equilibrium OLG model of the world to study whether the diverging demographic trends can explain the observed low-frequency patterns of international capital mobility over the past 50 years and predict future movements.

Beyond the social security system and capital flows, the rapid aging of the population is also expected to deeply affect the health insurance system because the demand for health services rises steeply after retirement (see Bohn, 2003; Heller, 2003) as well as financial markets, since the retired baby-boomers will increase the demand of particular financial products, such as short-term riskless bonds, that preserve asset value and liquidity (see Brooks, 2000; Poterba, 2001; Abel, 2003; Lim and Weil, 2003; Geanakoplos, Magill and Quinzii, 2004).

With this literature, we share the broad question and the structural approach to the answer. In contrast to this literature, our atten-

⁴In the U.S., for instance, it is projected that the social security trust fund, which is currently running a substantial surplus thanks to the presence of the large baby-boom generation in the labor force, will be exhausted around the year 2040 (OASDI Board of Trustees Report, 2004). Trends are even more daunting in Europe and Japan.

tion goes to developing regions rather than the U.S. or other developed economies. Moreover, we are not concerned about either the size of the demographics-induced capital flows or the dynamics of social security by themselves—even though our model has implications for both—but rather about their impact on the macroeconomy and on the welfare of households in the South.

The rest of the paper is organized as follows. In Section 2 we document the current and projected demographic trends in the North and the South. In Section 3 we present the overlapping generation model we use in our simulations. In section 4 we outline the calibration of our model economy. In Section 5 we present the results of our simulations. Section 6 concludes the paper.

2 Global demographic trends

We begin by briefly illustrating the main demographic trends that motivate the exercise we undertake below. Our main source of demographic data on fertility and longevity are two United Nations' publications: *World Population Prospects: The 2002 Revision Population Database United Nations* (2003) and *World Population in 2300* (2004). Cross-country data on female labor force participation are taken from *The International Data Base* of the U.S. Census Bureau (2004).

We aggregate all the countries in the world—weighting them by their population—in two macro-regions. The first region, which we label the “North”, corresponds to the UN’s set of “More Developed Regions” composed of North America, Europe, Japan, Australia and New Zealand. The second is called the “South” and corresponds to the UN’s “Less Developed Regions”, which combines the rest of the world. We use the so-called “medium variant” projection of the U.N. data set.⁵

⁵Even though projections are undermined by some degree of statistical uncertainty the longer is the time horizon, we have two strong reasons to be confident. First, past estimates have been very accurate: for example, in 1957 the projection overestimated the world population in 2000 by less than 4%. Second, most of the errors are made at the country-level, so aggregation into two large regions helps substantially.

In Figure 1 we plot actual and projected data on fertility rates, life expectancy, dependency ratios and female participation rates in the two regions for the period 1950 to 2100. See Attanasio, Kitao and Violante (2005) for the details of the calculations and the projections of age-specific fertility rates, surviving probabilities and female participation.

Longevity is rising—Improvements in medicine (such as the introduction of antibiotics, the treatment of diseases like malaria and tuberculosis), public health and sanitation (such as land reclamation) have substantially accelerated the decline in mortality. In the upper right panel we plot the life-expectancy at birth in the two regions. Life-expectancy in the developed world has risen almost by 10 years in the past half-century and is projected to increase, on average, by one year per decade for the next century—up to age 87 in 2100. Even though in the South life-expectancy has caught up considerably with the North, it still remains, today, roughly 13 years lower. This convergence process is expected to continue, albeit at a slower pace.

Birth rates are falling—An important part of longer life-expectancy is explained by the decline in infant mortality. If children are expected to survive longer, parents can give birth to fewer children and invest more in them—the Beckerian quality/quantity trade-off. In the upper left panel we plot average fertility rates (measured as the average number of children of women aged 15 to 49) in the two regions: notice that even though fertility has decreased dramatically in the South, it is still substantially above the levels observed in the North. Convergence of fertility rates is expected to happen around 2070. Notice also that the North is about to experience a significant rebound in fertility rates. Postponing child-bearing for women has been an important phenomenon in the developed world, as women became more educated and more attached to the labor market. This process has the transitional effect of reducing the aggregate fertility rate, but in the long run fertility will start rising again towards its stationary value.

Population is aging—In the lower left panel we plot the elderly de-

dependency ratio, defined as the fraction of individuals aged above 60 in the total population.⁶ The old dependency ratio in the North is increasing fast and it is projected to grow dramatically over the next 50 years. This sharp acceleration is caused by the drop in fertility and the increase in longevity illustrated above. The acceleration is particularly pronounced in Europe where the decline in fertility was greater. In the South, instead, the dependency ratio is still fairly stable and is not projected to start climbing until the year 2010. The absolute difference between the dependency ratios across the regions (7.7% in the South and 19.4% in the North, in the year 2000) is striking and shows that there is a substantial difference in the age-structure of the population between the two regions.

Female labor force participation is rising— The main reason demographic trends are important in our context is because they change the size of the workforce and, as a consequence, factor prices. For this reason, changes in female labor force participation are crucial. As can be seen from the lower right panel of Figure 1, the rise in female participation rate is almost exhausted in the North, whereas in the South the fraction of women at work is expected to increase substantially in the next 50 years. The demographic trends described above imply that, while population in the North is already close to zero growth and expected to decline slightly after 2025, the population of the South is still growing considerably and, in the next two decades, it will be growing above 1% per year. The difference in projected female labor force participation further amplifies the differences in population growth on the relative size of the labor force between North and South.

The divergence in the magnitude and the timing of demographic trends between North and South is a feature that has two important consequences for our analysis. First, there is enormous potential for cross-country factor mobility, so the closed and open economy bench-

⁶We used this definition rather than the more conventional definition of the dependency ratio computed as the ratio of the population 65+ to the working age population (15-64), since the long-run forecast of the latter is not available in the UN database.

marks may differ. Second, within the open economy benchmark, the extent of survival of the social security system in the North will potentially affect how demographic trends in the North transmit, through capital flows, to the macroeconomic aggregates in the South.

3 The model economy

3.1 Building blocks

Demographics– The economy consists of overlapping generations of ex-ante identical individuals who live for at most I_1 periods. Therefore, at any point in time, there are I_1 different generations alive. Individuals remain children until age I_0 and as children they do not make independent decisions, and they do not work. After I_0 periods, they become adults and form a household that consists of a male and a female. For the rest of their life, pairs of individuals make decisions jointly as a household.

A household of age j at time τ faces a time-varying probability $\pi_{\tau,j}$ of surviving into age $j + 1$ at time $\tau + 1$. Furthermore, in each period pairs of these households give birth to a certain number of children, according to a time and age-specific fertility rate $\phi_{\tau,j}$. Following Lee (1974), Rios-Rull (2001) and Storesletten (2000), the evolution of the population structure can be described by a simple matrix of dimension $(I_1 \times I_1)$. If we denote with Γ_τ such a matrix for time τ and with \mathbf{m}_τ the $(I_1 \times 1)$ vector containing the number of households in each age group at time τ , the evolution of the population structure is given by:

$$\mathbf{m}_{\tau+1} = \Gamma_\tau \mathbf{m}_\tau, \quad (1)$$

where the first row of Γ_τ contains the relevant fertility rates at each age, and each element $(j + 1, j)$, with $j = 1, \dots, I_1 - 1$, contains the terms $\pi_{\tau,j}$, i.e. the conditional probabilities, at time τ , of surviving from age j to age $j + 1$. The remaining elements of the Γ_τ matrix are all zero.

Since the economic problem is relevant only during adulthood, it is useful to introduce the following normalization. Let us denote by t the time when adulthood begins (i.e., $\tau + I_0$), by i the numbers of years spent

in adulthood (i.e., $j - I_0$), and by I the length of adulthood $I_1 - I_0$. Also redefine \mathbf{m}_τ as the $(I \times 1)$ vector of the number of households in each adult age group. Hereafter, when we talk about an agent of age i born at t , it is understood that we mean an agent that turned adult at time t and that has been adult for i years.

Preferences and household optimization— Households derive utility from a homogeneous consumption good. They do not derive utility from leisure. Each household has a unit of time endowment that can be devoted either to productive activities in the market or to child care at home.

Let the labor supply of an age i household at time t be $l_{t,i} = l_t(\mathbf{d}_{t,i})$, where $\mathbf{d}_{t,i}$ is the $(I_0 \times 1)$ vector of numbers of dependent children in the household. We interpret $1 - l_t(\mathbf{d}_{t,i})$ as an exogenous fraction of time devoted to child care which is increasing in the number of dependent children in the household. Although we choose to keep labor supply exogenous, we model the major secular trend in labor supply—the rise in female participation—and through the function $l_t(\mathbf{d}_{t,i})$ we capture, albeit mechanically, the key interaction between changes in fertility and changes in the female labor participation decision.

Market productivity of each agent varies with age according to a deterministic pattern: we denote the vector of efficiency units of labor with $\{\epsilon_i\}_{i=1}^I$ and the age of mandatory retirement by I_R .

