The Demographic Transition in Closed and Open Economy: A Tale of Two Regions *

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Abstract

This paper constructs a general equilibrium overlapping generation model to evaluate quantitatively how a demographic transition (falling mortality and fertility rates) affects aggregate variables (wages, interest rate, output), and inter-generational welfare in closed and open economy. We perform this analysis for two economies calibrated to resemble to the North (US and Europe) and Latin America. Our simulations suggest that the demographic transition could have generated income per capita growth up to .5% per year in excess of steady-state growth in the past 50 years in Latin America and .3% in the North. When we assume that the two regions will not open to capital flows, the main finding is that while the beneficial effects for the North will quickly fade away in the next decade, Latin America should still benefit from higher than average growth rates for the next half century at least. In terms of welfare, the demographic transition in closed economy is costly for the North, while in Latin America it will generate welfare gains up to 20% of lifetime consumption. When we allow for perfect capital mobility across the two regions, starting from the mid 90's, the key result is that international capital flows accelerate the adjustment process in Latin America by exacerbating income growth in the short-run and reducing it in the long-run. The largest relative welfare gains from opening the economy (relative to the closed economy transition) accrue to the baby-boom generations in the North (+2%), and to the cohorts born around the opening in Latin America (+6%). The reason is that the implied capital flows across regions raise the interest rate in the North and the wage rate in Latin America.

Keywords: Baby-Boom, Demographic Transition, Latin America, Open Economy, Overlapping generations, Welfare.

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1 Introduction

Many regions of the world are currently in the middle of significant demographic transitions. The main elements characterizing these transitions, namely a reduction in fertility rates and an increase in life expectancy, are common across many regions. However, the pace and timing of these changes are not, as different regions of the world are going through different stage of a demographic change that ultimately will result in a population structure characterized by a larger share of elderly individuals than that prevailing now.

Most of the developed world, and in particular the US, Europe and Japan have already reached very high levels of dependency ratios, as measured by the proportion of individuals aged over 65 to those aged between 16 and 64. On the other hand, Latin America has just experienced a dramatic drop in fertility rates, that, in the last 30 years, have declined from an average level of more than five children per woman to less than three. Even after such a dramatic decline, however, they are still well above the very low levels observed in Europe and the US. Other regions of the world are at different stages of the transition. Some countries of South East Asia have passed a few years ago through the phase Latin America is undergoing now, while Africa and other regions of Asia are still much younger and experiencing remarkably high growth rates of the population. Even 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.

The implications of these massive demographic changes are dramatic and far reaching. Most of the debate on social security reform in developed countries, as well as in Latin America, has been largely stimulated by the awareness that the recent demographic changes have made many of the existing social security systems, based on defined contributions schemes financed on a pay-as-you-go (PAYG) basis, unsustainable at the existing levels of contribution and benefits. In the US, for instance, it is projected that the Social Security fund, which is currently running a substantial surplus thank to the presence of the large baby-boom generation in the labor force, in a few years will run a deficit and will exhaust the fund before the year 2030. The debate on social security reform has received a tremendous amount of attention, both among academic economists and policy makers. But the effects of demographic changes, both in the US and in other regions of the world, do not end here, ranging from political economy issues, through the allocation of resources to health care, to the impact on financial markets.

For the developing world, and in particular for Latin America, the implications of the current trends are slightly different. Since the demographic transition in Latin America is less

advanced, the stock of labor force is projected to be particularly large in the near future. This has led some authors (see Behrman et al., 1999) to argue that the next decade constitutes a *window of opportunity* for Latin America. In particular, they speculate that the demographic structure that will be prevailing in the next few years might be associated to high saving rates and, therefore, to faster capital accumulation.

Some authors also stress that Latin America will soon go through a phase of demographic structure that is similar to that experienced by some of the economies in East Asia that developed most successfully. Bloom and Williamson (1997), for instance, calculate that demographic dynamics between 1965 and 1990 can explain between 1.4% and 1.9% of annual GDP per capita growth in East Asia, or as much as a third of its growth miracle. They evaluate the relative contribution of labor and capital input to be respectively one third and two thirds of the total demographic impact.

Methodologically, the results in this literature are vastly based upon estimation of reduced-form saving and output equations with demographic variables as regressors. Even though this empirical approach has yielded great insights on the economic association between demographic dynamics and macroeconomic outcomes, it has a number of limitations. First, it ignores the general equilibrium interactions between factor prices and capital accumulation. Second, although it allows to quantify the impact of demographic changes on aggregate output, it is silent on the inter-generational welfare consequences, which is ultimately a crucial question. Third, one cannot do any formal policy analysis with such reduced-form models.[1]

In this paper we contribute to the ongoing debate on the economic impact of the demographic transition in two ways. First, we rigorously quantify the effect that demographic trends have in general equilibrium on rates of return, wages, output and, more generally, on the welfare of the generations that live through the transition. For this purpose, we calibrate our general equilibrium models to reproduce some basic facts of both developed and developing economies, in terms of basic demographic trends and in terms of equilibrium steady state values. We then simulate the transition of our economies from an initial steady state to a new one characterized by much lower fertility rates and higher life expectancy.

What we want to stress is that the same demographic trends that make the current PAYG system unsustainable in many developed countries are bound to have important and possibly dramatic implications for the welfare of a relatively "large" generation followed by a relatively smaller one, even in situations where the pension system is fully funded and possibly private.

[1] Another limit is that the demographic transition is always assumed to be exogenous, but this is true in our model as well.

The reason is the general equilibrium effects on factor prices and in particular on the return to capital. In a situation in which the capital-labor ratio is relatively high, the return on capital is bound to be low. As a consequence, the consumption that can be sustained by the "large" generation when it retires might be small. This turns out to be true even when such a generation understands and forecasts the prevailing demographic trends and can save to provide for its retirement.[2] We find it remarkable that this basic implication of the current demographic trends has not been discussed much in the current debate on social security reform. To make this point starkly, we work in a model without social security where all expenditures during retirement are financed through lifetime savings.

Second, we develop a two-region open economy version of our model to evaluate to what extent the fact that demographic trends are not synchronized across regions gives rise to opportunities that might alleviate the general equilibrium consequences of the prevailing demographic trends. While in principle one could look both at labor and capital mobility between regions, in this paper we focus only on the latter. In a recent paper, Storesletten (2000) has considered explicit immigration within the context of social security reform in the US. Instead we assume that labor is immobile and study whether by allowing for capital mobility among two regions calibrated to look like Latin America and a combination of US and Europe (which we label the "North"), the welfare effects on the generations undergoing the transition are attenuated or exacerbated. For the North, the relevant effect is for the baby boomers' welfare, the generations that most suffer from the demographic transition. For Latin America, the interest lies in establishing whether the process of capital mobility could foster and bring forward the process of development.

For the purpose of our analysis, we use a very stylized overlapping generations model. To stress the main points we want to make, we keep the model very simple. In particular, we do not consider uncertainty except in the duration of life. We only have one type of asset, namely the capital stock, to transfer resources over time. We do not consider a government sector or an explicit social security scheme. Saving for retirement in our life cycle model is equivalent to a fully funded and private social security scheme. We only consider one type of labor, even though efficiency units vary deterministically over the life cycle, hence we have no heterogeneity within each cohort. Finally, we abstract from growth in technological progress. The demographic transition is also modeled in a very simple fashion. While these simplifications preclude us from addressing a number of important issues, such as the insurance properties and

[2] This effect can be even more dramatic if such a generation has to pay, at least in part, the cost of the transition from an un-funded to a funded scheme.

the inter- and intra- generational redistribution of alternative social security schemes, they also allow us to focus on the main point we want to stress: the effects in closed and open economies of demographic changes un-synchronized across regions of the world.

Several papers have used general equilibrium overlapping generations models of the kind pioneered by Auerbach and Kotlikoff (1987) and used in this paper. Recently, this type of model has been extensively used to evaluate the impact of different proposals of social security reforms. Huggett and Ventura (1998), for instance, look at the steady-state properties of such a model to compare the distributional consequences of the current US social security system with those of the so-called “Boskin proposal”. DiNardi et al. (1999) analyze an overlapping generation model with uninsurable idiosyncratic risk calibrated to the US demographic trends to analyze several social security reform proposals. Miles (1998), Miles and Timmermann (1999) also consider similar models for European countries. Abel (1999) looks at the effect of the changes in demographics on the risk premium. As he uses an AK model in which, effectively, the rate of return on capital is fixed and unaffected by the capital labor ratio, Abel focuses only on the risk-free rate. Brook (1999) studies the effect of such a baby-boom on factor prices and asset returns, but he does not calibrate his model to the actual demographic trends. To the best of our knowledge, nobody has analyzed the effect that unsynchronized demographic trends in different regions can have on asset returns once one allows for international capital mobility. In this sense, the exercise closest to ours in spirit is the recent paper by Storesletten (2000) who has quantified the effect that migration flows into the US can have on the sustainability of the current social security system. In a sense, our exercise complements Storesletten’s by looking at the mobility of capital rather than labor.

The rest of the paper is organized as follows. In Section 2 we document the current and projected demographic trends in Europe, the US and Latin America. We also present some evidence on the differences in the capital stock and in the current size of capital flows. In Section 3 we present the overlapping generation model whose basic structure we use in most simulations. In section 4 we explain how we parameterize and calibrate our model economies. In Section 5 we first present the benchmark simulations for two closed economies. These economies are chosen to mimic, in their demographic trends, Europe and the US (which we will call the “North”) and Latin America. Second, we move away from the assumption that the two economies considered are closed and we allow capital mobility from a given date to equalize the rate of return in the two regions. We use simulations to compute the welfare of the generations born around the demographic transition in the open and closed economy cases. Section 6 concludes the paper by commenting on the results obtained and by indicating a number of important extensions of

our model that are left for future research.

2 Demographic trends in the North and Latin America

In this section we briefly illustrate the main demographic trends that motivate the exercise we undertake below. For this purpose, rather than focusing on a few countries or detailing the trends in all countries in the regions of interest, we construct two wide aggregates. The first, which we label the "North", is composed of the United States and the European Countries. The second is composed of the majority of South and Central American countries (including Mexico). The source of information on the demographic variables and projections is a United Nations data set.

In Figure 1 we plot, from 1950 to 2050 actual and projected data on fertility rates, life expectancy, population growth and dependency ratios in the two regions. In the first panel we plot average fertility rates (measured as the average number of children of women aged 15 to 45) in the two regions : notice that even though fertility has decreased dramatically in Latin America , it is still substantially above the levels observed in the North. Convergence of fertility rates is expected to happen around 2040. Life expectancy, on the other hand, is still much higher in the North (as of today, it is still 7 years longer) although there is some tendency for the two series to slowly converge.

As can be seen from the upper-right panel of Figure 1, while population growth in the North is slowing down and even expected to be slightly negative after 2025, the population of Latin America is still increasing considerably: in the next two decades population in Latin America will be growing above 1% per year, thus the relative size of the two regions in terms of population is projected to reach 1 around the year 2020.

Dependency ratios are usually defined as the number of children (possibly adjusted to convert them in adult equivalents) plus the number of individuals aged over 65 over the number of individuals aged 16 to 64. Plotting this variable for the two regions, one would observe that the one for Latin America is now decreasing (and will start increasing only in about 15 years), while the one for the North is increasing. In our paper, we stress the potential created by differences in capital-labor ratio across the two regions. Given that older individuals are the holders of capital, which they have accumulated to finance consumption during retirement, in the aggregate capital-labor ratios will be a function of the number of retired individuals to working age ones. Therefore, it is more appropriate for us to consider an alternative definition of dependency ratio that excludes the children completely. For this reason, in the lower-left panel

we plot the elderly dependency ratio, defined as the ratio between the number of individuals aged more than 64 to the number of individuals aged 15 to 64.

The elderly dependency ratio in the North, after decelerating during the 1970s and 1980s, when the bulk of the baby boomers reached maturity, is now increasing faster and it is projected to increase dramatically over the next 50 years. This sharp acceleration is caused by the dramatic 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 Latin America, instead, the dependency ratio is still fairly constant and is not projected to start climbing until the year 2010. The absolute difference between dependency ratios across regions (7% in Latin America and 22% in the North, in the year 2000) is striking and shows that there is a substantial potential for capital accumulation in Latin America as a large number of working age individuals will have to support a relatively small number of retirees. Only towards the end of the period considered (2050) there is a slight tendency for the dependency ratio in Latin America to catch up with that of the North. But even then, the difference will be substantial.

The simple demographic trends illustrated so far show the enormous potential for factor mobility that might exist between the two regions. However, these trends are only part of the story. There are some important factors they neglect. The three more important ones are: (i) labor force participation rates, (ii) human capital accumulation and (iii) differences in the existing stock of capital. While an detailed discussion of these factors is beyond the scope of this paper, it is worth to mention briefly some of their implications for the issues at hand.

(i) Labor force participation rates have changed dramatically over the last 25 years and keep changing. In the North, men's participation has decreased and women's participation has increased so that, in many countries, nowadays the two are quite similar. The large increase in female labor force participation means that in the North there is a limited scope for a further rise in the workforce that could come from this source. In Latin America, female labor force participation has also increased. However, it is still considerably lower than that of men or that of women in the North. Therefore an additional change in the relative sizes of the labor forces could result from historical trends towards higher female participation into the labor force in Latin America. We will not investigate this phenomenon because it would require a considerably richer model with an endogenous participation decision. Nevertheless, we reckon that neglecting this issue leads us to underestimating the effects we stress in the paper.

(ii) We will also neglect the issue of human capital accumulation. This is a very important topic of research that, however, is beyond the scope of this paper. What is important is not so much the different level of human capital across regions, which we somehow capture, but

rather the different evolution of the stock over time. For example, higher schooling levels are associated to steeper wage income profiles, and in turn to different lifetime patterns of savings. However, modeling this transition in the income profile is far from the objective of this paper, where we wish to focus solely on the demographic transition. It must be kept in mind that the quantitative analysis might be affected by this omission.

(iii) In addition to the differences in number of workers, the initial per-capita capital stock in the two regions are also very different. We will calibrate the two model economies so to start them with the observed different levels of capital stocks and capital/labour ratio. To give an idea of the magnitude involved, the PENN tables show that capital per worker for the US in 1965 was about 3 times that of Mexico, Colombia and Chile. The US value relative to other Latin American countries look quite similar.

Finally, in Figure 2 we have plotted the growth rate of GDP per capita in the past 50 years in the North and Latin America. The sample averages are 2.4% for the North and 1.8% for Latin America. This difference is entirely due to the recessions post-1980 which hit Latin America particularly strongly: until the late 70's both regions were growing at around 2.9% per year. It is useful to keep these numbers in mind because, when we simulate our model, we'll be in the position to assess how much of the observed growth in income can be attributed to the demographic transition.

3 The Model Economy

To quantify the effects that the demographic trends we discussed above have on the variables of interest (and ultimately on the welfare of different generations), we calibrate a relatively simple general equilibrium model in the spirit of Auerbach and Kotlikoff (1987), DeNardi, Imohoroglu and Sargent (1999) and others. While the construction of a manageable general equilibrium model will require some strong and at time questionable assumptions, such a model is very useful to quantify rigorously the effects under study. The model we propose necessarily leaves out a number of important factors. With some exception discussed below, however, we do not believe that the assumptions made affect our results in any crucial way.

As mentioned above, we present two versions of the model. The first assumes that the two regions (North and Latin America) are completely isolated. In the second, we still assume that capital can freely move from the North to Latin America. In this section we discuss those blocks of the model that are common to the two versions, and then we define the two concepts of equilibrium for the closed and the two-region open economy model.

3.1 Demographics

The economy consists of overlapping generations of ex-ante identical individuals who live for at most N_1 periods. Therefore, at any point in time, there are N_1 different generations alive. Individuals remain children until age N_0 and as children they don't make independent decisions, they do not consume nor work. After period N_0 they become adults and, for the rest of their life, they make decisions. An individual of age j born at time τ, faces a time-varying probability $\pi_{\tau+j,j}$ of surviving into age $j+1$. Furthermore, in each period these individuals give birth (without mating) to a certain number children, according to a time and age-specific fertility rate $\phi_{\tau+j,j}$. Following Lee (1974), Rios-Rull (1992) and Storesletten (2000), the evolution of the population structure can be described by a simple matrix of dimension $(N_1 \times N_1)$. If we denote with Γ_τ such a matrix for time τ and with μ_τ the $(N_1 \times 1)$ vector containing the number of individuals in each age group at time τ, the evolution of the population structure is given by:

$$\mu_{\tau+1} = \Gamma_\tau \mu_\tau,$$

where the first row of Γ contains the relevant fertility rates at each age, and each element $(j+1, j)$, with $j = 1, ..., N_1 - 1$, contains the probability, at time τ, of surviving from age j to age $j+1$. The remaining elements of the matrix are all zero.[3]

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 $\tau + N_0$, by i the numbers of years spent in adulthood $j - N_0$, and by N the length of adulthood $N_1 - N_0$. Hereafter, when we talk about an individual of age i born at t, it is understood that we mean and individual who has been adult for i years and became adult at time t.

3.2 Preferences and Household Optimization

Individuals derive utility from a homogeneous consumption good. They do not derive utility from leisure or from their children. Each individual is endowed with one unit of labor that she supplies inelastically to the market. The productivity of each individual, however, changes with age according to a deterministic pattern. We denote the vector of efficiency units of labor with $\{\epsilon_i\}_{i=1}^N$. As typical in these models, we assume that labor productivity is zero at very early ages (until age 16) and late in the life cycle (after age 70). This is an admittedly simple of way to

[3]The largest eigenvalue of the matrix A is the rate of growth of the population in steady-state. The eigenvector corresponding to this eigenvalue describes the share of each age group in the population in steady-state.

capture (exogenous) retirement.[4] Instantaneous utility is assumed to be of the $CIES$ family:

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

where $\frac{1}{\gamma}$ is the elasticity of intertemporal substitution. An individual of (adult) age i born (adult) at time t, discounts next period utility at rate $\beta^{i-1}\pi_{t+i,i}$, where β is a constant discount factor.

Mortality risk is the only uncertainty faced by individual consumers. There are annuity markets to cover the event of early death: each individual writes a contract with the rest of society that every period entitles the survivors to equally share the wealth of those prematurely dead. Because there are a large number of individuals, the idiosyncratic mortality risk is washed out at the economy-wide level and the aggregate amount of accidental bequests is perfectly predictable by the agents. The claims on the capital stock used in production are, in the baseline specification, the only asset available to households to transfer resources to the future. We impose no borrowing constraints.

An individual born at time t solves the following problem:

$$\begin{aligned}
&\max \sum_{i=1}^{N} \beta^{i-1}\pi_{t+i,i}\, u(c_{t,i}) \\
&s.t. \\
&c_{t,i} + a_{t,i+1} = (1 + r_{t+i})a_{t,i} + w_{t+i}\epsilon_{t,i} + b_{t+i} \\
&a_{t,1} = 0
\end{aligned} \tag{1}$$

where $c_{t,i}$ denotes consumption of an individual aged i and born at t, and $a_{t,i}$ her assets at time $t+i$. The variable $b_{t,i}$ denotes the fraction of the aggregate accidental bequests B_{t+i} received by each individual alive at time $t+i$:

$$b_{t,i} = \frac{B_{t+i}}{\sum_{i=1}^{N} \mu_{t+i}},$$

where the aggregate accidental bequest B_t is defined in equation below (5). The wage and interest rates at time t,taken as given by the individuals, are denoted respectively by w_t and r_t. ¿From the individual's Euler Equation, we obtain:

$$\frac{c_{t+1,i+1}}{c_{t,i}} = \left[\beta\pi_{t+i,i}\left(1 + r_{t+i+1}\right)\right]^{\frac{1}{\gamma}}$$

[4]In many Latin American countries child labor is not uncommon. As for the retirement issue, a richer model would endogenize the choice between schooling and work for children. We exogenously assume that individuals start being productive at age 16 (when adulthood starts).

which determines the slope of the household consumption profile. The initial level of consumption is determined by the present discounted value of lifetime resources W_t:

$$W_t = \sum_{j=1}^{N} (w_{t+j} + b_{t+j}) \prod_{i=1}^{j} \left(\frac{\pi_{t+i,i}}{1 + r_{t+i}} \right)$$

3.3 Technology and Firm Optimization

Output is produced by competitive firms operating a constant returns to scale Cobb-Douglas production function with capital share equal to α and total factor productivity equal to θ. The firms rent capital and labor every period from competitive spot markets, thus firms maximize static profits by taking factor prices as given. The implied optimality conditions are:

$$\begin{aligned} r_t &= \alpha\theta K_t^{\alpha-1} L_t^{1-\alpha} - \delta, \\ w_t &= (1-\alpha)\theta K_t^{\alpha} L_t^{-\alpha}, \end{aligned} \tag{2}$$

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

At this point we need to distinguish between closed and open economy. In a closed economy, the aggregate capital stock evolves according to the law of motion:

$$K_t = (1-\delta) K_{t-1} + S_t,$$

where S_t are aggregate national savings. In the open economy model, we denote the variables for the North with the subscript N and the ones for Latin America with the subscript A. The transition equations for aggregate capital stock are, respectively:

$$K_{N,t} = (1-\delta) K_{N,t-1} + S_{N,t} - F_t,$$

$$K_{A,t} = (1-\delta) K_{A,t-1} + S_{A,t} + F_t,$$

where F_t is the capital flowing from the North to Latin America in period t, and $S_{r,t}$ is the flow of capital invested domestically in region r at time t.

3.4 Equilibrium

An *equilibrium for the closed economy* is a sequence for the variables $\{c_{t,i}, a_{t,i}, K_t, B_t, w_t, r_t, \mu_{t,i}\}$ such that: the population shares are determined by the transition matrix Γ_t; households and firms solve optimally their problems taking prices as given; factor

prices are set to marginal productivities as in (2); the aggregate resource constraint in the economy requires:

$$\theta K_{t+i}^{\alpha} L_{t+i}^{1-\alpha} = S_{t+i} + \sum_{i=1}^{N} c_{t,i}\mu_{t,i}; \tag{3}$$

where $S_{t+i} = \sum_{i=1}^{N} a_{t,i}\mu_{t,i}$. Market clearing in the labor and asset markets imply the conditions:

$$\begin{aligned} L_{t+i} &= \textstyle\sum_{i=1}^{N} \epsilon_{t,i}\mu_{t,i}, \\ K_{t+i+1} &= \textstyle\sum_{i=1}^{N} a_{t,i+1}\pi_{t+i,i}\mu_{t,i}; \end{aligned} \tag{4}$$

and the aggregate accidental bequest is determined by:

$$B_t = \sum_{i=1}^{N} a_{t,i+1}\left(1-\pi_{t+i,i}\right)\mu_{t,i}. \tag{5}$$

An *equilibrium for the two-region open economy* is a sequence for the variables $\left\{c_{r,t,i}, a_{r,t,i}, K_{r,t}, B_{r,t}, w_{r,t}, \mu_{r,t,i}\right\}$ in each region $r = N, A$, an international capital flow F_t and a world interest rate r_t such that: the population shares are determined by the region-specific transition matrix $\Gamma_{r,t}$; households solve optimally their problems taking prices as given; wages in each country are set to marginal productivity of labor as in (2); the aggregate resource constraint in the two regions requires (3) to be satisfied; market clearing in the labor market imply the condition in the first line of (4); equalization of rate of return in the two countries implies the no-arbitrage condition:

$$r_t = \alpha\theta_N \left(\frac{L_{N,t}}{K_{N,t}}\right)^{1-\alpha} = \alpha\theta_A \left(\frac{L_{A,t}}{K_{A,t}}\right)^{1-\alpha}; \tag{6}$$

while the equilibrium flow of capital across regions satisfies equation (11) in the Appendix.[5]

For a given parameterization 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. We describe the details of the numerical solution method in the Appendix.

4 Parameterization of the Model Economy

In this section, we describe the choice of the preference, demographics and technology parameters used in the baseline simulations. We calibrate the original steady state using average

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

fertility rates, mortality rates and population shares in the 1950s and 1960s in the two regions of interest. We choose some of the preference and technology parameters to match a number of properties of the steady state solution (such as the capital-output ratio), and others in accordance with related studies.

The main exercise we perform consists in perturbing the original stationary equilibrium of each economy by changing fertility and mortality rates. In particular, we anchor our final steady state to one that roughly matches the long-run UN projections discussed above. We then move our economy from the initial steady state to the next by imposing a path of mortality and fertility rates that roughly matches the data and projections of the UN over a 100 year period. We assume that the two regions converge to the new steady-state around year 2100. Moreover we assume that even though the shock initiating the transition takes households by surprise, the whole future convergence path is fully anticipated.

The assumption that the two economies convergence towards a unique final steady-state is needed in the open-economy version of the model. The reason is that in the long run, if one economy grows more than the other, it will become the only relevant one and the steady state values will only reflect the features of that economy. As documented in Figure 1, the projected demographic transition is very slow, hence we do not think that this assumption is problematic.

4.1 Preferences and Endowments

We chose to model differences between the North and Latin America only in terms of demographic structure and technology. Preferences, and the age profile of efficiency units of labor are common across regions. Thus, in both regions the coefficient of risk aversion γ is set at 2, corresponding to an elasticity of intertemporal substitution of .5. The discount factor β is set to an annual value of 1.011, based on the study of Hurd (1989) for the US. The age-profile of efficiency units of labor $\{\epsilon\}_{i=1}^{N}$ is chosen to roughly match the lifetime wage profile, as documented for example in Gosling, Machin and Meghir (1999). It peaks at age 50, with an increase of about 100% vis-a-vis the initial level, and then it declines modestly in the years close to retirement. Beyond age 70 it is zero, which is equivalent to a retirement status. These assumptions about preferences and labor productivity were chosen to match a K/Y ratio of roughly 3 on an annual basis in the North. We obtain a lower level of the K/Y of about 2 in Latin America by scaling down the entire earning profile by a factor of 3 (see the discussion of the technology assumptions below). This is meant to reproduce differences in productivity and per-capita income in the two regions.

4.2 Demographics

We calibrate the first steady state of the model economy to the 50's and 60's, and the second steady state to the period 2030-2050, for which we have demographic forecasts. We divide the lifetime of an household in the model in 20 5-year periods, hence the unit of time in the model is 5 years. For the fertility rate, we have used the data described in Figure 1, assuming that women are fertile between ages 15 and 45 with a peak between 25 and 30 years old. [6] The fertility rates in the initial (SS1) and final (SS2) steady state for the two regions are given in Table 1 below.

Table 1: Fertility rates

	SS1		SS2
Age	LA	North	Both
<15	.0	.0	.0
15-19	1.06	.50	.30
20-24	1.24	.60	.46
25-29	1.60	.80	.60
30-34	1.40	.60	.44
35-39	.54	.20	.26
40-44	.16	.10	.14
>44	.0	.0	.0
TOT	6.00	2.80	2.20

The survival probabilities for the initial and final steady states in the two regions were computed on the basis of actual data and projections of the United Nations on the age structure of the population in US, Europe and Latin America. After constructing the shares of the population by 5-year age groups in the two periods, we obtained the implied surviving probabilities, assuming that the population is in steady-state. For the US, we have also used the Life Tables for the US Social Security put together by Bell, Wade and Goss (1992).