The instantaneous utility of a household depends on consumption of the adults $c_{t,i}^a$ and that of their dependent children $c_{t,i}^d$ given as

$$u(c_{t,i}^a, c_{t,i}^d) = \frac{(c_{t,i}^a)^{1-\gamma} - 1}{1 - \gamma} + d_{t,i}\omega(d_{t,i})\frac{(c_{t,i}^d)^{1-\gamma} - 1}{1 - \gamma}, \quad (2)$$

where $\omega(d_{t,i})$ defines the weight on the children's consumption that can potentially depend on the number of children $d_{t,i}$. The (inverse of the) parameter γ measures the elasticity of intertemporal substitution. Notice that with the optimality condition of the household with respect to $c_{t,i}^d$, we can express children's consumption as $c_{t,i}^d = c_{t,i}^a\omega(d_{t,i})^{1/\gamma}$. Using this

relationship in (2), the utility function is simplified as

$$u(c_{t,i}) = \Omega_{t,i} \frac{(c_{t,i})^{1-\gamma} - 1}{1-\gamma},$$

where $c_{t,i} = c_{t,i}^a + d_{t,i}c_{t,i}^d$, the total consumption of a household, and $\Omega_{t,i} = [1 + \omega(d_{t,i})^{1/\gamma}d_{t,i}]^\gamma$. An agent born at time t solves the following problem:

$$\begin{aligned} & \max_{\{c_{t+i-1,i}\}_{i=1}^I} \sum_{i=1}^I \beta^{i-1} \Pi_{t+i-1,i} \Omega_{t+i-1,i} u(c_{t+i-1,i}) \\ & s.t. \end{aligned} \tag{3}$$

$$(1 + \tau_t^c)c_{t,i} + a_{t+1,i+1} = y_{t,i} + [1 + (1 - \tau_t^a)r_t] a_{t,i} + b_{t,i}$$

$$a_{t,1} = a_{t,I+1} = 0.$$

The term $\Pi_{t,i}$ denotes the unconditional probability of surviving until age i at time t , obtained through the product of all the past conditional surviving probabilities. Thus, a household of (adult) age i at time t discounts next period utility at rate $\beta\pi_{t,i}$, where β is a constant discount factor. Asset holdings $a_{t,i}$ represent claims on the capital stock used in production. We assume that initial wealth is zero for each agent and we impose no borrowing constraints, except for a no-Ponzi scheme condition that requires every agent to hold non-negative assets when they reach the terminal period of life.

We assume that households have access to perfect annuity markets and share the assets of the deceased within the same cohort. The annuity payment $b_{t,i}$ to the survivors is given by

$$b_{t,i} = \frac{m_{t,i}(1 - \pi_{t,i})}{m_{t,i}} a_{t+1,i+1} = (1 - \pi_{t,i})a_{t+1,i+1} \tag{4}$$

The wage and interest rate at time t , taken as given by households, are denoted respectively by w_t and r_t . The variable $y_{t,i}$ denotes the net-of-tax labor income of a household of working age and the social security benefits of a retired household:

$$y_{t,i} = \begin{cases} (1 - \tau_t^w) w_t \epsilon_{t,i} l_{t,i} & \text{if } i < I_R, \\ p_{t,i} & \text{if } i \geq I_R, \end{cases} \tag{5}$$

The retirement benefit $p_{t,i}$ is given by the replacement ratio ρ_t times the average past labor income. Households pay proportional taxes $\{\tau_t^c, \tau_t^a, \tau_t^w\}$ on consumption, capital income and labor income, respectively.

From the household's Euler Equation, we obtain:

$$\frac{c_{t+1,i+1}}{c_{t,i}} = \left[\beta \frac{\Omega_{t+1,i+1}}{\Omega_{t,i}} \frac{1 + \tau_t^c}{1 + \tau_{t+1}^c} R_{t+1} \right]^{\frac{1}{\gamma}}, \quad (6)$$

where $R_t \equiv 1 + (1 - \tau_t^a)r_t$ denotes net-of-tax gross interest rate. This equation determines the slope of the household consumption profile. The initial level of consumption is determined by a condition stating that the present discounted value of lifetime consumption equals the present discounted value of lifetime resources W_t , where

$$W_t = y_{t,1} + \sum_{j=1}^{I-1} y_{t+j,j+1} \prod_{i=1}^j \left(\frac{\pi_{t+i-1,i}}{R_{t+i}} \right).$$

Technology and firm optimization— Output is produced by competitive firms operating a constant returns to scale Cobb-Douglas production function $F(\theta_t, K_t, L_t) = \theta_t K_t^\alpha L_t^{1-\alpha}$ with capital share equal to α and total factor productivity at time t equal to θ_t . The firms rent capital and labor every period from competitive spot markets and maximize static profits by taking factor prices as given. The implied optimality conditions are:

$$\begin{aligned} r_t &= \alpha \theta_t K_t^{\alpha-1} L_t^{1-\alpha} - \delta \\ w_t &= (1 - \alpha) \theta_t K_t^\alpha L_t^{-\alpha}, \end{aligned} \quad (7)$$

where L_t denotes aggregate efficiency units of labor and K_t the aggregate capital stock used in production at time t . The firms set marginal product of labor equal to the wage rate (per efficiency unit) w_t and the marginal product of capital net of depreciation equal to the rate of return on capital r_t .

Fiscal policies and government budget constraint— The government collects revenues by taxing consumption, capital income and

labor income and by issuing one-period riskless bond B_t . The government uses revenues to finance public expenditures G_t and social security benefits $p_{t,i}$ for the retired agents. The government's budget constraint is given by

$$G_t + (1+r_t)B_t + \sum_{i=I_R}^I p_{t,i} m_{t,i} = \tau_t^w w_t \sum_{i=1}^{I_R-1} \epsilon_{t,i} l_{t,i} m_{t,i} + \sum_{i=1}^I (\tau_t^a r_t a_{t,i} + \tau_t^c c_{t,i}) m_{t,i} + B_{t+1}. \quad (8)$$

Factor mobility— At this point, we need to distinguish between closed and open economy. In the closed economy, gross investment in each region r equals the regional saving rate. In the open economy with frictionless capital markets, the marginal product of capital is equalized in both regions and determines the world interest rate. If, for example, capital moves from the North to the South, the associated capital flow adds to the productive stock in the South and, at the end of the period, the appropriate interest income is paid from the South to the North as a remuneration for its rental.

3.2 Equilibrium

Our model economy undergoes a transition between two steady states. The transition is induced by simultaneous changes in the region-specific TFP parameters $\{\theta_{r,t}\}_{t=1}^{\infty}$, demographic matrices $\{\Gamma_{r,t}\}_{t=1}^{\infty}$ and participation functions $\{l_{r,t}\}_{t=1}^{\infty}$. We provide two definitions of equilibrium, one for the closed economy and one for the open economy. In both cases, we let the labor income tax be the residual policy variable that adjusts to balance the government budget, given all other fiscal variables. In one of our experiments, the payroll tax in the North is kept fixed and the retirement benefits adjust: it is straightforward to modify the equilibrium definitions below to this latter case, so we omit it.

Given region-specific productivity and demographic sequences $\{\theta_{r,t}, \Gamma_{r,t}, l_{r,t}\}_{t=1}^{\infty}$, an *equilibrium for the closed economy* is a sequence of variables $\{\{c_{r,t,i}, a_{r,t,i}\}_{i=1}^I, K_{r,t}, L_{r,t}, w_{r,t}, r_{r,t}, \tau_{r,t}^w\}_{t=1}^{\infty}$ in each region $r = N, S$ such that: the population shares $\{\{m_{r,t,i}\}_{i=1}^I\}_{t=1}^{\infty}$ are determined

by the law of motion (1); households solve optimally their problems (3) taking prices as given; factor prices are set to marginal productivities as in (7); the aggregate resource constraint in the economy of region r requires:

$$\theta_{r,t} K_{r,t}^\alpha L_{r,t}^{1-\alpha} = S_{r,t} + \sum_{i=1}^I c_{r,t,i} m_{r,t,i} + G_{r,t}. \quad (9)$$

where $S_{r,t}$ is aggregate national savings. Labor and asset markets clearing implies the conditions:

$$\begin{aligned} L_{r,t} &= \sum_{i=1}^{I_R-1} \epsilon_{r,t,i} l_{r,t,i} m_{r,t,i}, \\ K_{r,t} + B_{r,t} &= \sum_{i=2}^I a_{r,t,i} m_{r,t-1,i-1}. \end{aligned} \quad (10)$$

The government policy $\{\tau_{r,t}^w\}_{t=1}^\infty$ satisfies the budget constraint (8) in each region.