Table 2: Demographic Variables

	SS1		SS2
	LA	North	Both
population growth	.033	.01	.003
life exp. (years)	56	63	82
dependency ratio	.055	.16	.39
average age (years)	21	31.5	42

[6] We have also attempted to model the observed shift of child bearing towards later stages in life. As clear from Table 1, we have increased, in the second steady-state, the fertility rates for women older than 35.

4.3 Technology

As mentioned above, the production function is Cobb-Douglas with share of capital α set at 0.36 in both countries. For Latin America we set the shift parameter θ in order to normalize income per capita to 1 in the first steady state. Based upon the Summers-Heston dataset, income per capita in the North in 1950 was approximately 3 times that of the South, thus θ for the North is set accordingly. The depreciation rate of capital is set to 5% per year, as commonly done in the literature.

5 The computational experiment

5.1 Methodology

We assume that changes in the demographic structure are exogenous to households' decisions. The experiment we run is of an unexpected change in the steady-state demographic variables (fertility and mortality rates) of the 1950s and 1960s in the two regions of interest. We assume that the change in mortality happens gradually and monotonically, whilst that in fertility follows an inverse U shape in order to generate the *baby-boom* observed in both economies during the early 60's. We parameterize the speed of adjustment towards the new steady-state level of fertility and mortality rates in order to replicate the actual demographic transition.

Technically, what changes (unexpectedly) across steady states is the matrix Γ_t governing the demographic structure of the population. Although the initial change is, as of 1950, unexpected, we assume that the all generations alive during the change can perfectly forecast the future path of population shares, and factor prices. In other words, in the initial steady state the matrix Γ is (and is expected to be) constant. Once the change occurs in the form of a sequence of matrices Γ_t that converges slowly towards the new steady state, all generation alive are assumed to forecast perfectly the new path. We discuss the likely implications of this assumption below.

5.2 Steady-States

Before describing the features of the transition, it is worth to discuss briefly the properties of the initial steady state in the two economies. First of all notice that we do not consider technical progress so that in steady-state the growth rate of the economy is normalized to zero.

We start with the equilibrium consumption and asset profiles. The most noticeable result is that consumption profiles are hump shaped, even in the absence of demographic effects and precautionary saving motives. The reason for this shape lies in the changes in the effective

discount factor along the lifetime of an individual induced by the different mortality probabilities at different stages of life.

As far as the age profile of assets is concerned, even though the assumed earnings profile is relatively steep, it does not imply borrowing in the early part of life. This is because of the strong incentives to save for retirement.

Moving to factor prices, we notice that in the initial steady-state the equilibrium return to capital is 4% in the North and 8.5% in Latin America.[7] The relatively low rate of return to capital in the North could be justified because of the absence of any form of risk in investment. The capital-output ratio is 3.6 which matches (as it was designed to) the stylized facts for the North. In Latin America the capital-output ratio is 2.4, consistent with a higher interest rate.

In the next sections we analyze several simulations. In describing the results, we first start with the closed economy and analyze separately what we label the "fertility transition", and the "surviving rate transition". That is, in order to disentangle the macroeconomic effects of the two types of shocks, we first assume that only fertility changes, and then that only longevity does. We then proceed to study the full demographic transition. At every step, we compare Latin America with the North. Next, we analyze the demographic transition for the North and Latin America in open economy, using our two-region model with international capital flows. In that experiment, we assume that a few periods after the demographic transition in the closed economy, capital markets are suddenly and unexpectedly open. The period we choose for the opening is the year 1995.

5.3 The Fertility Transition

In Figure 3, we plot the simulated fertility transition which matches very closely the actual data, as clear from a comparison of the first panel across Figures 1 and 3. The fertility transition accounts for a very large rise in the average age of the population, especially in Latin America. The fertility transition generates an acceleration in the dependency ratio between 2020 and 2040 in the North which is clearly visible in the data of Figure 1: it is the crest of the baby-boom entering the retirement age. In Latin America the dependency ratio picks up earlier, around year 2010, as in the data. Overall, the effect of the baby boom in Latin America is negligible.[8]

The simulated transition path of some of the most important aggregate variables during the fertility transition are plotted in Figure 4. In the long-run, the fertility transition brings about a reduction in the growth rate of the labor force, and an increase in the share of the elderly

[7]Because the interest rate exceeds the aggregate growth rate in both regions, the two economies are dynamically efficient.

[8]In this experiment life expectancy does not vary, as we keep the surviving rates unchanged.

population. The key consequence of the decline in the population growth rate is a decrease in the capital-labor ratio, hence an increase in wages and a reduction of interest rates. Aggregate saving rates move because of changes in individual saving profiles and because of changes in the composition of the population. Aggregation effects increase aggregate saving rates, as during the transition the age groups with relatively high saving rates are more numerous as a consequence of the baby boom. The fall in the interest rates and the increase in wages have several and often contrasting effects on individual saving profiles. On the one hand the fall interest rate and the subsequent substitution effects induce flatter consumption profiles and therefore reduce savings. On the other, it is easy to have counteracting income effects. Which of the two sets of effects prevails depend on a variety of factors ranging from the curvature of the utility function, the discount factor, the slope of the life time earning profile, the length of retirement. In our calibrated model, it is clear that the overall effect on aggregate savings is strongly positive. The generations alive at the time of the shock are forced to make a fairly dramatic adjustment in their consumption plans, and this explains the spike in the saving rate in the first period, particularly strong for Latin America, where the fertility shock is larger.

The effects on the growth rate of wages are also quite substantial. In the first decade of the fertility transition. It should be remembered that we have normalized our model so that in steady state, per capita income growth is zero. The observed rate of growth in our simulations are therefore induced completely by the demographic trends. From Figure 5 one can therefore guess that the fertility shock can explain 1.8% of the average wage growth in Latin America and about 0.5% in the North. However, much of this result is due to the surprise effect. Interestingly, the shock is extremely persistent, especially in Latin America where, according to the model, even in the year 2000, 50 years after the initial shock, the slowly unfolding decrease in fertility trends can generate wage growth of about 0.2% per year for another 50 years.

Notice that, while the interest rate drops extremely quickly in Latin America in the wake of the sharp reduction in fertility rates, the model suggests that the fertility transition could still lead to a reduction of the annual interest rate in the next 50 year of around 1 basis point.

Finally, it is worth analyzing the effects on the average efficiency level of the labor force. In the North, after a labor productivity slowdown in the 70's (which interestingly is in the data as well) related to the entry of the baby-boomers into the labor force, the average efficiency units of labor increase, and a rise is expected for the next two decades as the baby-boomers go through their most productive years. The rise of average efficiency of labor in Latin America is much bigger, around 10% in the long run. The model suggests that, looking ahead, Latin America can still exploit half of the rise in labor productivity associated to the fertility transition in the

next 50 years.[9] It is this, in our model, the 'window of opportunity' referred to by Berhman et al. (1999).

5.4 The Surviving Rate Transition

The demographic changes caused by the rise in the surviving probabilities are represented in Figure 5. The rising longevity manifests itself mainly through a decline in infant mortality rates and in the mortality rates of the oldest generations. In the North the latter is more pronounced, which generates a considerable rise in the average age from 32 to 36, and a rise in the dependency ratio from 16% to 27%. In Latin America child mortality falls sharply during the transition. This force counteracts the aging effects of an increase in the surviving rates of the elderly. As a result, the effects on average age and on the dependency ratio are quantitatively fairly small.

Figure 6 shows that from the point of view of the household, an improved longevity (especially during the retirement period) calls for more life-cycle savings during the productive years. The consequent rise in the capital stock increases wages and lowers the rate of return. In the North the saving rate increases by 5%. The impact on wage growth is .3% per year in the 60's to decline to .12% in the year 2000. The effects on Latin America are fairly small: no change in the saving rate, and a small growth effect on wages. In both economies the rate of return falls, and average efficiency units of labor increase very mildly, since most of the increase in longevity is enjoyed by retirees.

5.5 The Full Demographic Transition

Figure 7 displays the simulated demographic transition in the model which, as clear from a quick comparison with Figure 1, reproduces the data very closely. The simulations of the key macroeconomic variables for the full demographic transition are pictured in Figure 8. It is easy to see the combined effects of the falling fertility rate and the rising surviving rates.In particular, notice the increase in the aggregate saving rate at impact and the decline in the interest rate.

In Figure 9, we have summarized the impact of the full demographic transition on income per capita. If one remembers, once again, that our initial steady state is benchmarked to have zero per-capita growth, one can interpret the growth in per-capita income generated during the transition by our model as due to the observed demographic trends. It is remarkable that,

[9] The rise in the average efficiency units of labor counteracts the decline in population growth, but the latter effects dominates and the total labor input falls.

according to our model, the observed changes in the age structure can account for 0.55% per year of income per capita growth in Latin America and .3% per year in the North in the past 50 years. Moreover, while the beneficial effects for the North are quickly fading away, the simulation suggests that Latin America should still benefit from higher than average growth rates for the next half century.

To summarize, the closed economy model suggests that:

1. *the North has largely exhausted the macroeconomic benefits of the demographic transition*, in particular:

   (a) only an additional 2% increase in the average efficiency units of the labor force should be expected in the next few decades.[10]

   (b) in the next two decades the contribution to wage growth will stand at around 0.2%. After a positive echo effect due to the retirement of the baby-boom generation around 2020, it will decline quickly towards 0.1%.

   (c) the additional effect on income per capita will be around 0.1% per year in the next two decade, but it will decline quickly to zero afterwards.

   (d) The North experiences a dramatic drop in the rate of return to capital that goes from 4% to 1% between the two steady states. Notice that by the time the baby boomers retire, most of the transition in the rate of return has occurred.

2. *Latin America can still enjoy large gains from the demographic transition*, in particular:

   (a) a rapid increase in average efficiency units of labor should be expected in the next 30 years,

   (b) the demographic transition could contribute up to .45% in the yearly growth of real wages in the next 30 years, with a declining, but persistent effect for further 50 years,

   (c) income per capita growth associated purely to capita accumulation and improvements in efficiency units of labor will be fairly substantial in the next 50 years: from .6% per year in 2000, down to .1% in 2050,

   (d) however, most of the rise in the aggregate saving rate seems, according to our model, to have taken place.

[10] The size of this effect depends, obviously, on the assumed slope of the earning profile.

5.6 Welfare Analysis in Closed Economy

The use of a general equilibrium model allows us to determine what are the welfare gains (or losses) for each generation alive during the demographic transition. This is probably the most relevant question to answer to evaluate the effects of the demographic transition. To answer it, we compute a measure of compensated variation, i.e. how much we would have to rescale (up or down) the consumption profile of each individual in each period to leave her with the utility level of the generations living entirely in the first steady-state. Notice that since we are abstracting from technological growth, this comparison makes sense. In Figure 10 we plot this compensating variation against the year of birth of the individuals living around the transition. Note that a positive (negative) number corresponds to a welfare loss (gain).

The largest losses are borne by the baby-boomers as not only they face a sharply falling rate of return, but also the rise in wages is dampened for them by the size-effect of their cohort. This loss stands at 8% for the North, while it is more modest for Latin America (just above 2%), where the baby-boom occurred more mildly. In the long-run there is a small gain in the North, whose second steady-state displays a modestly larger welfare, and there is a staggering welfare gain in Latin America, standing around 22% of lifetime consumption in the new steady-state. The size of the welfare gain in Latin America is explained by the large change in fertility and longevity between the two steady states which results in a two-fold increase in the saving rate. The higher capital-labor ratio reflects, in turn, in higher levels of lifetime labor earnings.

By examining Figure 10 one can observe that the generations which are expected to be born in the next 30 years in Latin America will still improve their welfare level considerably with respect to the existing ones. The same is not true for the North.

It should be stressed that the welfare losses for the baby boomers we have estimated here are probably a lower bound on the actual loss that these generations could observe. The main reason for this assertion lies in the assumption that the baby boomers fully anticipate and act upon the decline in fertility. As many of them are born after the demographic transition has started, they are not subject, in our model, to any demographic surprise.

The size of the welfare losses for the baby boomers in the North is, in our opinion, one of the elements that is missing in the current debate on social security reform. The factors that generate these losses in our model, where retirement is financed completely by private savings, are the same that make the social security systems currently in place in the US and in many European countries unsustainable.

6 The Demographic Transition in Open Economy

To our knowledge, there are only very few papers that have explored the implications of different global demographic trends in open economy. One example is Higgins and Williamson (1998) where the focus is on how the demographic transition in East Asia affects the region's international capital flows. Their main finding is that there is a statistically significant link between demography and net capital flows. The slow convergence of the East Asian demographic structure towards the developed world's structure could have generated, according to the authors, a fall of 6% in the current account balance (as a share of GDP).

All the previous experiments in our paper were performed under the assumption of closed economy, thus no interaction was allowed between the two regions. Our two-country model allows us to analyze the macroeconomics of the demographic transition in an open economy context. The data on international capital flows between Latin America and the rest of the world suggest that on average, between 1970 and 1990 these flows were below 3% of GNP. By the year 1997 this ratio had doubled to 6%. Therefore if one had to choose a single date to model the opening of capital markets, somewhere in the mid 90's would seem reasonable.[11]

In our experiment, we assume that until 1995 the two regions were in autarchy, with no capital flowing across the borders. In 1995 we shock the two regions by allowing capital to flow. Once again, the shock is unexpected.

The lower-right panel of Figure 11 displays the transition for interest rate. As we have imposed no restrictions on capital flow, in the period immediately following the opening the rates of return on capital across regions must be equalized. Equalization requires a fall from 5.5% to 4.5% in Latin America, and an upward jump from 2.5% to 4.5% for the North. Following the impact of the shock, the interest rate slowly decays towards its long-run value (equal to the closed economy value) of roughly 1% per year.[12]

The upper-right panel of Figure 11 pictures the flows of capital into Latin America as a percentage of output in Latin America. The model predicts that a flow equal to 18% of output in Latin America would be necessary on impact. The flow would slowly decrease until reaching almost zero in 2100, however notice that in 2040 it would still stand at a remarkable 6% of GDP.[13] The sudden spike in the capital flow implies a shift of savings towards Latin America

[11] The numbers on capital flows are derived from the World Bank Development Indicators.

[12] This number might be considered low in comparison with current returns on investments. However, it should be remembered that we have completely abstracted from risk in this model, so it is a plausible number for a risk-free rate of return.

[13] The model implies that in the long run the two economies have no capital flows among them. This is because they converge to the same rate of growth of the population. Capital flows adjust capital labor ratios in the transition.

and a rise in the capital-labor ratio in Latin America, with beneficial effects on wage growth: in the years following the opening, Latin America enjoys labor income growth rates up to 2% per year.

Figure 12 shows the differential impact of the demographic transition on output for Latin America, in closed and open economy. Upon impact, the large inflow of capital could generate growth rates of output around 2%, at levels much higher than those observed in the closed economy. After a couple of decades, however, the rate of growth of per capita output in the open economy decreases to levels lower than those in the closed economy. In other words, it seems that opening capital markets brings forward the rate of growth in per-capita income induced by the demographic transition.

An important remark at this point is that the size of our open-economy results is largely driven by the extreme assumption of perfect mobility of capital across borders. This explains the fact that the model overpredicts the magnitude of capital flows. A more realistic setting would allow for some sort of frictions in financial markets which would delay the rate of return equalization and maintain a positive differential for some time.

A somewhat different conclusion should be drawn for the saving rate. In the closed economy (see Figure 8) the transition of the saving rate was almost concluded around 2020, while in the open economy model, in 2020 the saving rate still stands quite far from its long-run value. The reason is that it falls after the openness, because of a sort of "crowding out" effect whereby the inflow of capital from the North substitutes for domestic savings which allows more resources to be devoted to consumption.

To summarize, the open economy model suggests that *opening capital markets can bring forward the additional growth in per capital income implied, for Latin America, by the demographic transition.* One way to think about these issues, therefore, is in terms of redistribution across generations. The fundamental reason is that international capital flows accelerate the adjustment process by exacerbating income per capita growth in the short-run and reducing it in the long-run.

The next two Figures, 13 and 14, plot the welfare losses due to the demographic transition in closed and open economy for North and Latin America separately. Welfare is ultimately the best measure of the consequences of the demographic shock, and in our experiment it allows to answer the following question: if, in the middle of the demographic transition, these two economies were opened to capital flows, who would be the winners and the losers in each region?

Figure 13 gives us the answer for the North. Notice first that, as in the closed economy, essentially all generations lose from the demographic transition. In relative terms, however, the

winners are the baby-boom generations who, once the economy is open are near retirement and therefore do not suffer from the drop in the wage rate, but enjoy the higher (than expected) returns on their savings. The losers are all those generations who will still supply labor after the opening, because of the lower wage rate. Figure 14 contains the answer for Latin America. Here the logic is exactly reversed: the relative winners are those generations which will be productive in the labor market after capital has massively flown into Latin America from the North, boosting the wage rate. The biggest relative welfare gains from financial liberalization accrue to those cohorts born around the opening and are approximately equivalent to 6% of lifetime consumption.

How to reconcile the findings on income growth with those on welfare? The answer is that welfare is largely determined by the *level* of the wage rate, and the fast growth of the years following the opening increases the capital-labor ratio above the closed economy level. This generates a further welfare gain even for the future generations. Overall, our model suggests that by opening to financial flows Latin America will compress the growth benefits of the demographic transition into a shorter time horizon, but this will generate a significant welfare gain for future generations as well. Although the future generations will face an economy with slower growth compared to a closed economy, their level of income per capita will be higher on average.

7 Concluding Remarks

In this paper we have used calibrated general equilibrium model to study and quantify the effects of the demographic transition on factor returns and, ultimately, on the welfare of the generations alive around and during the transition. While the models we use are very stylized, the results we present are important for a variety of reasons. First, while the demographic trends discussed in this paper have been the main determinant of the current policy debate on the sustainability of the pension systems currently in place in the US and several European countries, the implications of the same trends on the return to capital - and the implications of this for the welfare of the baby boomers, has been almost absent from the debate. Second, we want to stress that the fact that the current demographic trends are not synchronized in different parts of the world, affords important opportunities. In particular, in the next few decades, while the North of the globe ages, the existence of regions where the demographic transition is much delayed, puts in place strong incentives to factor mobility. If labor mobility is precluded or limited by political or other costs, capital mobility can constitute an important

alternative.

In our simulations, we show the importance of the two points we want to make. First, we show that the effect of the current demographic trends on the welfare of a large generation followed by a much smaller one are important even in a situation in which the saving for retirement happens in a completely funded and private way. The welfare decrease, that we quantify for the baby boomers of the North at around 8% of annual consumption, is caused mainly by shifts in factor prices and, in particular, of rates of returns, which decline considerably as a consequence of the aging of the population. Such an effect is likely to be a lower bound, as in our simulations we assume that the baby boomers fully anticipate the decline in fertility and the increase in longevity that drive population aging and act consequently. If they do not, or if they act believing in the sustainability of a social security system that will not eventually deliver its promises, the costs can be much higher. The same is true if these generations have to finance somehow the transition from an unfunded to a funded scheme. The demographic transition also induces some additional growth in Latin America.

Second, we show that opening financial markets it would change the effects of the transition considerably. The obvious effect is the equalization of the rates of return in the two economies. The capital flow from the North to the South would also involve an increase in wages in Latin America (and a reduction in the rate of return there). While for the North baby-boomers the welfare effect of opening the economy is positive, as it alleviates the effect of the demographic transition induced by the dramatic reduction in rates of return, the effects for all other generations are negative because of the reduction in the wage rate. In Latin America essentially every generation in the workforce at the time of opening is subject to a slight welfare loss due to the opening, however large gains accrue to future generations. Another interesting result for Latin America is that the opening will bring forward the growth of the economy induced by the demographic transition.

Obviously our results should not be taken too literally. Several important caveat should be kept in mind and should constitute the topic of future research. Here we list what we think are the most important and urgent items.

1. The capital flows implied by our exercise are very large, and much larger than those currently observed. Our baseline simulations implied, on opening the capital markets, a flow of capital equal to 18% of the Latin American GDP. Currently, capital flows, are much lower. According to the World Bank Atlas Tables, for the Latin American and Caribbean region, they were just above 6% of GNP in 1997. Our model cannot match this number for several reasons. First, we start from a situation in which capital markets

are completely close, which is not a realistic description of the world. Second, and more importantly,in our simulations, we neglect completely all sources of risk, including political uncertainty. Third, when the markets are open, we do not consider any impediment to capital mobility. All these aspect will have to be addressed carefully if one wants to quantify realistically the extent to which differences in demographic trends constitute an opportunity to be exploited by fostering capital mobility.

2. In our model we do not consider labor supply choices. An extension in this direction would not only make the model more realistic, but allow to focus on two factors that are extremely relevant for our arguments. First, the increase in female labor force participation that is realistic to expect in Latin America (while it has already happened to a large extent in the North), would reinforce the asymmetries between the two regions that we have stressed and that are at the basis of our argument. Second, the trend towards early retirement in the North would also go in the same direction, at least to the extent in which it is not mirrored by a similar phenomenon in Latin America.

3. In our model, we do not consider the presence of a large unfunded pension system that is currently in place in the US and in many countries in Europe. While this allowed us to focus on the demographic trends and stress that the problems they create are relevant in a situation where the 'pension system' is private and funded, more realistic simulations would take into account the existing pension systems and, possibly, different adjustments to make them sustainable in the new steady state.

4. We model in a very crude way the stock of human capital available in the two regions and do not allow for its accumulation. It would be important, to make our simulations more realistic, to model human capital explicitly.

5. While in the current paper we have focused only Latin America, it would be interesting to include in the picture other regions, such as South East Asia.

6. In the current version of our model, children do not enter the utility function. Introducing them, would probably dampen the amount of life cycle saving, as consumption needs would rise in the middle of the life cycle.

A Appendix: Description of the Algorithm

A.1 Steady-State of the closed economy

The absence of aggregate and idiosyncratic uncertainty greatly simplifies the solution of this model, which can be solved in two steps. The model can be expressed in terms of a pair of aggregate state variables, the capital stock and the aggregate accidental bequests, thus the steady state computations are very simple and involve the solution of two nonlinear equations. Given an initial guess for the capital stock and the accidental bequests, it is possible to construct factor prices and from these one can construct age specific consumption and saving decisions which, in turn, by aggregating through steady-state population shares will imply a value for the aggregate capital stock that, in equilibrium, coincides with the original guess.

A.2 Transition of the closed economy

We fix the length of the transition to NT periods. We guess a path of $\{K_t\}_{t=1}^{NT}$ and $\{B_t\}_{t=1}^{NT}$ such that K_1 and B_1 and K_{NT}, B_{NT} are respectively the initial and the final steady-state values computed as described above. We linearly interpolate these two points to obtain first guess. Given this path we can compute factor prices along the transition and then, for every period t of the transition we can compute the assets and consumption profiles. ¿From these and the population shares implied by the demographic transition, we can then aggregate to compute the implied capital stocks and accidental bequests. If the path for the implied capital stock and accidental bequests does not coincide with the original guess we adjust the latter. Otherwise, the solution has been found.

A.3 Steady State of the open economy

In the final steady state, the demographic variables in the two countries must be equal. This implies a unique final growth rate of population, call it η.

The law of motion for aggregate capital in the North and in Latin America in steady state:

$$\begin{aligned} K_N\delta &= S_N - F \\ K_A\delta &= S_A + F \end{aligned} \tag{7}$$

No arbitrage between the two countries requires a unique rate of return, so it implies the condition:

$$\left(\frac{L_N}{K_N}\right)\theta_N^{\frac{1}{1-\alpha}} = \left(\frac{L_A}{K_A}\right)\theta_A^{\frac{1}{1-\alpha}} = \left(\frac{r}{\alpha}\right)^{\frac{1}{1-\alpha}} \tag{8}$$

Hence, using (7) and (8) we obtain:

$$\frac{S_N - F}{S_A + F} = \left(\frac{L_N}{L_A}\right)\left(\frac{\theta_N}{\theta_A}\right)^{\frac{1}{1-\alpha}} \equiv \phi$$

which yields:

$$F = \frac{S_N - \phi S_A}{1+\phi} \tag{9}$$

The algorithm that we use to compute the steady-state is the following. First, we guess K_r, B_r, and we obtain the wages in each region from marginal productivities, and the world rate of return from (8). Given prices, we can compute permanent income in steady-state, and through the Euler equation the vector of consumption profiles $\{c_{i,r}\}_{i=1}^{N}$. Using the steady-state population shares, we obtain aggregate savings S_r. Given S_r, we can compute F from (9) and then use F into (7) to check whether the guess of K_r and B_r is verified, otherwise we update our guess and continue the iteration.

A.4 Transition of the open economy

We start from a vector of guesses of length NT for $B_{r,t}$ and $K_{r,t}$. In each country, for every period t, from the Euler equation we obtain the age profile for consumption and asset holdings. We can therefore derive the implied value for $B_{r,t}$. We then compute savings of every individual of age i in period t in region r from the budget constraint, and we aggregate to obtain aggregate savings $S_{r,t}$. From the law of motion for capital, we obtain with some simple algebra:

$$\begin{aligned}
\tfrac{K_{N,t+1}}{L_{N,t+1}} &= (1-\delta)\tfrac{K_{N,t}}{L_{N,t}}\left(\eta_{N,t+1}\right)^{-1} + \tfrac{S_{N,t}}{L_{N,t}}\left(\eta_{N,t+1}\right)^{-1} - \tfrac{F_t}{L_{N,t}}\left(\eta_{N,t+1}\right)^{-1}, \\
\tfrac{K_{A,t+1}}{L_{A,t+1}} &= (1-\delta)\tfrac{K_{A,t}}{L_{A,t}}\left(\eta_{A,t+1}\right)^{-1} + \tfrac{S_{A,t}}{L_{A,t}}\left(\eta_{A,t+1}\right)^{-1} - \tfrac{F_t}{L_{A,t}}\left(\eta_{A,t+1}\right)^{-1}.
\end{aligned} \tag{10}$$

Using (10) into the no-arbitrage condition (6), it is easy to obtain an expression for the flow of capital:

$$F_t = L_{N,t}\frac{(1-\delta)\left[\frac{K_{N,t}}{L_{N,t}}\widetilde{\eta}_{t+1} - \frac{K_{A,t}}{L_{A,t}}\right] + \frac{S_{N,t}}{L_{N,t}}\widetilde{\eta}_{t+1} - \frac{S_{A,t}}{L_{A,t}}}{\frac{L_{N,t}}{L_{A,t}} + \widetilde{\eta}_{t+1}} \tag{11}$$

where $\widetilde{\eta}_{t+1} = \frac{\eta_{N,t+1}}{\eta_{A,t+1}}\left(\frac{\theta_A}{\theta_N}\right)^{\frac{1}{1-\alpha}}$. One can now use F_t into one of the equations of (10) to obtain the implied value of $\frac{K_{r,t+1}}{L_{r,t+1}}$ from which it is immediate to derive the implied value for $K_{r,t+1}$. Once again comparing the vector of guesses with the vector of implied values, we can update the guesses until convergence is reached.