Given region-specific productivity and demographic sequences $\{\theta_{r,t}, \Gamma_{r,t}, l_{r,t}\}_{t=1}^\infty$, an *equilibrium for the open economy* is a sequence for the variables $\{\{c_{r,t,i}, a_{r,t,i}\}_{i=1}^I, K_{r,t}, L_{r,t}, w_{r,t}, \tau_{r,t}^w\}_{t=1}^\infty$ in each region $r = N, S$, external wealth owned by the North in the South $\{X_t\}_{t=1}^\infty$ and a world interest rate $\{r_t\}_{t=1}^\infty$ such that: the population shares are determined by the law of motion (1); households solve optimally their problems (3) taking prices as given; wages in each country are set to marginal productivity of labor as in (7); the aggregate resource constraint in the two regions requires conditions

$$\begin{aligned} \theta_{N,t} K_{N,t}^\alpha L_{N,t}^{1-\alpha} &= \sum_{i=1}^I c_{N,t,i} m_{N,t,i} + K_{N,t+1} - (1-\delta) K_{N,t} + X_{t+1} - (1+r_t) X_t + G_{N,t}, \\ \theta_{S,t} K_{S,t}^\alpha L_{S,t}^{1-\alpha} &= \sum_{i=1}^I c_{S,t,i} m_{S,t,i} + K_{S,t+1} - (1-\delta) K_{S,t} - X_{t+1} + (1+r_t) X_t + G_{S,t}, \end{aligned}$$

to be satisfied; market clearing in the regional labor markets imply the condition in the first line of (10); the government policy $\{\tau_{r,t}^w\}_{t=1}^\infty$ satisfies the budget constraint (8) in each region; equalization of rates of return in the two countries implies the no-arbitrage condition:

$$r_t + \delta = \alpha \theta_{N,t} \left(\frac{L_{N,t}}{K_{N,t}} \right)^{1-\alpha} = \alpha \theta_{S,t} \left(\frac{L_{S,t}}{K_{S,t}} \right)^{1-\alpha}. \quad (11)$$

For a given parametrization of the model economies, described in the next section, we compute numerically the steady states of the model (before and after the demographic transition) as well as the equilibrium transition between the two steady states.⁷

4 Calibration of the model economy

In this section, we describe the choice of the demographics, preference, technology and policy parameters used in the baseline simulations. We assume all demographic parameters and TFP growth rates converge to the same values in the two regions by 2200, so that in the long-run the two regions converge to a common balanced growth path.⁸ Data aggregation across countries into the regional variables is population-weighted for demographic variables, and GDP-weighted for macroeconomic variables.

Demographics— We calibrate the first steady state of the model economy to the 1950s, and the final steady state based on demographic forecasts for 2200 (United Nations, 2004). During the transition away from the initial steady-state, the population size in both regions is determined by the evolution of age-specific fertility rates and survival rates broadly described in section 2 and Figure 1. See Attanasio, Kitao and Violante (2005) for details.

We divide the lifetime of an household in the model into 24 5-year periods, hence the unit of time in the model is 5 years and the maximum length of life is 120 years. We set $I_0 = 3$, i.e. the agents become adult and economically active at age 17 and $I_R = 11$ so that agents retire at age 67.

Preferences— Preferences are common across the two regions and we set the coefficient of risk aversion γ at 2, corresponding to an elastic-

⁷As customary, a *steady-state* equilibrium requires the population shares, the capital-labor ratio (hence, factor prices), and (in the open economy model) the international capital flows to be constant over time.

⁸This is to avoid that one region becomes negligible in the long-run. Note that even though in the long-run the two regions face the same population growth and productivity growth rate, there will be differences in the levels of all macroeconomic variables (in particular, in income per capita).

ity of intertemporal substitution of 0.5. The discount factor β is set to 1.047 (or 1.009 on an annual basis) to match the target annual capital-output ratio of 2.5 in the North in 2000. We calibrate the weight of children in the utility function to match the commonly used consumption adult-equivalent scales. Based on the micro-evidence summarized in Fernandez-Villaverde and Krueger (2004), we set the weight parameter $\omega = 0.216$.⁹

Efficiency profile— The age-profile of efficiency units of labor $\{\epsilon_i\}_{i=1}^I$ is chosen separately for the two regions. For the North, we use the U.S. Consumer Expenditure Survey (CEX) for the period of 1982-1999. For the South, we used the equivalent of the U.S. CEX for Mexico.¹⁰ In both surveys, we restrict the sample to 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. Beyond age 67, the efficiency units ϵ_i is set to zero, which is equivalent to a retirement status.

Labor force participation— The total labor supplied to the market by each household is given by the total time endowment net of time spent for child care. We normalize the time endowment of the household to 1 unit and assume that males work full time (i.e., 0.5 units of time). Hence, $l_t(\mathbf{d}_{i,t}^r) = 0.5 [1 + P_t(\mathbf{d}_{i,t}^r)]$, where $P_t(\mathbf{d}_{i,t}^r) \in (0, 1)$ denotes the fraction of time a female worker of age i supplies to the labor market in region r at time t , when her household has a vector of dependent children $\mathbf{d}_{i,t}^r$. This function captures, albeit mechanically, that increased women’s participation is partially due to the decline in fertility.

To parameterize the function P_t , we use Consumers Expenditures Survey (CEX) data on female hours worked and number of children of different age groups and estimate, through a Probit regression, the marginal

⁹This choice of ω yields ratios of the consumption of a household with 1, 2 and 3 children compared to a household without children respectively equal to 1.23, 1.46 and 1.69, i.e. extremely close to the numbers reported by Fernandez-Villaverde and Krueger (2004, Table 3.2.1).

¹⁰We used the 1989, 1992, 1994, 1996, 1998, and 2000 waves of *Encuesta Nacional de Ingreso y Gasto de los Hogares* (ENIGH) to estimate an age-efficiency profile. See Attanasio and Szekely (1999) for a detailed description of the survey data.

effect of having dependent children of a particular age on hours worked measured as a fraction of the time endowment. As expected, we find that a newborn child has the strongest negative impact on participation and, as the child ages, the effect is smaller.

The other components, beyond the decline in fertility, affecting female labor force participation are captured by a region-specific exponential trend. As for demographics, we assume convergence in participation rates in 2200. The model for the dynamics of P_t is described more in detail in Attanasio, Kitao and Violante (2005).

Technology— The production function is Cobb-Douglas with share of capital α set at 0.3 in both countries. For the calibration of TFP, we use the World Bank's *World Development Indicators* (WDI). The UN's definition of "More Developed Regions" and "Less Developed Regions" correspond to the WDI's "High Income Countries" and "Low and Middle Income Countries", respectively.

We set the initial value of TFP in the North $\theta_{N,0}$ to 1.802 in order to normalize income per capita in the North to 1 in the first steady state. $\theta_{S,0}$ is set at 0.677 so that the per-capita output in the South in 1950-2000 is approximately 7 times smaller than for the North, as reported by the WDI. The average per-capita output growth rate in the North is 2.7% during 1950-2000 and 2.2% in the South. We let the TFP $\theta_{N,t}$ and $\theta_{S,t}$ grow at 1.78% and 1.50% during 1950-2000, respectively so that the model achieves these growth rates during the period. After 2000, the TFP of the North continues to grow at 1.78% and we let the TFP growth in the South converge smoothly to that of the North. A depreciation rate of 5% per year allows to match the investment-capital ratio in both regions. The implied equilibrium return to capital in 2005 is 6.6% in the North and 8.5% in the South.

Social security— In the North, we set the replacement rate of the average past earnings at $\rho_N = 46.7\%$ during 1950-2005, based on the study of Whitehouse (2004) on nine OECD countries. In the South, PAYG social security systems are much smaller in size. The more important roles played by self-employment and informal production in the South

relative to the developed world implies that a vast part of the working population is not covered by any public pension system. The WDI reports that social security tax revenues represent only 0.3% of GDP in Low and Middle Income countries; we set the social security replacement rate in the South to $\rho_S = 10.05\%$ to match this statistics.

Fiscal policy– We use the tax data of Mendoza, Razin and Tesar (1994) for seven OECD countries to calibrate the tax rates in the North. The consumption tax rate is set at $\tau_N^c = 9\%$ and the capital income tax is set at $\tau_N^a = 38\%$. The labor income tax τ_N^w adjusts in the model to achieve the balanced government budget. The closed-economy model yields $\tau_N^w = 26.2\%$ as the average during 1950-2000, which is close to 27.9% reported in Mendoza, et al. (1994).¹¹ For the South, we use the same capital income tax rate as in the North and we set the consumption tax $\tau_S^c = 15\%$, higher than in the North, reflecting the argument that the governments in the developing countries rely much more on indirect taxation.¹² The equilibrium average wage tax for the period 1950-2000 is $\tau_S^w = 6.0\%$ in the model.

We use the WDI (1970-2000) to compute the government debt and expenditures as a fraction of GDP. For the North, the government expenditures $G_{N,t}$ are set to 26.5% of GDP and the government debt $B_{N,t}$ equal to 35.5% of GDP. For the South, we set the government expenditures-GDP ratio at 20% and the debt-GDP ratio at 50%.

5 The computational experiment

In order to disentangle the macroeconomic effects of changes in demographics, we switch on, one at the time, changes in the fertility rates, in the survival rates, and in the female labor force participation rate and

¹¹The tax data Mendoza, et al. (1994) refer to the period 1965-1988 and we also used an unpublished extension up to 1996 available in Mendoza's web page. We take the average of the tax rates over the countries weighted by GDP.

¹²See, for example, Heady (2002), who argues the importance of the informal sector in the South and a heavier reliance on the indirect taxation compared to the developed world.

we study, respectively, the “fertility transition”, the “longevity transition”, and the “participation transition”. The initial changes in all these parameters are, as of 1950, unexpected. Once the initial change occurs, all generation alive are assumed to perfectly forecast the new path of demographics, productivity and participation.

In each case, we look at our three scenarios. The first is a closed economy. In the second (labelled “open 1”), capital is allowed to flow across regions and governments of the North maintain the PAYG system: the benefits are unchanged and the labor income tax increases to finance the additional inter-generational transfers. Under this scenario, τ_N^w rises up to 45.0%. In the third (labelled “open 2”), capital is allowed to flow across regions and the governments in the North begin to phase out the PAYG: the labor income tax remains unchanged and the replacement ratio ρ_N gradually declines down to 12.5% in order to balance the budget. This latter reform is assumed to begin in 2010. Throughout the analysis, we assume that no reform is implemented in the South, so we simply let the payroll tax τ_S^w adjust period by period to satisfy the government budget constraint, as demographic trends unfold.

In order to limit the impact of demographic projections 100-200 years ahead from now on the results, we report simulations of our model only up to 2050.

5.1 The fertility transition

In Figure 2, we report the simulated demographics associated to the fertility transition.¹³ The sharp decline in fertility accounts for a very large rise in the median age of the population, especially in the South where median age is projected to rise by 9 years in the next half century. The fertility transition generates the hump-shape in median age in the North because of the rebound in fertility rates around 2000 which reduces slightly the median age of the population, after 2030. For the same

¹³Recall that in this experiment life expectancy does not vary, as we keep the surviving rates unchanged. However, female participation does vary since the function P_t depends on the age vector of dependent children $\mathbf{d}_{i,t}^r$ in the household of age i at time t .

reason, the hump is also clearly visible in the dynamics of the old dependency ratio in the North, whereas in the South, the fraction of elderly population grows monotonically after 2000. The decline in fertility raises mechanically the female participation rate: interestingly, the estimated impact of the fertility transition is quite small for the North, explaining only 1/7 of the total change in participation from 1950-2000, whereas it is large for the South, explaining almost one fourth of the climb in female market hours over the same period.

The simulated path for some key aggregate economic variables of the South, during the fertility transition, are plotted in Figure 3. The fertility transition brings about a reduction in the growth rate of the population. Two forces counteract this decline in aggregate labor input. First, the increase in female market hours due to lower birth rates. Second, because of the rise in median age from 20 to 35 years old, the economy witnesses a remarkable rise in average efficiency units, by over 35% in the period 2000-2050.

Aggregate saving rates move because of changes in the composition of the population. Composition effects are very visible: the aggregate saving rate follows qualitatively the pattern of median age, since over time the age groups with relatively high saving rates become more numerous. Because of the rise in capital accumulation and the decline in aggregate labor input, wages rise and interest rates fall. The growth in the wage rate w_t (i.e., the marginal product of an efficiency unit of labor) due to the fertility transition is expected to remain positive for the next 50 years, with a peak of 0.25%-0.3% per year around 2020.

Our simulations show that, compared to the closed economy benchmark, in the open economy the (world) interest rate the South would face is lower and capital flows from the North to the South. Even though, due to the lower interest rate, open economy savings are smaller in the South, initially wage growth is faster in the open economy because of the large external wealth adding to domestic capital. However, as the demographic trend develop and the interest rates converge in the two regions, capital flows slow down and so does wage growth in the open economy.

Finally, it is remarkable that, in spite of their difference, the two policy scenarios in the North yield very similar predictions for all the aggregate variables of interest. We return on this point when we describe the effects of the full demographic transition.

5.2 The longevity transition

The demographic changes caused by the rise in the surviving probabilities are described in Figure 4. The rising longevity consists mainly of a decline in the infant mortality rates and in the mortality rates of the old generations. In the North, the latter is much more pronounced, which generates a slight rise in the median age, from 28 to 31 years old, a rise in life expectancy by over 10 years and a surge in the dependency ratio from 12% to 17%. In the South, child mortality falls significantly as well during the transition. This force counteracts the aging effects of an increase in the surviving rates of the elderly. As a result, the overall impact on median age and on the dependency ratio are quantitatively fairly small, whereas life expectancy rises sharply in the South, too.

Figure 5 shows that, from the point of view of an individual household, improved longevity (especially during the retirement period) calls for more life-cycle savings during the productive years. The consequence is a more substantial rise in the saving rate compared to that caused by the fertility transition. The growth in the quality of the labor force is slightly negative under the surviving rates transition: falling infant mortality increases the population share of very young workers, and this is a group with low labor productivity. The implied wage growth is quite high during the period 1950-2000, and it levels off around 0.1% per year in the next five decades.

The longevity transition is sharp for the North as well, and capital accumulation in the North due to life-cycle reasons is large. As a result, capital keeps flowing in large amounts from the North to the South and the wage growth in the open economy remains higher than that in the closed economy benchmark also for the period 2000-2050, in contrast to the wage dynamics in the fertility transition. This is especially true

in the scenario with PAYG privatization in the North (open 2), where the implicit North-South interest rate differential—and the capital flow needed to realign them in the open economy—is sizeable.

5.3 The participation transition

Figure 6 plots the behavior of some key aggregate economic variables following the rise in female participation attributable to the exogenous trend, i.e. the residual component that cannot be directly attributed to the fall in the number of children per household.

The rise in female participation rates increases aggregate labor input. Since this rise is proportionately larger for young women, average efficiency units of labor decline slightly from 1950-2000, but the net effect on aggregate labor input is positive. As a result, even though the saving rate increases mildly over this period, wage growth is negative and settles around zero after 2020.

As for the previous experiments, because of capital flows, the open economy wage growth is higher and the open economy interest rate is lower. The difference between the paths of the interest rate in closed and open economy is very large because while the participation transition exhausts quickly in the North, it keeps going for much longer in the South, thus reducing the capital labor ratio and preventing the interest rate from falling, in the closed economy.

5.4 The full demographic transition

The full demographic transition combines changes in fertility rates, surviving rates and female participation rates. Its main macroeconomic effects for developing economies are pictured in Figure 7 and can be summarized as follows. First, a strong rise in the saving rate from 14% in 1950 to around 27% in 2050. Second, an increase in average productivity of the workforce by a factor of 1.5 over the same period, due to the changes in the age-structure of active households induced by the fertility transition. Third, an annual growth in the wage rate that will average

0.40% per year in the next 50 years. Fourth, a steady decline in the interest rate.

In both open-economy fiscal policy scenarios, wage grows initially at a faster rate because of the large capital flows, then at a slower rate, compared to the closed economy benchmark. This is due to the fact that at some point along the transition (the exact turning point depends on the policy scenario) capital begins flowing out of the South into the North. The main cause of this reversal is the small-scale PAYG in the South paired with the demographic changes which generates a very large supply of capital in the South. This pattern is less marked under the “open 2” policy scenario where the PAYG is phased out in the North, relative to the “open 1” where the PAYG survives. In the former case capital accumulation is strong in the North as well, because households replace pension benefits with life-cycle savings. As a result, wage growth in the “open 2” case lies in between the closed economy case and the “open 1” case.

Figure 8 plots external wealth as a fraction of output in the South under our two open economy scenarios. It shows clearly that around 2000-2020 (the exact date depending on the social security policy adopted in the North) foreign assets owned by the developed world reduce dramatically, as capital flows change direction.

Growth accounting— In Figure 9, we report the impact of the full demographic transition—and its three components—on detrended income per capita growth in the South. The impact of the fertility transition is dominant because it generates such a large quality improvement in the labor force. According to the model, the so called “demographic dividend” in income per capita growth accounted for 1.35% per year in the past three decades. This number is on the high end of the “demographic dividend” estimates obtained via reduced form regressions (see Bloom, Canning and Sevilla, 2004, for a survey).

According to our model, in the next 50 years, output growth in developing economies will remain positive, but it will slowly decline to reach 0.4% by 2050. This is our estimated magnitude of the “window of oppor-

tunity” discussed by Berhman et al. (1999). Interestingly, the dynamics of income per capita are remarkably similar across the closed and open economy scenarios: in the closed economy wages grow at a faster rate, but rates of return on capital fall more quickly. Quantitatively, these two counteracting forces appear to roughly offset each other in shaping income dynamics.