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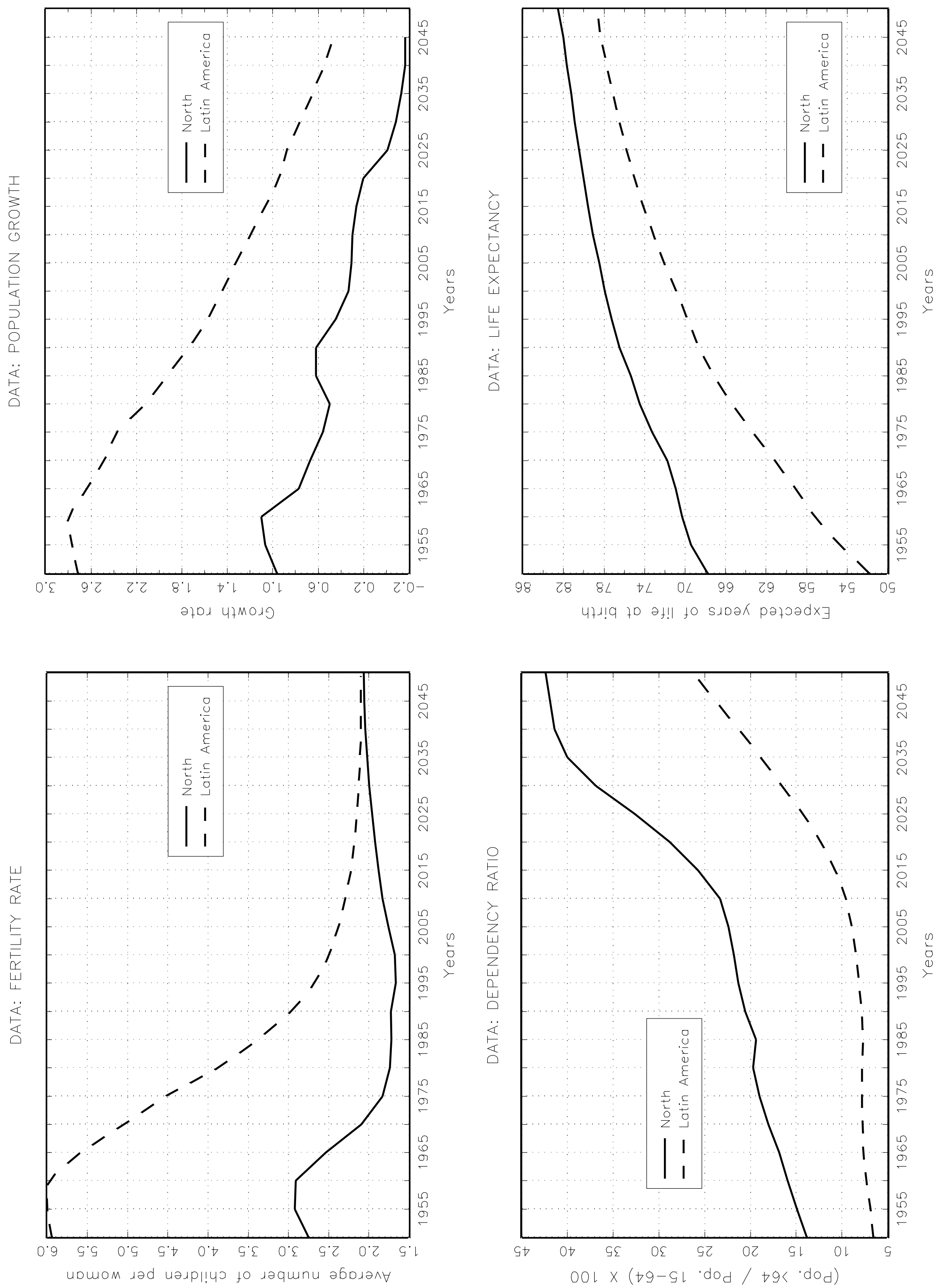