Even though the PAYG scenario seems largely irrelevant for average income growth in the South, it does affect how income is distributed between labor and capital. For example, under privatization of PAYG in the developed economies, wages would grow faster and rates of return to capital would fall more rapidly in the South, compared to a no-reform scenario. Therefore, the privatization choice in the North is more favorable to “laborers” in the South relative to the choice of maintaining the PAYG system.

It is possible to compute how much of the measured growth in income per capita in the developing world over the past 50 years can be explained by demographic factors and TFP growth. In the tradition of growth accounting, from the aggregate production function, one can express annual growth in output per capita as

$$\Delta y_{S,t} = \Delta \theta_{S,t} + \alpha \Delta \kappa + (1 - \alpha) (\Delta \bar{\varepsilon}_{S,t} + \Delta \lambda_{S,t}),$$

where κ is the capital-population ratio, $\bar{\varepsilon}$ denotes average efficiency units, λ is the labor-force participation rate, and Δ denotes log changes. From WDI data, we calculate that output per capita in the South (y_S) grew at an average rate of 2.20%, in the period 1950-2000. Over the same period, the demographic transition generates around 0.70% annual income per capita growth, so it explains just below 1/3 of the observed growth experience of developing economies. Out of this fraction, 0.11% is associated to improvements in the average quality of the labor force (weighted by the labor share), 0.32% to the rise in labor force participation (weighted by the labor share), and the residual 0.27% to the surge in the capital-population ratio (weighted by the capital share). TFP growth explains the remaining 1.5% per year, i.e. 2/3 of total output growth in

developing economies.

5.5 Welfare analysis

A structural general equilibrium model has at least one clear advantage, compared to a reduced-form analysis. It allows to determine the welfare gains/losses associated with the demographic transition: welfare is, arguably, the most relevant criterion to evaluate the macroeconomic effects of the demographic transition.

We compute welfare changes for each cohort alive during the transition in terms of a compensated variation in consumption, using the first-steady-state as a benchmark. In other words, we compute how much we would have to rescale the whole consumption profile of a household in order to make her indifferent between entering the labor force at time t (therefore, undergoing the demographic transition from t to $t + I$) and living its entire life in the first steady-state (without any transition occurring).

Underlying this computation, there are two subtle issues deriving from the fact that the demographic transition changes households' preferences. First, over time surviving rates improve; as a result, even if consumption were unchanged, the demographic trends would imply a higher expected utility. Second, preferences depend on the number of children: by reducing birth rates, the fertility transition would imply lower expected utility for the representative household, just because mean household size is shrinking. This makes the standard definition of consumption equivalent variation meaningless.

To avoid our welfare calculations from being contaminated by this problem, we propose the following methodology to assess welfare changes. Our objective will be to assess, cohort by cohort, the *welfare implications of the changes in equilibrium prices (interest and wage rate) and taxes (or benefits, if the policy scenario is "open 2") induced by the demographic trends*. Specifically, the welfare change ω_t for cohort t is the solution to

the following equation

$$\sum_{i=1}^I \beta^{i-1} \Pi_{t+i-1,i} \Omega_{t+i-1,i} u(\hat{c}_{i-1,i}) = \sum_{i=1}^I \beta^{i-1} \Pi_{t+i-1,i} \Omega_{t+i-1,i} u((1 - \omega_t) c_{t+i-1,i}^*).$$

The “star” allocations are the optimal choices made by the household under the sequence of wages, interest rate and payroll taxes/benefits arising in equilibrium from t to $t + I$, taken as given by the household. The “hat” allocations are the optimal choices taken under the initial steady state equilibrium (constant) pre-transition vector of prices and policies.¹⁴ Thus, ω_t measures how much a household in cohort t would be willing to pay to maintain the prices and policies generated by the demographic transition instead of facing the pre-transition prices and policies (our benchmark) over its entire lifetime. In other words, ω_t is the consumption-equivalent value of the (prices and policies induced by the) demographic transition for cohort t .

Recall that, compared to the initial steady state, the demographic transition steady-state features higher wages and lower interest rates, with contrasting effects on welfare, but higher labor income taxes—needed to sustain the PAYG with an older population—which tend to induce a welfare loss from the demographic transition. In Figure 10 we plot the welfare gain (loss if negative) from the demographic transition for each year of entry in the labor force between 1900 and 2000.

Our calculations lead us to two conclusions. First, on average, changes in equilibrium prices and taxes induced by the demographic trends are not favorable to households alive during the transition.¹⁵ They are especially unfavorable to the latest cohorts who will not exploit the high wage growth of the previous generations and will face lower rates of return on their savings and higher taxes on labor income. Second, the open economy has the power to mitigate substantially these welfare costs for the latest cohorts—i.e. those who will be working in the next 50 years

¹⁴Recall that leisure is not valued, so reallocation of time between child care and market work does not affect welfare in the model.

¹⁵Clearly, the decline in infant mortality and the longer life-expectancy do increase welfare, but as explained, the objective of our welfare calculation is different.

and retired after then—in an unexpected way: by reverting towards the North, capital flows will slow down the decline in the interest rate in the South, allowing these households to afford more life-cycle consumption.¹⁶ This effect would be limited in a scenario where there is a PAYG privatization in the North, since the additional capital accumulation in the North for life-cycle reasons would delay the reversal of capital flows.

6 Concluding remarks

In this paper we have used a two-region calibrated equilibrium model to study and quantify the macroeconomic and welfare effects of the demographic transition in developing economies. Our main results can be restated as follows. Thanks mainly to the fertility transition, and the associated rise in average labor productivity, the developing economies will still benefit significantly from the demographic dividend (roughly equal to an additional income growth of 0.80% per year) for the next 50 years. The degree of openness and the extent to which the North will privatize its PAYG system have a small impact on future income growth. However, these factors affect the distribution of income between labor and capital. For example, under a PAYG privatization scenario, wages would grow faster and rates of return to capital would fall more rapidly in the South, compared to a no-reform scenario. The fall in the interest rate and the rise in the wage tax induced by the demographic trends reduces welfare. However, the presence of unrestricted international capital flows can mitigate the adverse implications of factor prices for the South. This is especially true in absence of social security reforms in the North.

A caveat to our conclusions should be kept in mind. In our open

¹⁶The result that the closed vs. open economy distinction matters quantitatively for welfare calculations but not for income per capita growth is not contradictory. Income for year t is a “static” variable. Welfare for a cohort born in t is a forward looking variable that depends largely on the path of wages until retirement and on the path of interest rates after retirement. Take, for example, the 2000 cohort. In the open economy (“open 1”), wage *levels* are higher than in the closed economy until 2040, thanks to the faster wage growth which occurred until 2000. Interest rates are lower in the open economy until 2040, but higher after then, i.e. in most of the retirement stage for that cohort.

economy exercise, the net foreign assets of the North are around 65% of GDP in the South, for the period 1960-1990, i.e., roughly three times larger than those observed (see Kraay et al., 2004). In our simulations we abstract from all sources of aggregate risk, including political uncertainty and sovereign default and we do not consider any impediment to capital mobility. We do not necessarily believe that our two-region benchmark with frictionless capital flows is more appropriate than the closed-economy benchmark. It is just the opposite end of the spectrum, where the actual economies lie somewhere in the middle.

In defense of our approach, we make three remarks. First, due to the new information and communication technology, the extent of global linkages across markets is rapidly growing. Second, as predicted by our model and several other demographics-based models of current account dynamics, capital flows will soon start flowing from the South to the North. Then, the classical critique of frictionless open-economy models (they overpredict the size of external wealth) will become much less relevant since, arguably, sovereign risk, political uncertainty, and expropriation risk are much smaller in the developed world thanks to the presence of better institutions. Third, by using these two extreme scenarios (closed and frictionless open economy) our analysis can be interpreted as providing an upper and lower bound for the macroeconomic and welfare impact of the demographic transition in developing economies.

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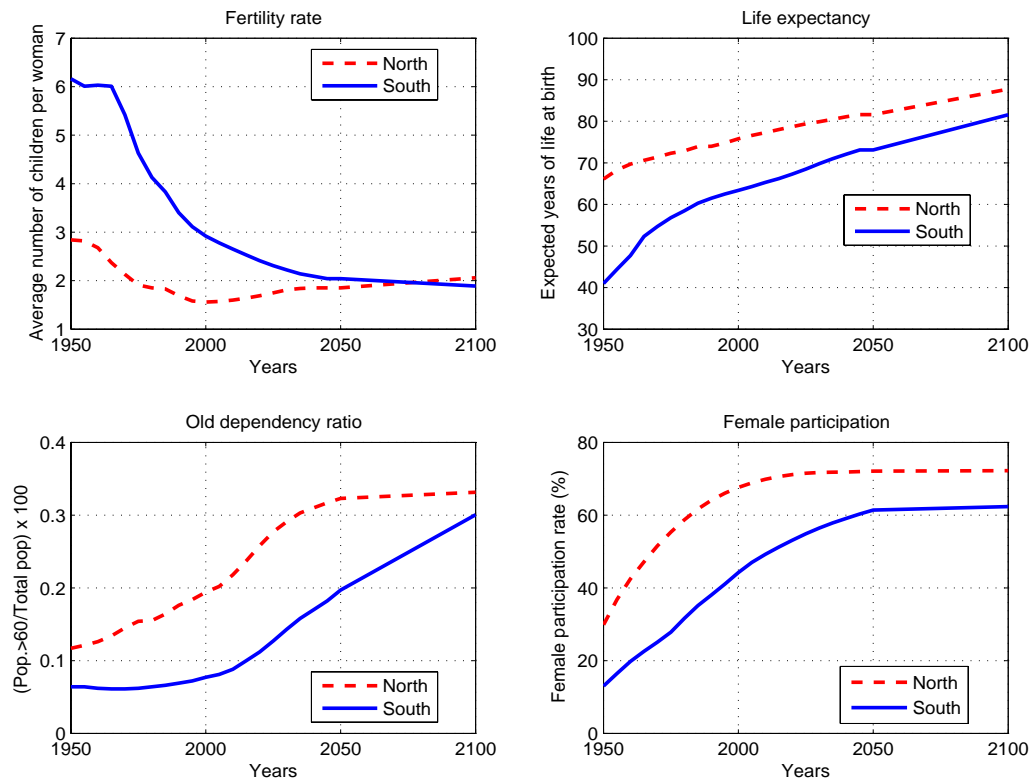


Figure 1: Demographics of North and South. Actual values until 2005, projected values 2005-2100. Various sources (see main text).