Figure 1: Demographics of US/Europe (North) and Latin America

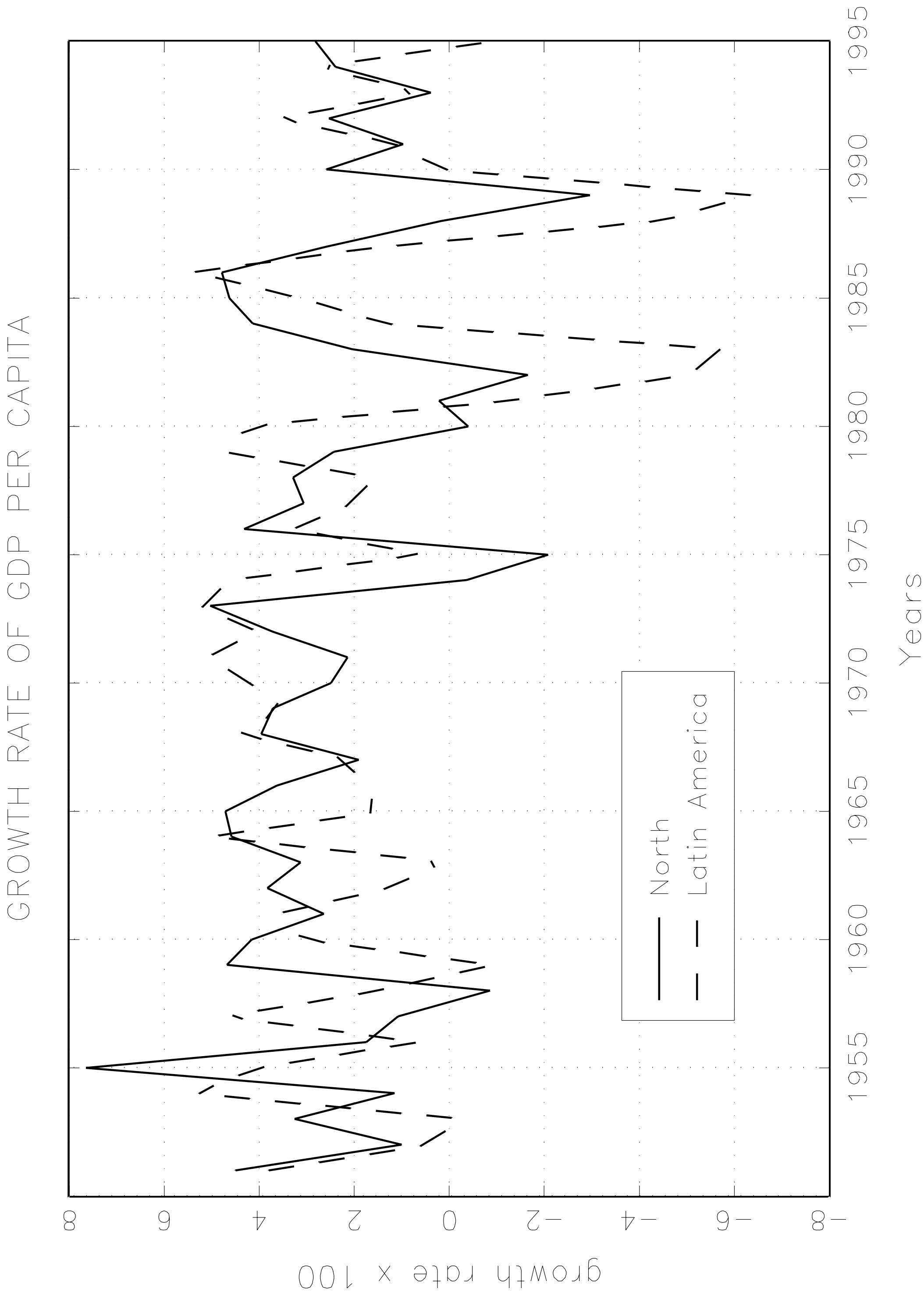

Figure 2: Income per capita growth in US/Europe (North) and Latin America

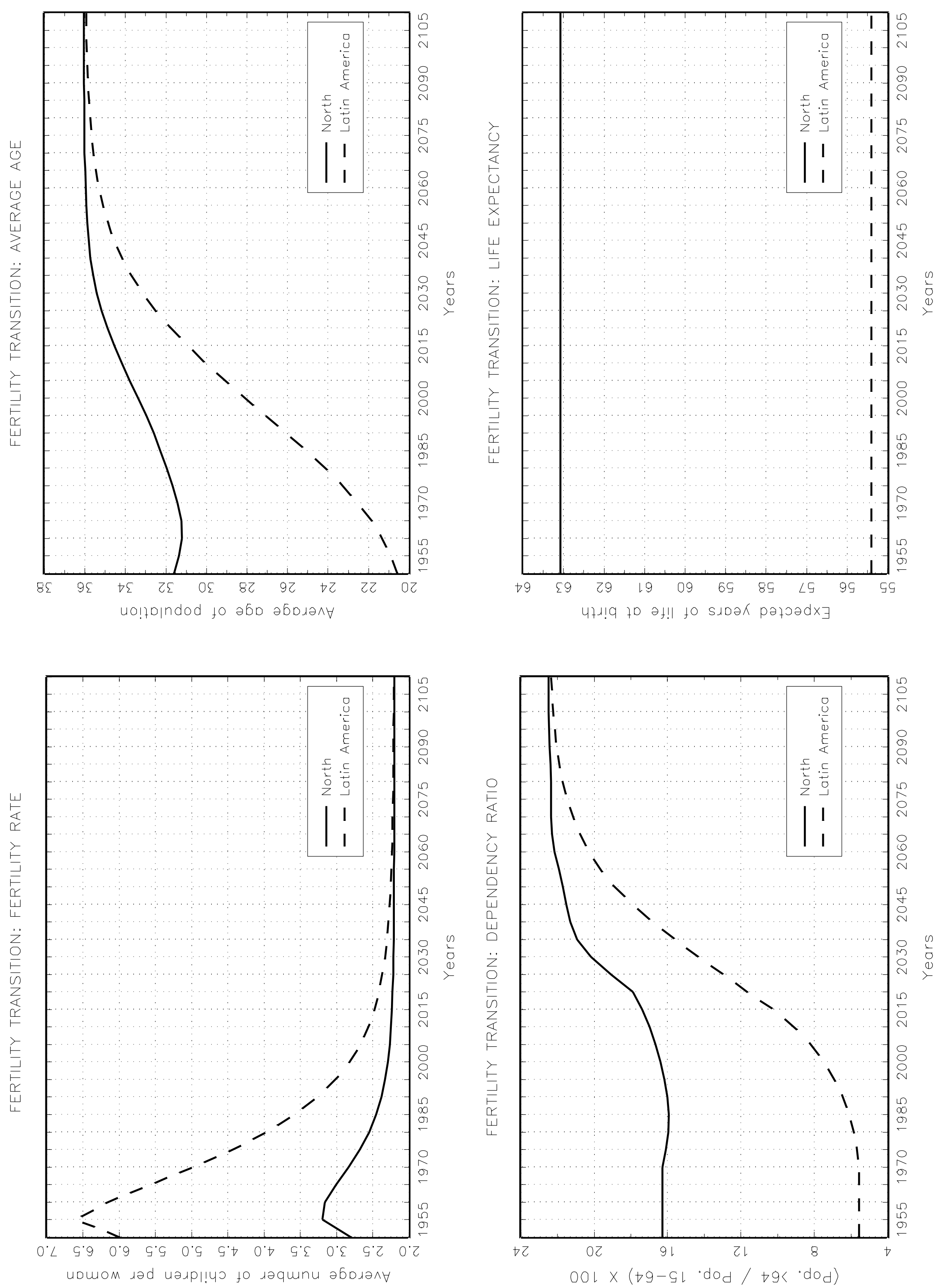

Figure 3: Fertility Transition: Demographic Variables

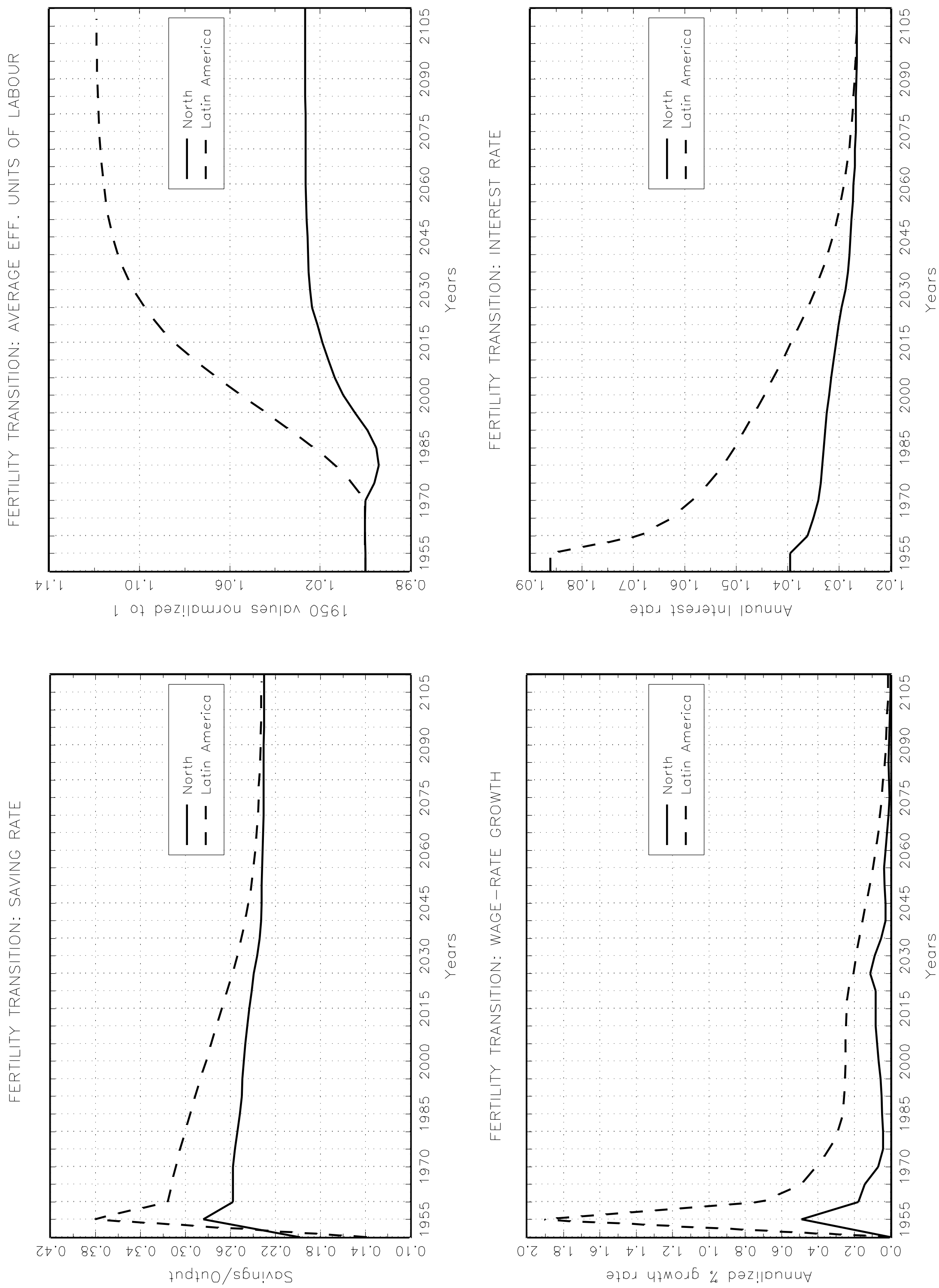

Figure 4: Fertility Transition: Macroeconomic Variables

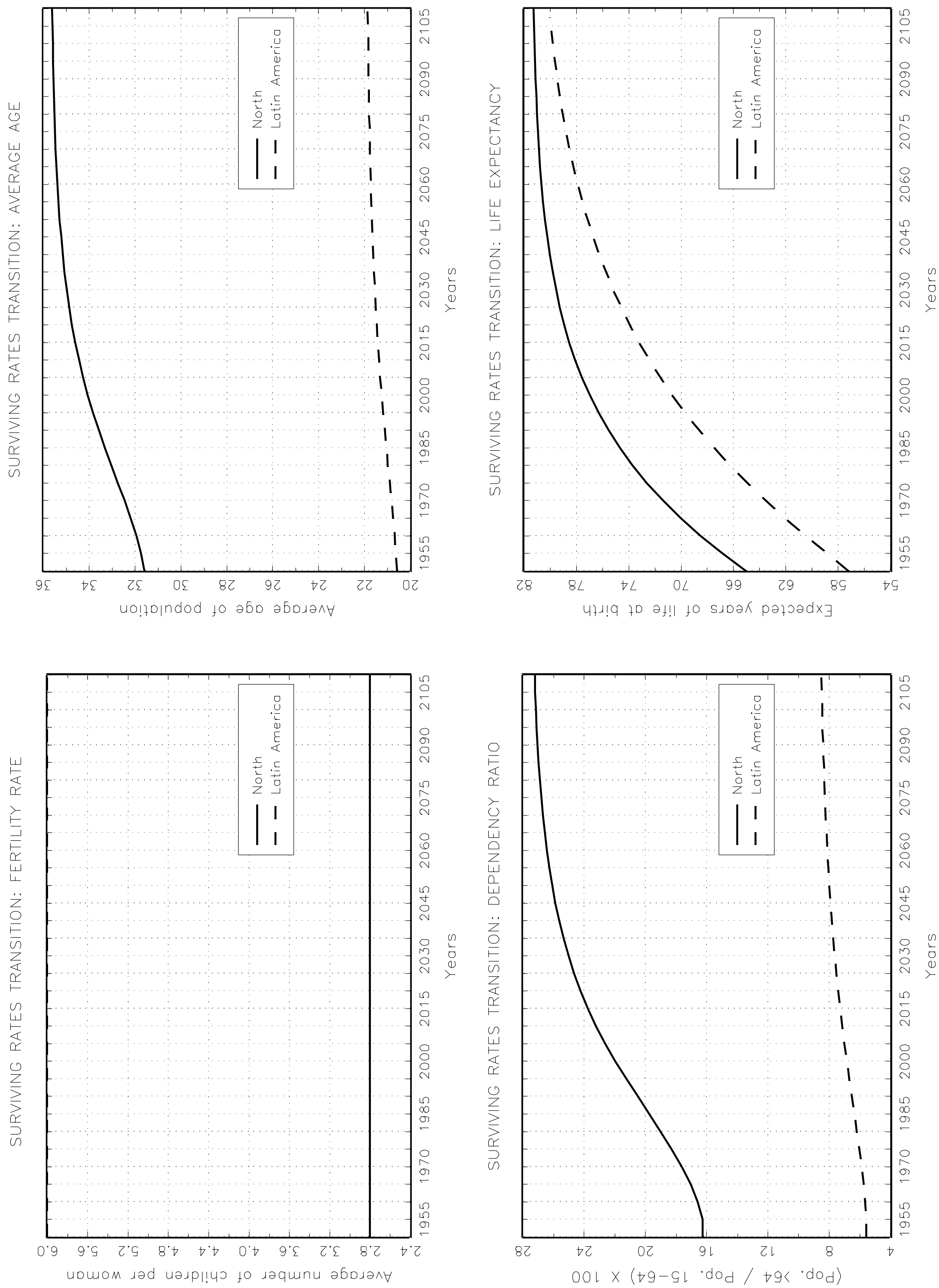

Figure 5: Surviving Rates Transition: Demographic Variables