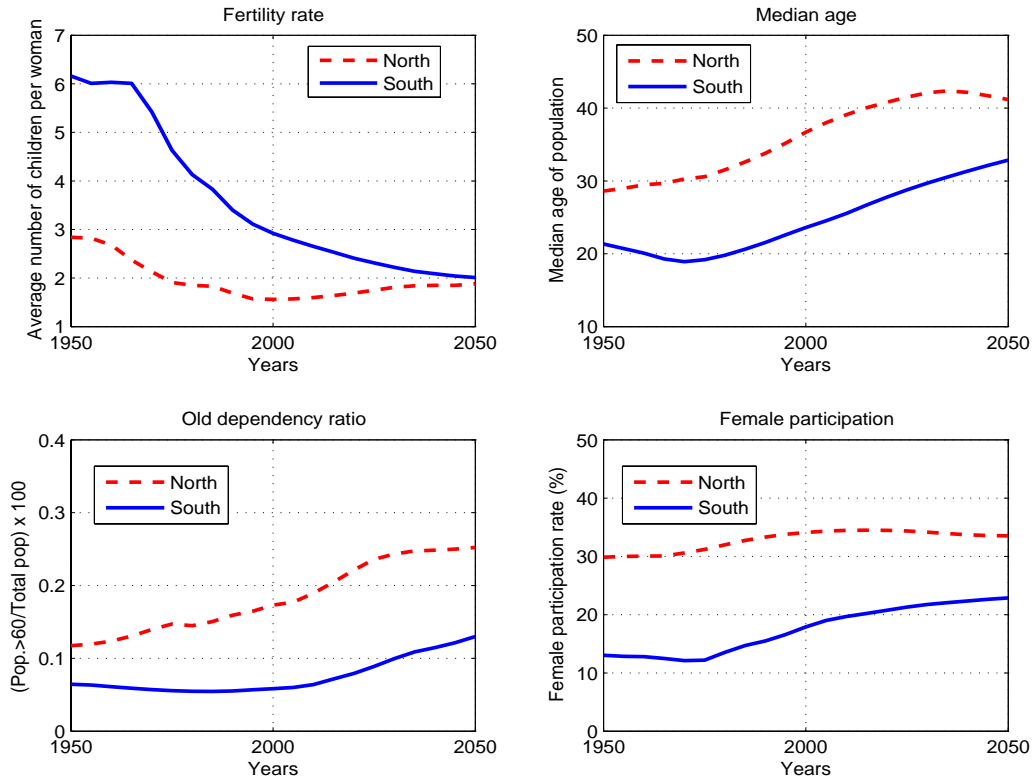


Figure 2: Fertility transition: demographic variables

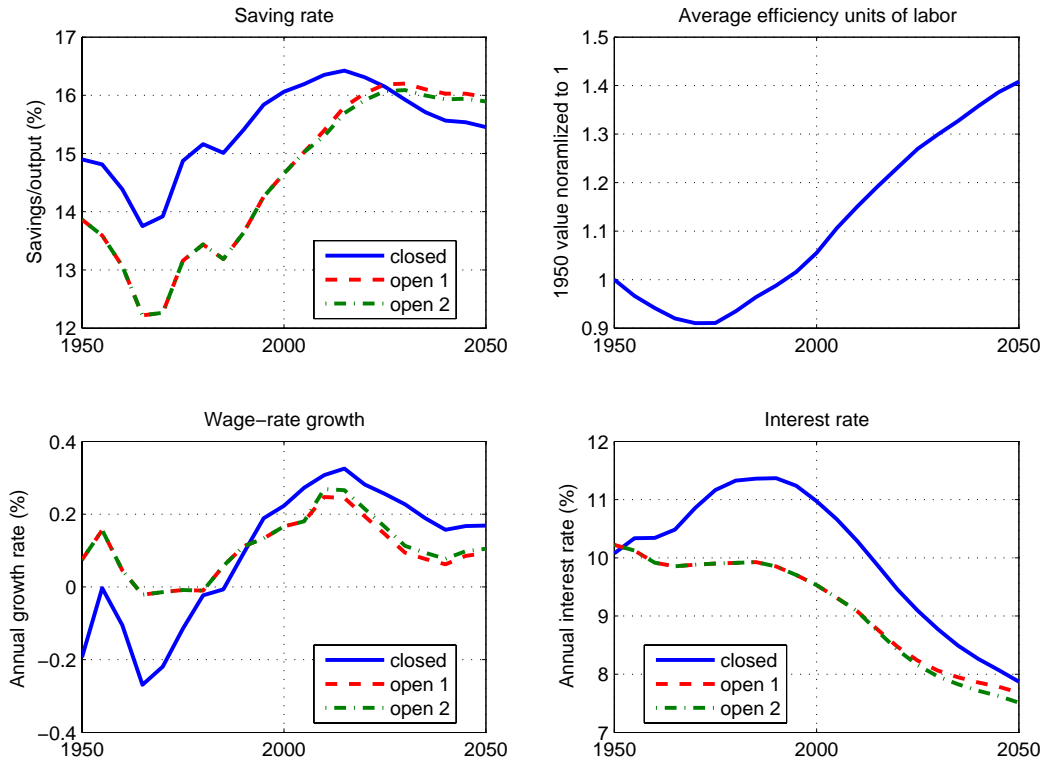


Figure 3: Fertility transition: macroeconomic variables

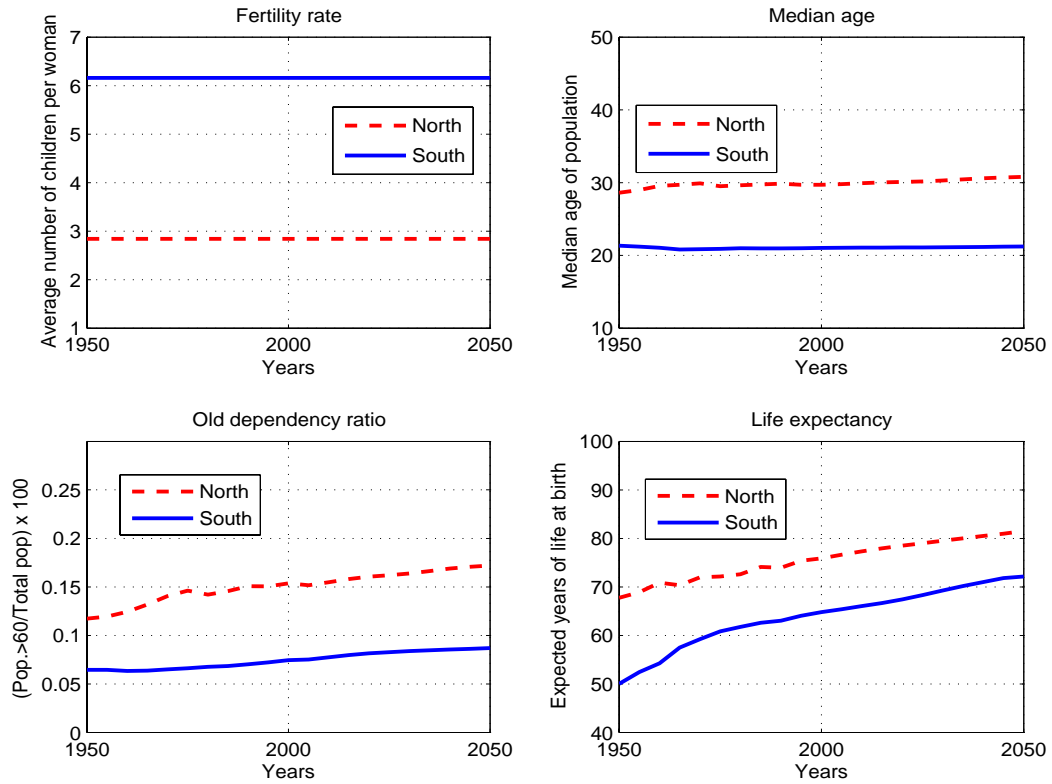


Figure 4: Longevity transition: demographic variables

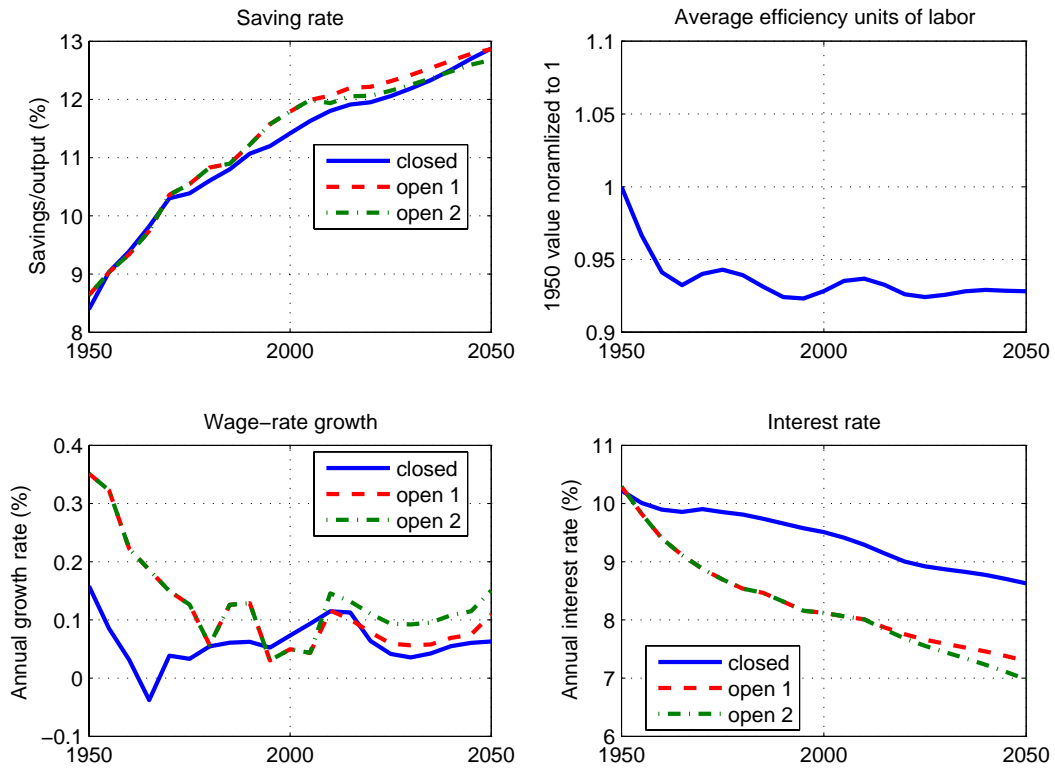


Figure 5: Longevity transition: macroeconomic variables

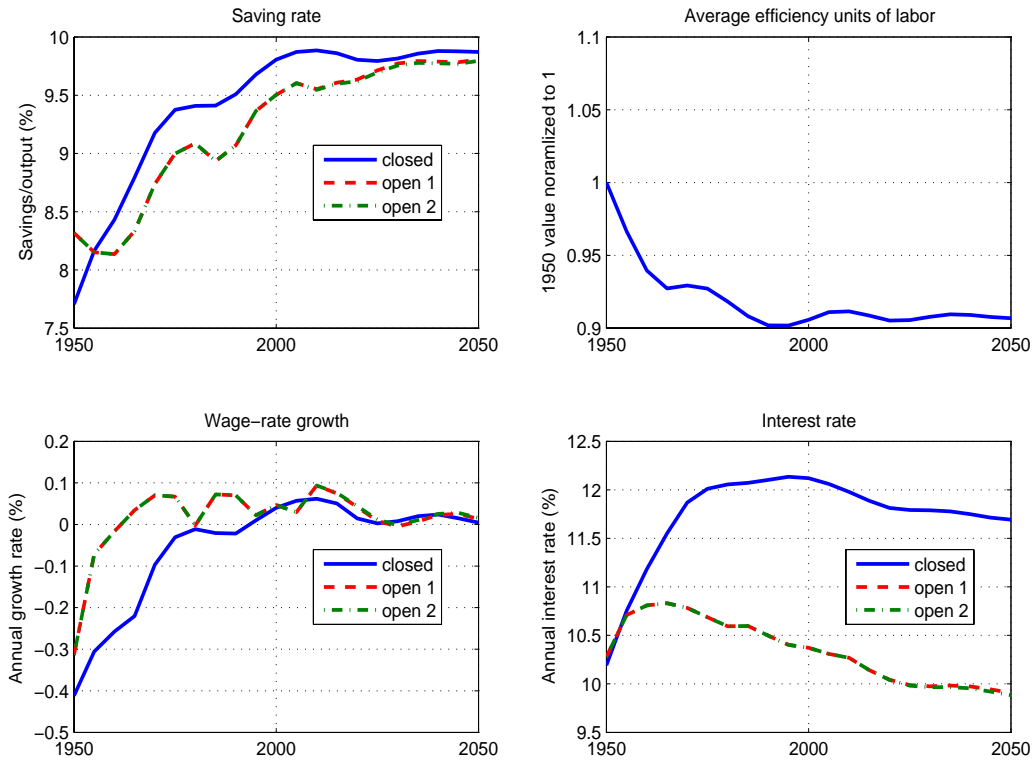


Figure 6: Participation transition: Macroeconomic variables