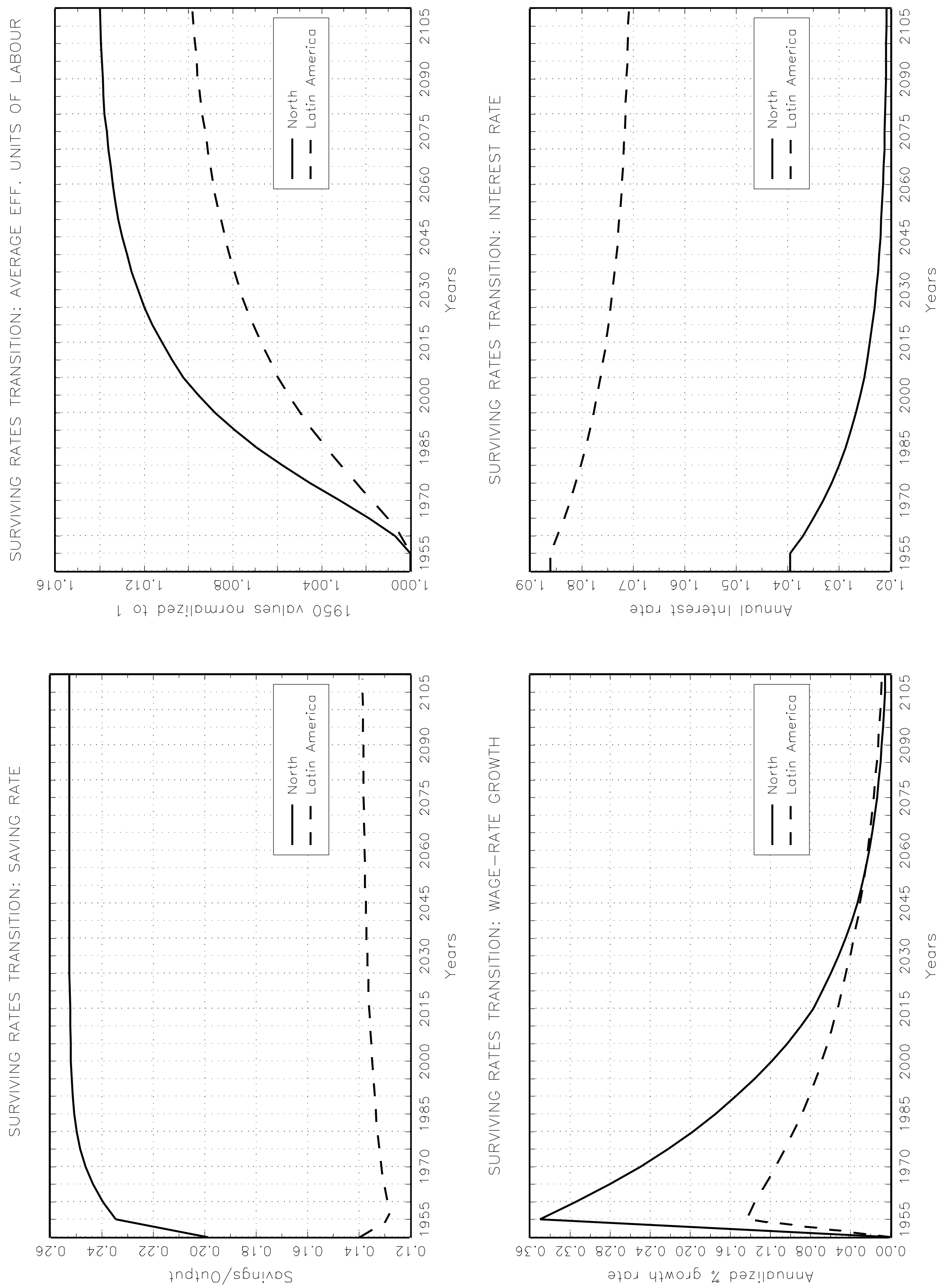

Figure 6: Surviving Rates Transition: Macroeconomic Variables

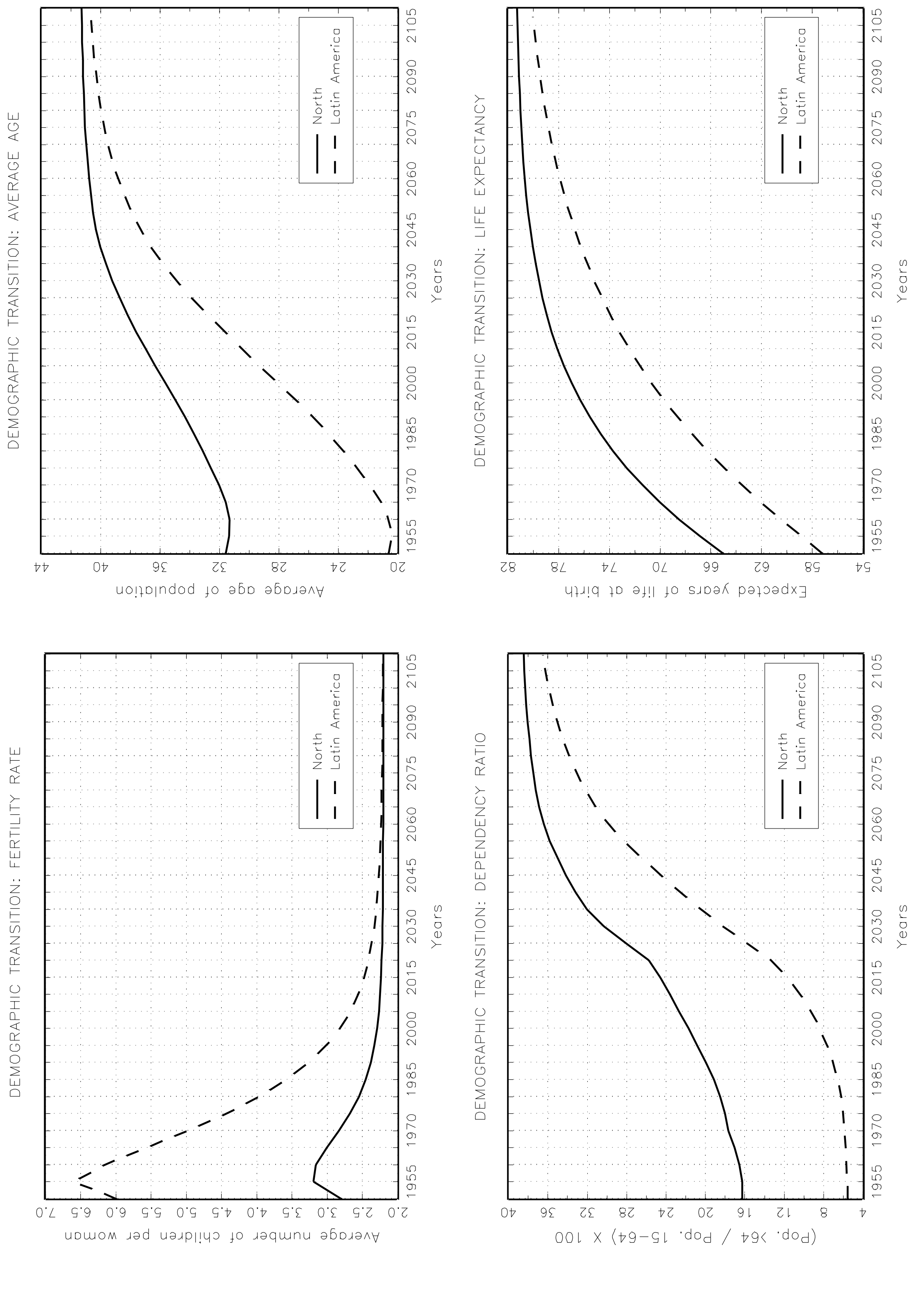

Figure 7: Demographic Transition: Demographic Variables

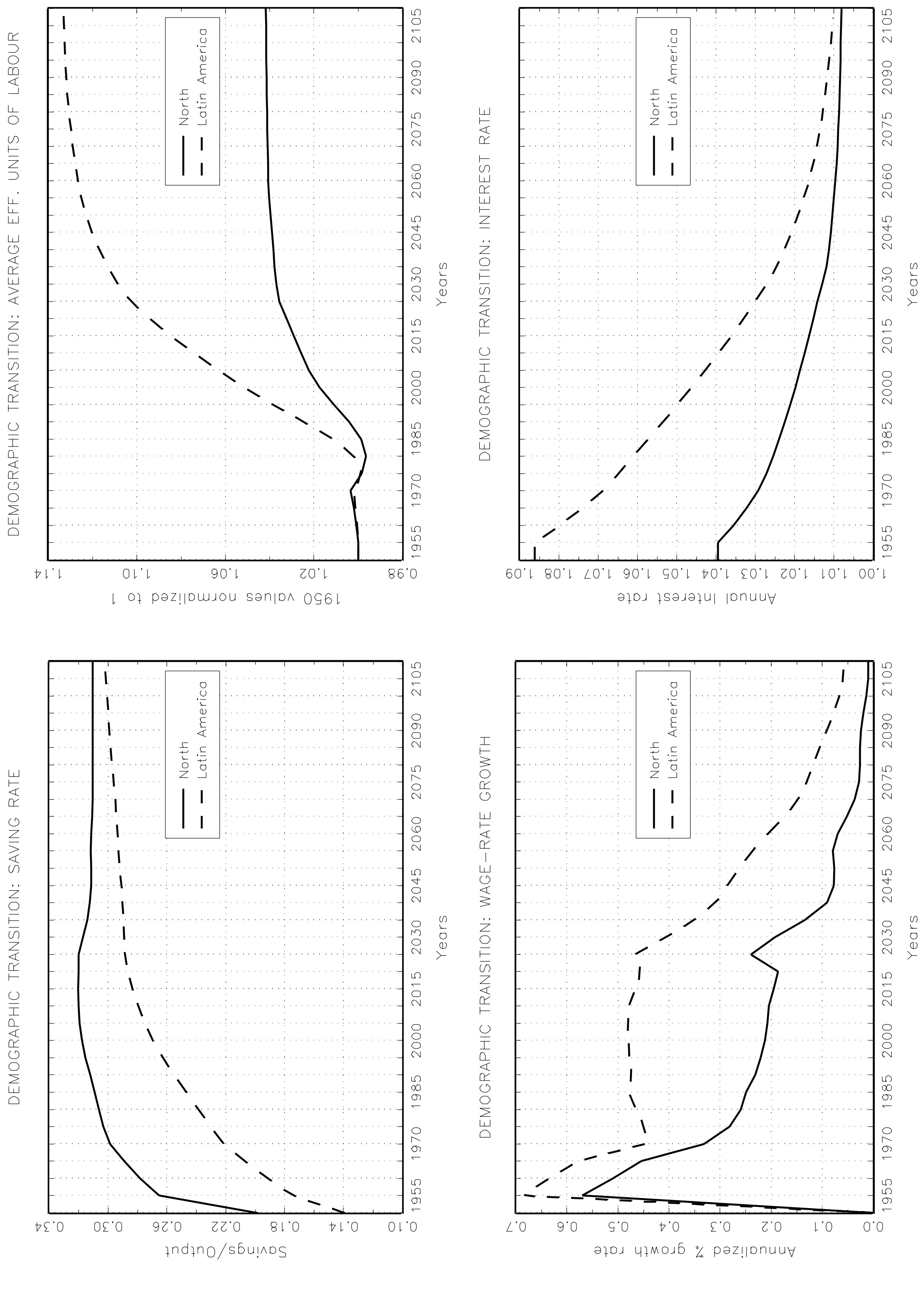

Figure 8: Demographic Transition: Macroeconomic Variables

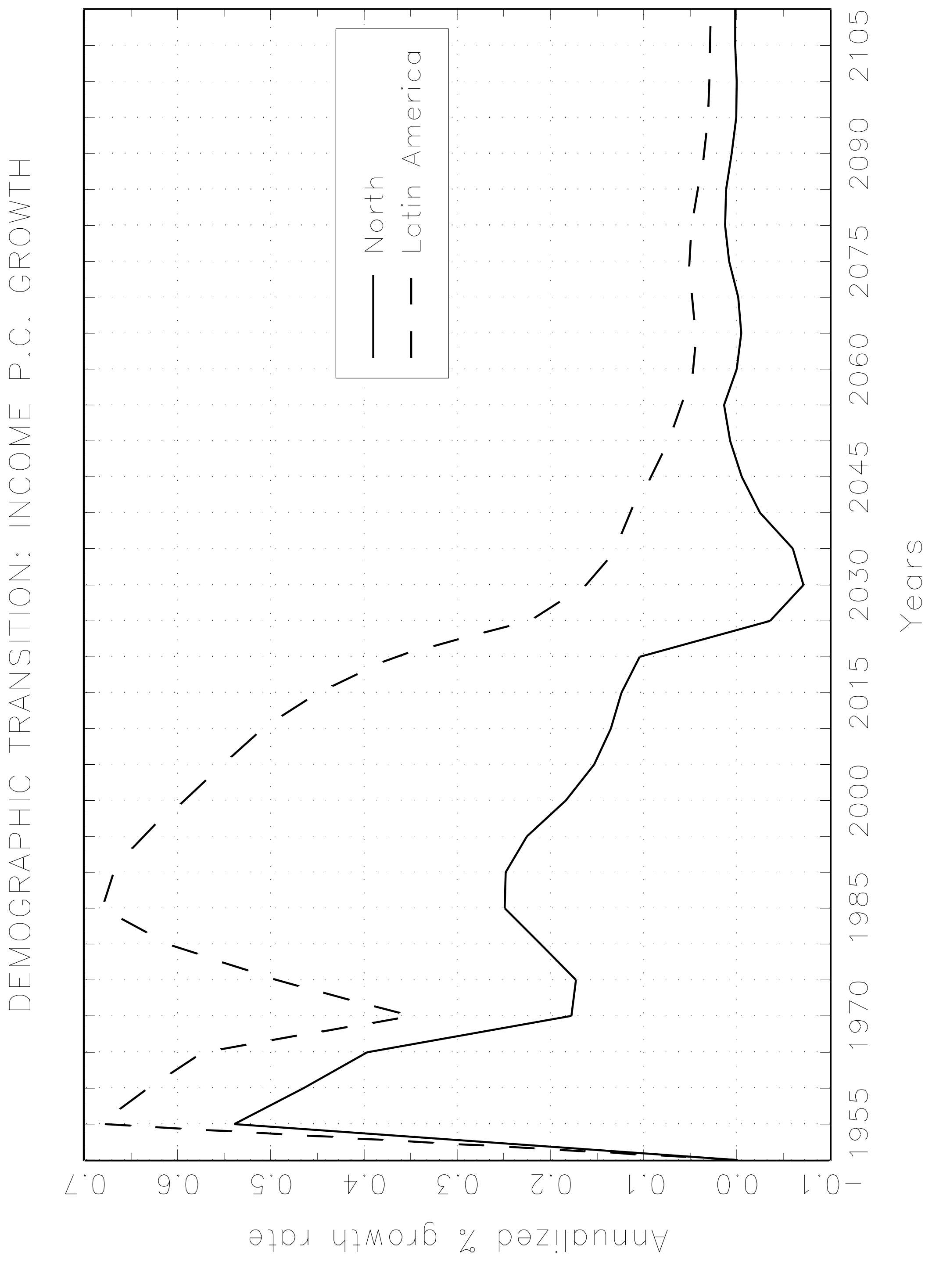

Figure 9: Demographic Transition: Income per capita Growth

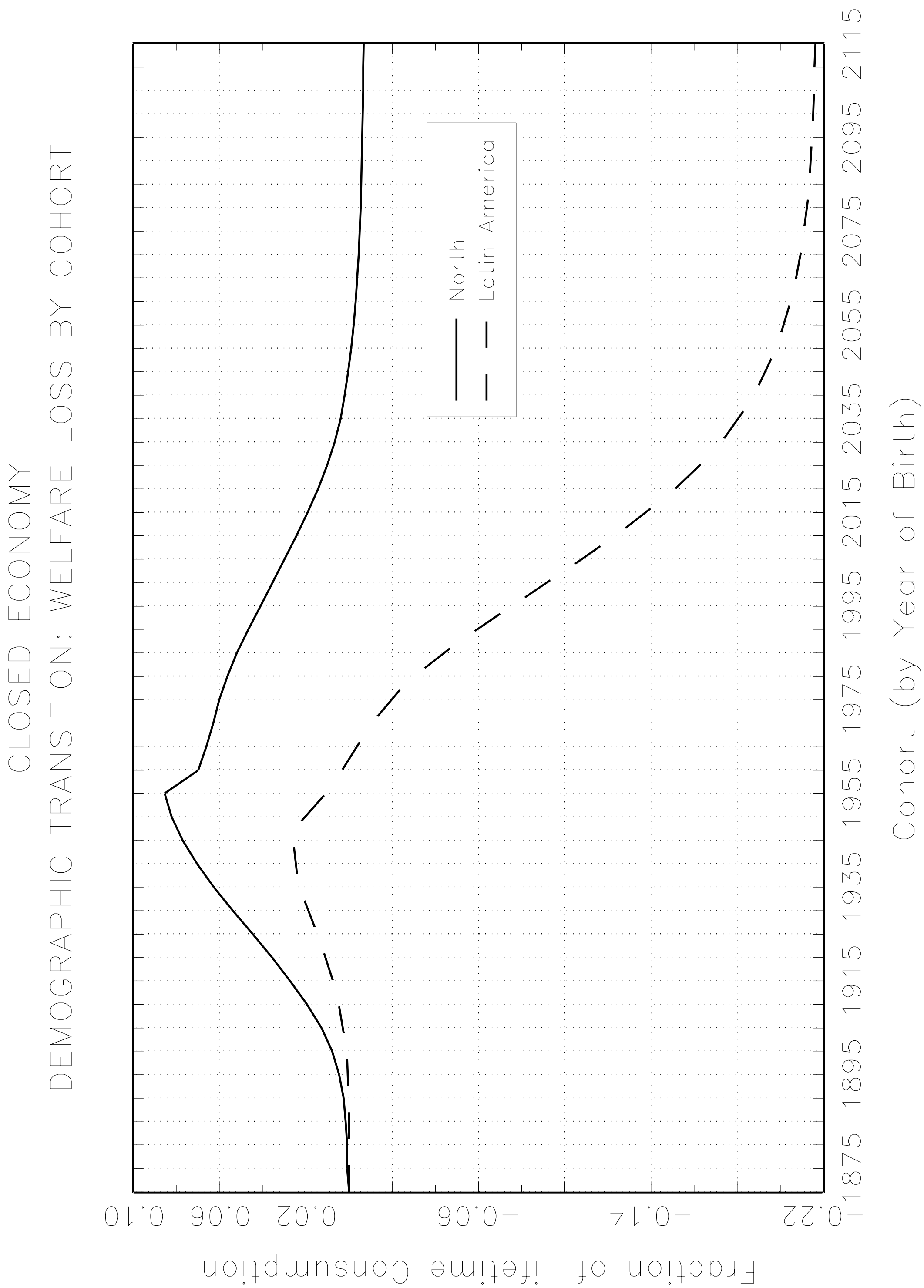