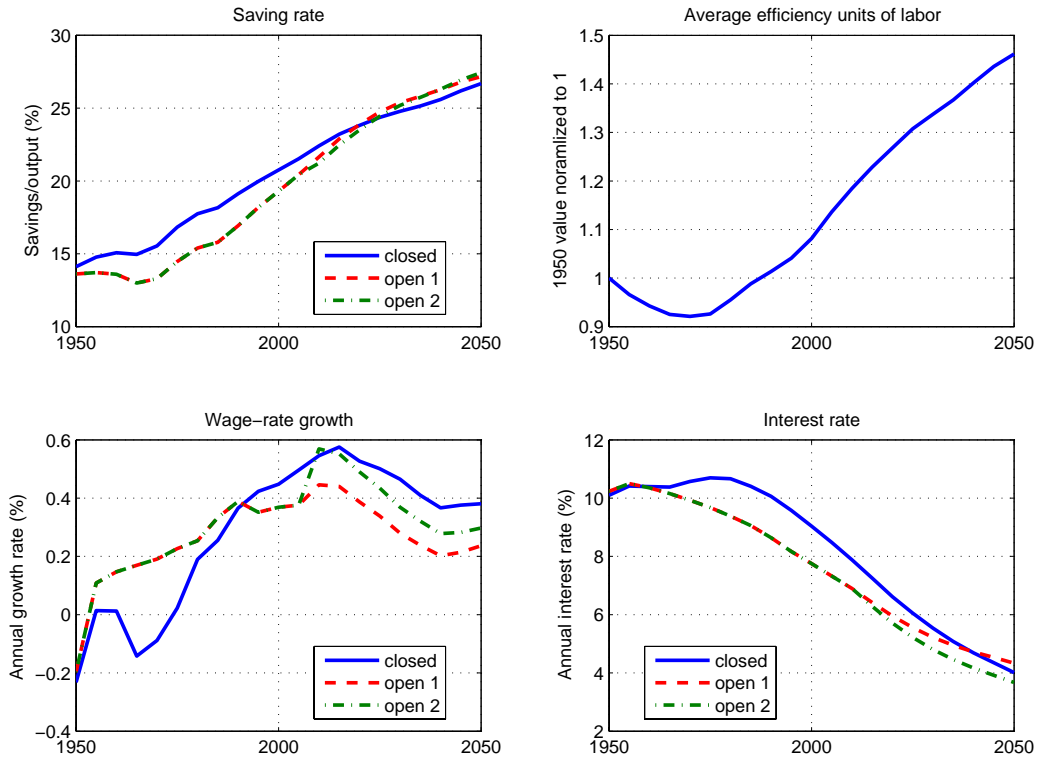


Figure 7: Full demographic transition: Macroeconomic variables

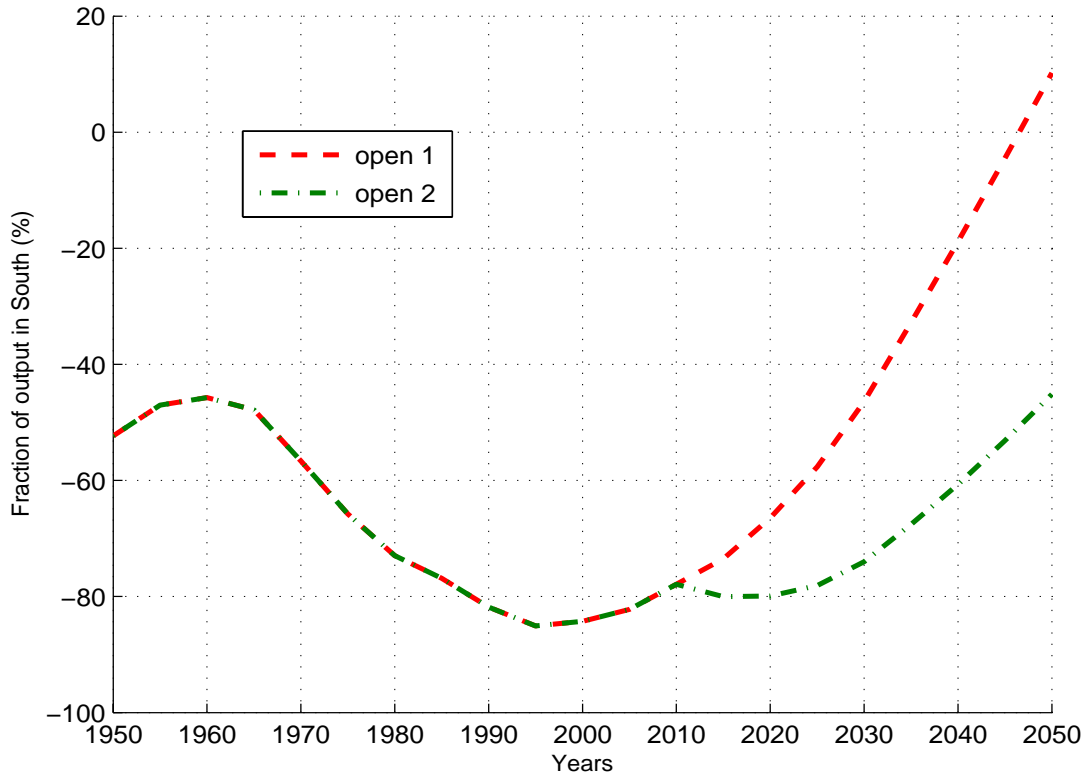


Figure 8: External wealth of the North as a fraction of GDP in the South

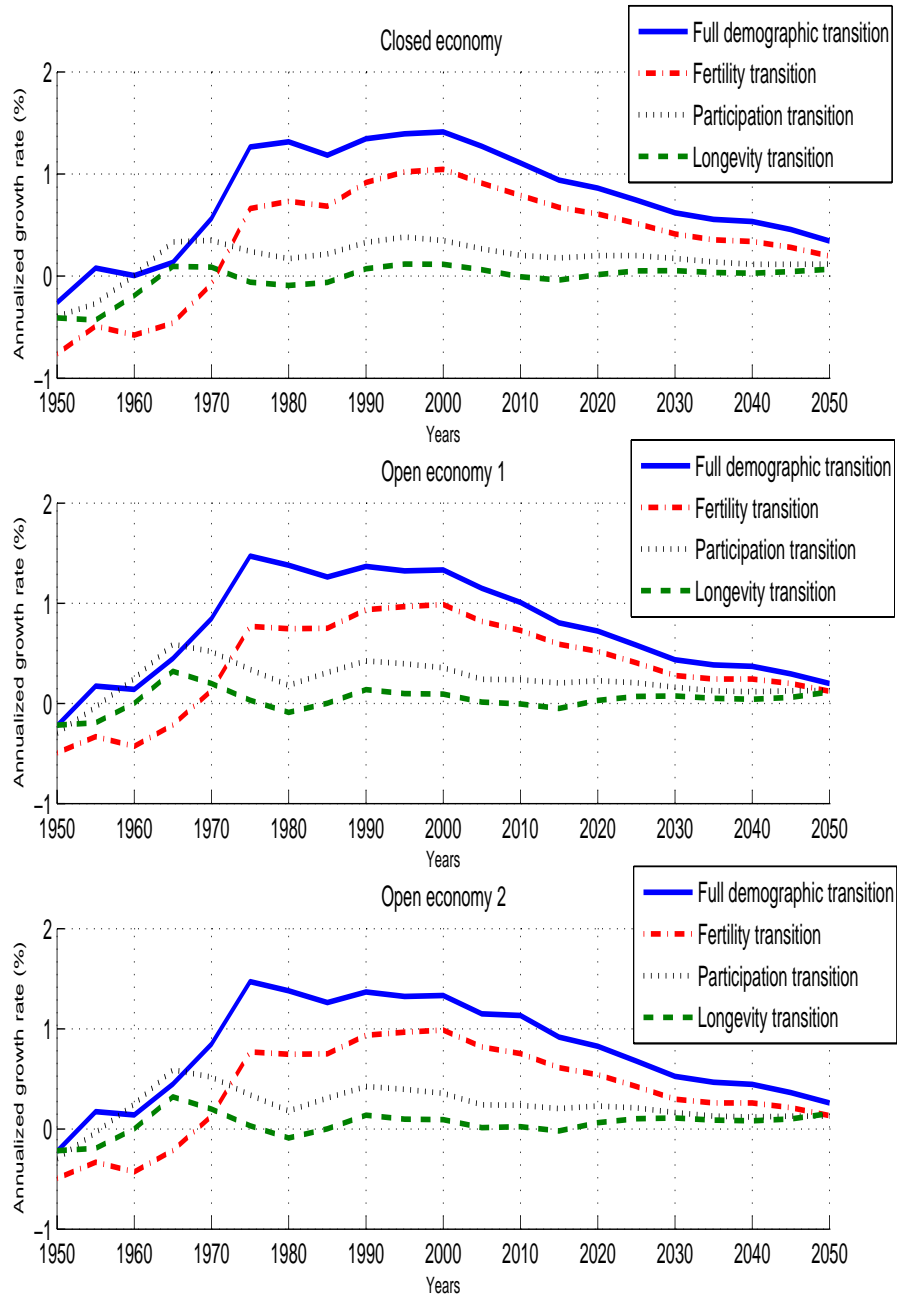


Figure 9: Full demographic transition: income per capita growth

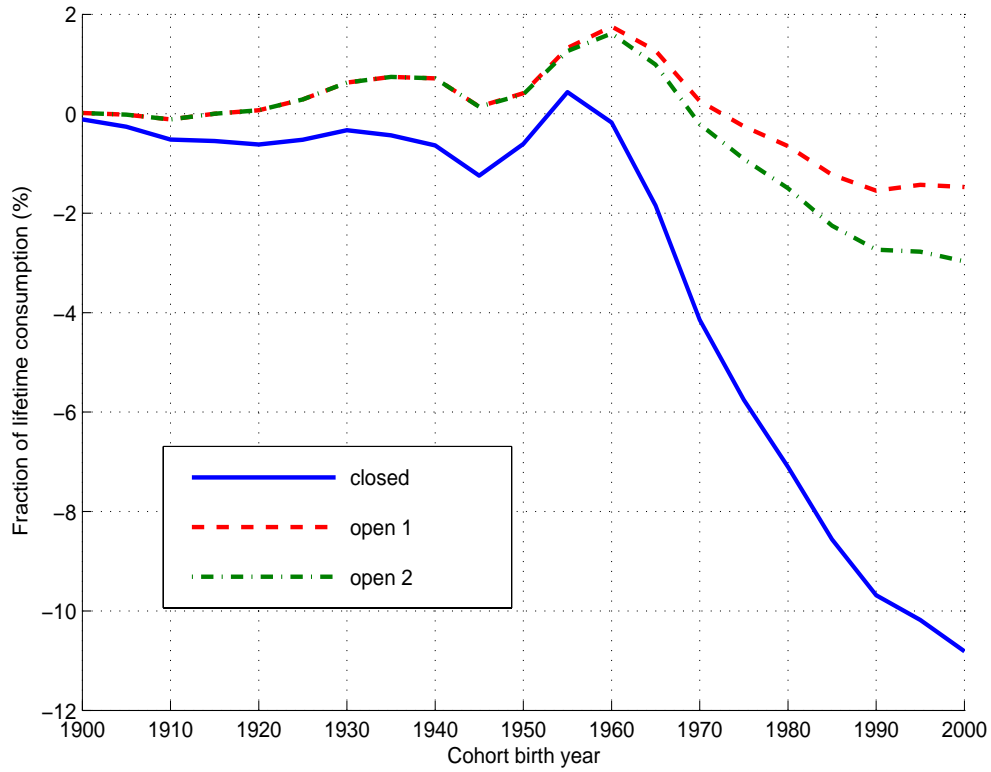


Figure 10: Welfare analysis by cohort: welfare gain (loss if negative) from equilibrium prices and taxes induced by the demographic transition