Figure 10: Demographic Transition: Welfare Analysis by Cohort

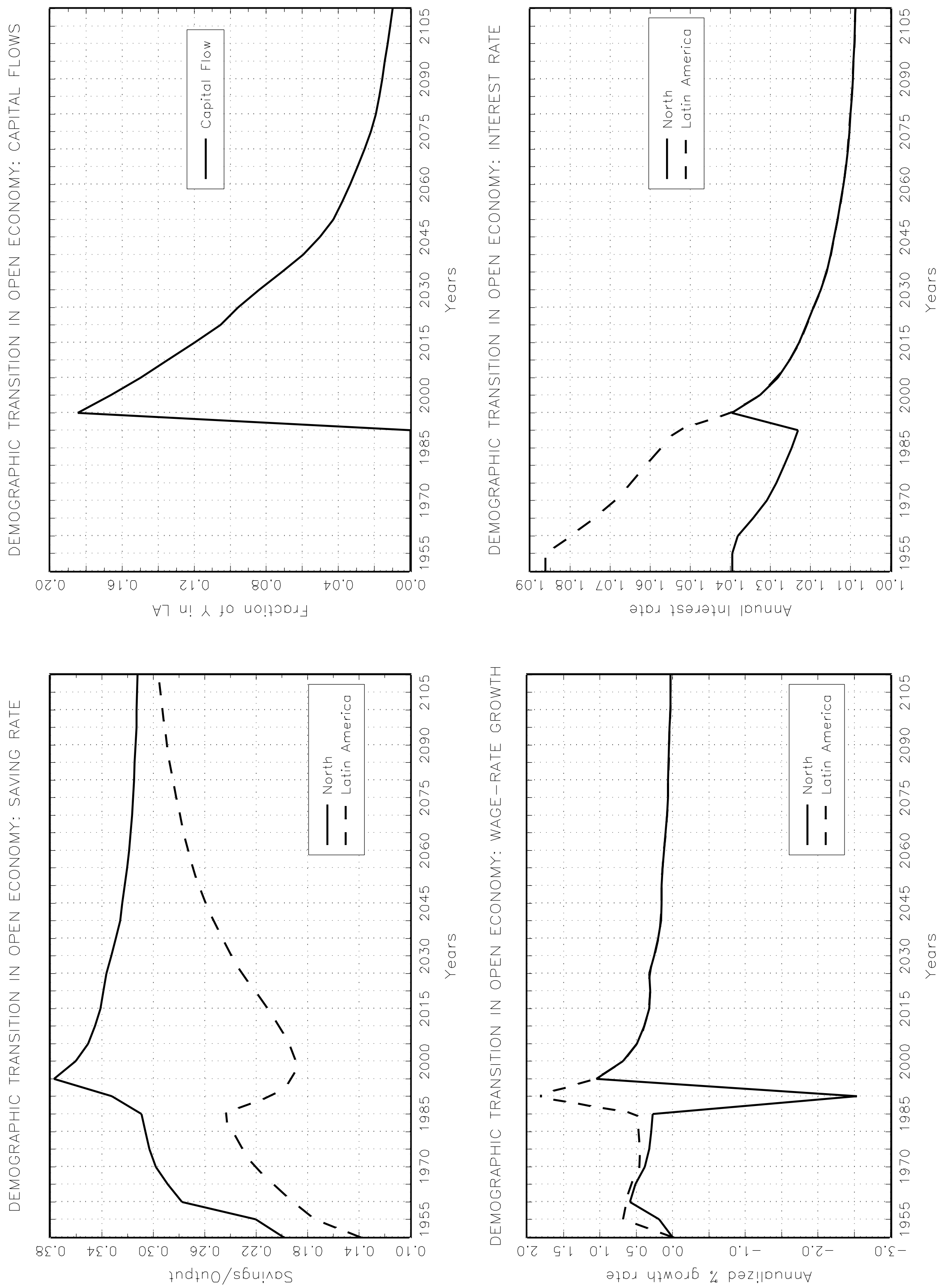

Figure 11: Open Economy Transition: Macroeconomic Variables

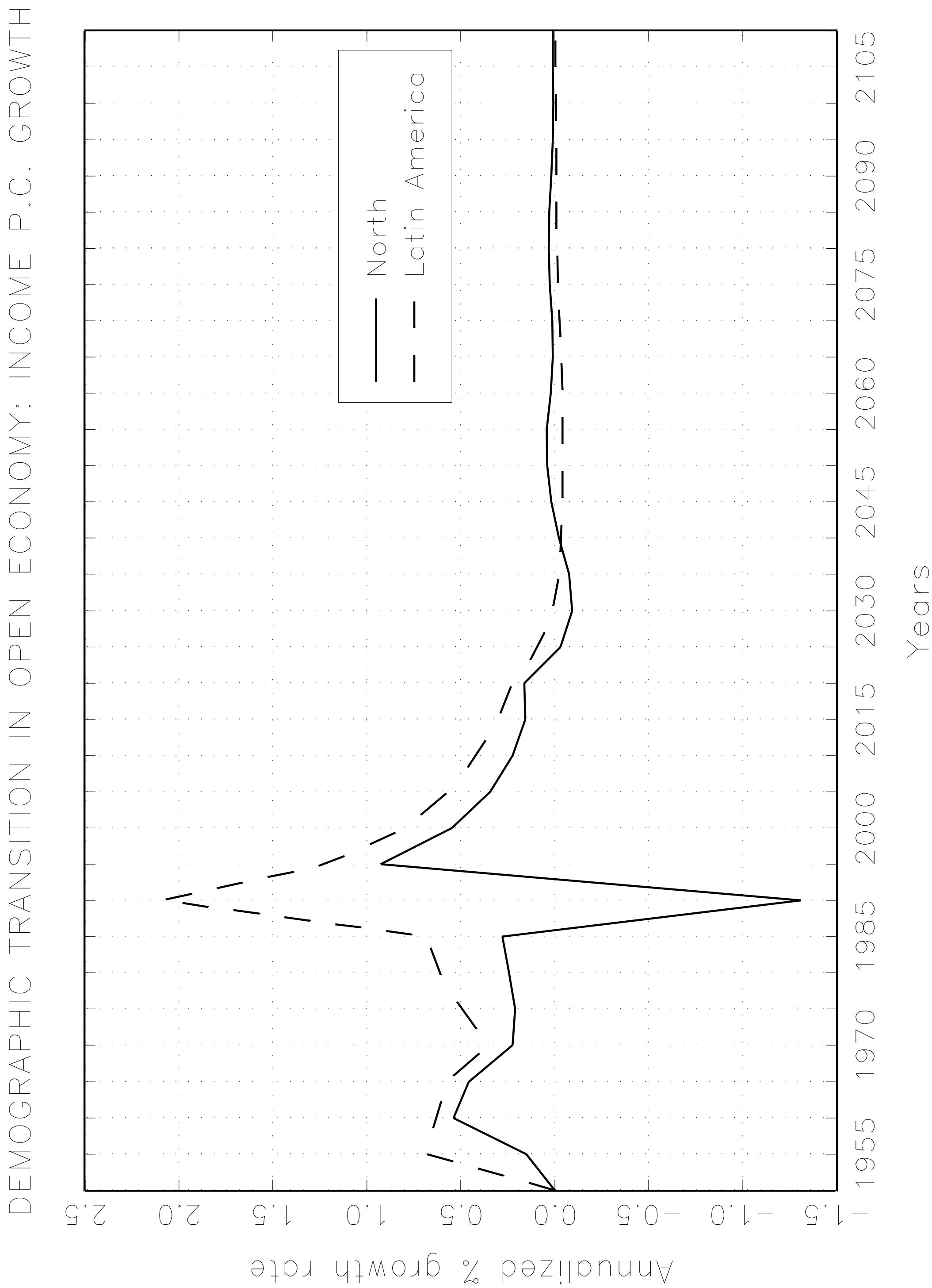

Figure 12: Income per capita Growth in Latin America

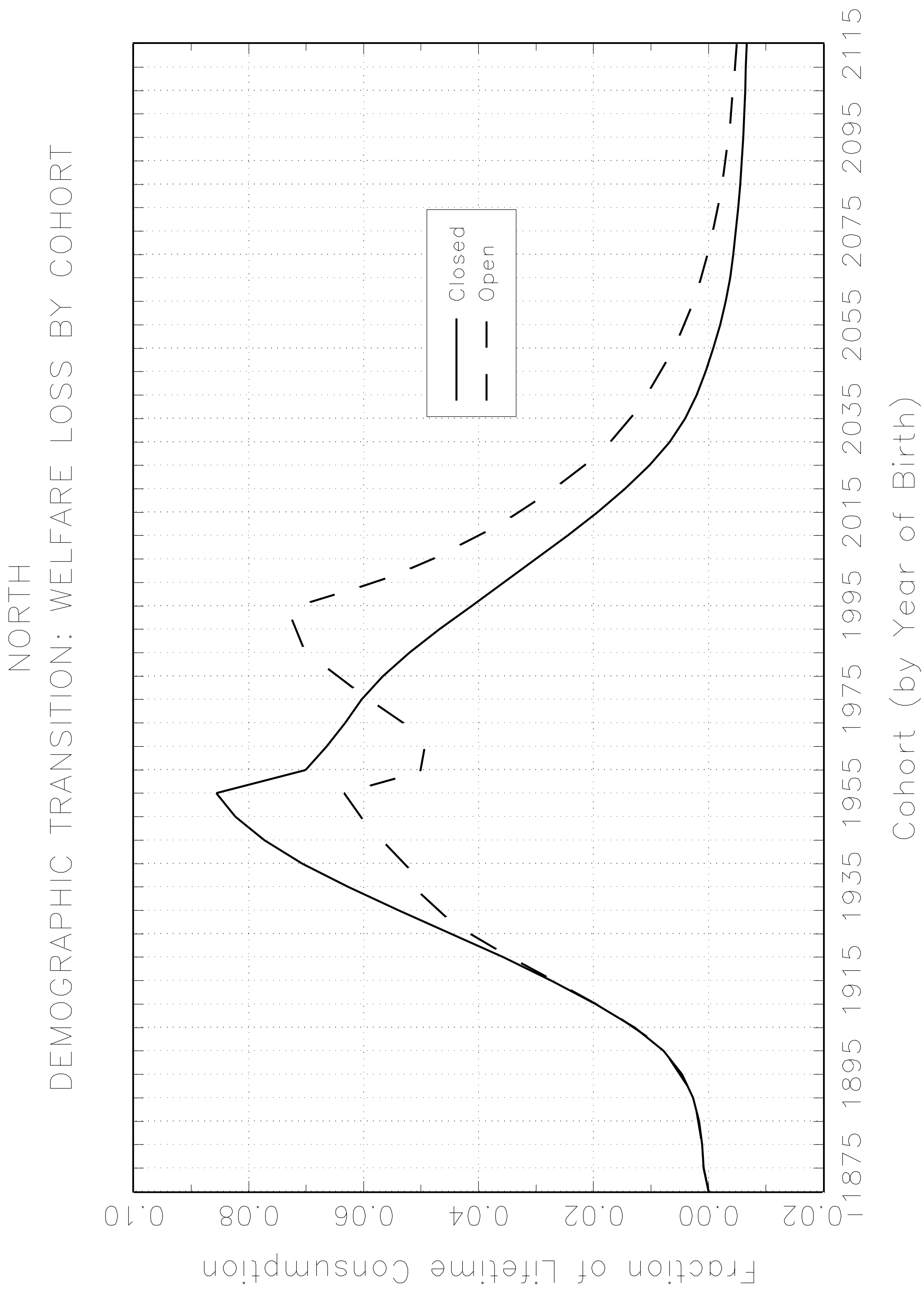

Figure 13: Welfare Analysis by Cohort in the North

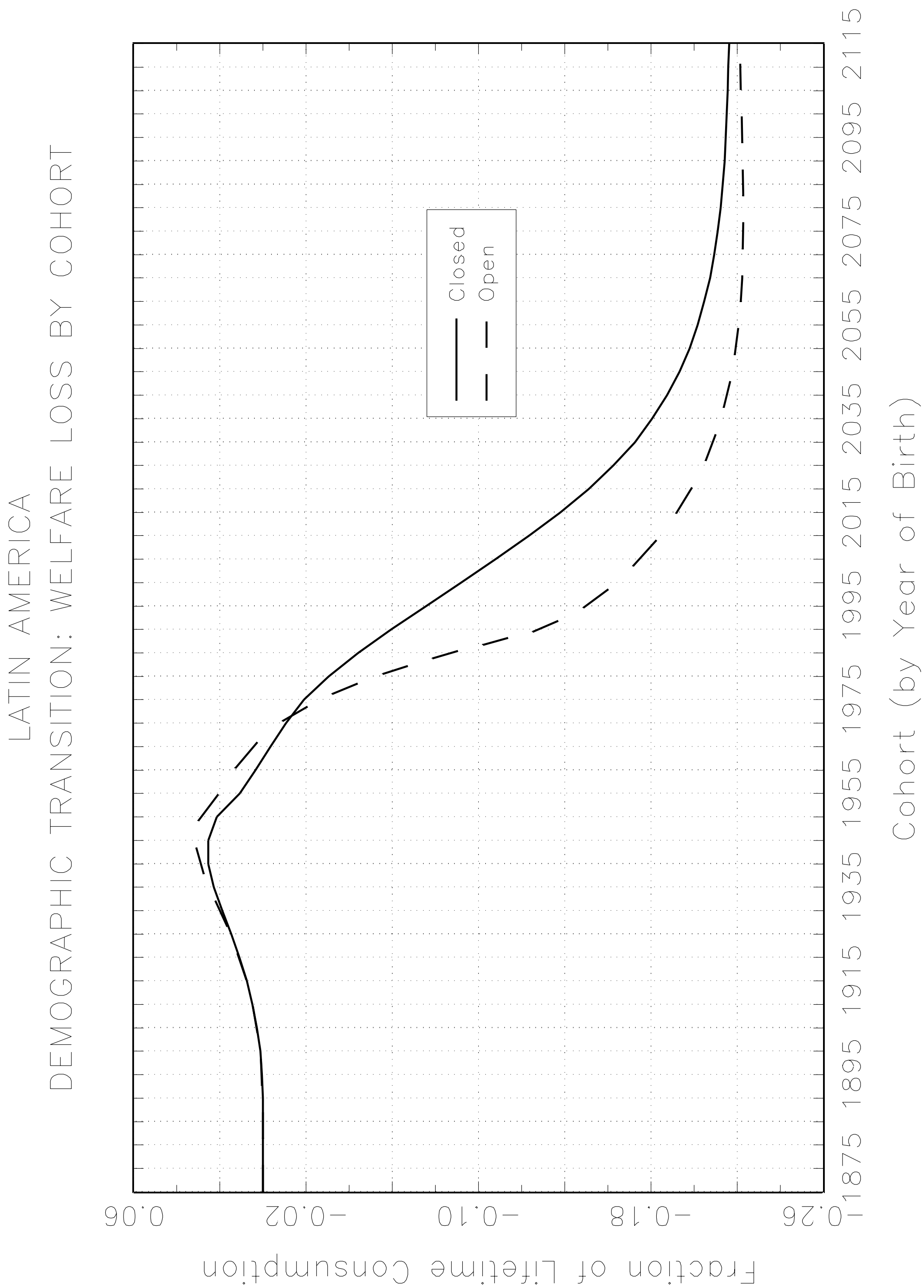

Figure 14: Welfare Analysis by Cohort in Latin America