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AGING, INTERNATIONAL CAPITAL FLOWS AND LONG-RUN CONVERGENCE

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Abstract

This paper analyses how the economic, demographic and institutional differences between two regions -one developed and called the North, the other emerging and called the South- drive the international capital flows and explain the world economic equilibrium. To this end, we develop a simple two-period OLG model. We compare closed-economy and open-economy equilibria. We consider that openness facilitates convergence of South's characterics towards North's. We examine successively the consequences of a technological catching-up, a demographic transition and an institutional convergence of pension schemes. We determine the analytical solution of the dynamics of the world interest rate and deduce the evolution of the current accounts. These analytical results are completed by numerical simulations. They show that the technological catching-up alone leads to a welfare loss for the North in reason of capital flows towards the South. If we add to this first change a demographic transition, the capital demand is reduced in the South whereas its saving increases in reason of a higher life expectancy. These two effects contribute to reduce the capital flows from the North to the South. Finally, an institutional convergence of the two pension schemes reduces the South's saving rate which increases the capital flow from the North to the South. Keywords: International capital flows, OLG, economic convergence, demographic transition. JEL codes: D91, F40, J10, O33.

Introduction

In all regions of the world, population is aging, but at different paces, and according to the United Nations (2013) demographic projections, this phenomenon should go on until after the end of the century. This generalized but unequal aging process is occurring in a world of increasing capital mobility and technological transfers, which can offer new opportunities for trade between regions. Moreover, this aging process increases the demographic dependency putting the unfunded pension schemes under pressure in developed countries, which in turn induces countries to change their rules of sharing of resources between generations, which infers on the individual choices of savings. Conversely, in the emerging countries, the unequal sharing of growth benefits and a longer life expectancy could encourage governments to settle or improve unfunded pension schemes and smooth the differences in welfare across generations. How in a globalized economy these antagonistic problematics resolve?

The purpose of this paper is to investigate how the demographic and economic differences between countries and their changes, notably their reduction resulting from realistic convergence process, affect the world market equilibrium, and how each domestic characteristic explains the internal equilibrium. This issue has been partly addressed in applied versions of multi-regional and multi-period OLG model (Aglietta et al., 2002 and 2007; Börsch-Supan et al., 2002; Fehr et al., 2003 and 2005; Attanazio et al., 2007; Marchiori, 2011; Coeurdacier et al., 2015). However, in such "big" computational models, it is not easy a task to disentangle the role of the different factors.

For the sake of clarity, in this paper, we then develop a two-country two-period OLG model of the world economy where a strong heterogeneity is assumed among the countries. This heterogeneity focuses on the demographic, economic and institutional characteristics. Also, we suppose that each region has specific levels of demographic growth, life expectancy, Social Security size and total factors productivity. The analytical approach adopted in the paper allows to detail the weight of the various components of world economic growth. The world economy is divided into two regions: one developed and called the North, the other emerging and called the South. We compare closed with open economies in a two-region framework. We characterize the analytical solution of the dynamics of the world interest rate. Everything else being equal, when financial markets open, we show that capital flights from the North to South and that, due to the demographic expansion of the South, South's economic and social patterns determine the new world equilibrium in the long run. However, as mentioned above, it is very unlikely that the South will not experience a demographic transition, a technological catching-up and a development of its pension schemes. In this perspective, we then propose numerical simulations based on a calibration that mimics the North-South differences. Our results show that the technological catching-up alone leads to a welfare loss for the North in reason of additional capital flows towards the South. If we add to this first change a demographic transition, the capital demand is reduced in the South whereas its saving increases in reason of a higher life expectancy. These two effects contribute to reduce the capital flows from the North to the South. Finally, an institutional convergence of the two pension schemes reduces the South's saving rate which increases the capital flow from the North to the South.

Two-country two-period OLG theoretical models of the world economy, represented as a closed system, have first been proposed by Fried (1980) and Buiter (1981). Eaton (1987), Obstfeld and Rogoff (1996) also used two-country OLG models to study trade and related issues. Eaton (1987) studies the international trade in a context of specific factors. The two-sector OLG model developed by Galor (1992) was extended to a two-country framework by Galor and Lin (1994), Mountford (1998), Guilló (2001), Jelassi and Sayan (2004), S. Sayan (2005), Naito and Zhao (2009), Song et al. (2011) and Yakita (2012). These studies focus mainly on the consequences of the economic openness on the sectorial specialization and on welfare considerations. Some of these studies have investigated the demographic issues but none coped explicitly with the technological differences in the process of catching-up.

In one-sector models, Adema et al. (2008), Eugeni (2015) and Bárány et al. (2015) introduce Social Security. Adema et al. (2008) conclude "a country using a funded pension system experiences negative spillovers from the fact that the other country uses a pay-as-you-go system". Eugeni (2015) adresses the global imbalance issue. She explains the "saving behavior of emerging economies and capital outflows to the United States can be attributed to their poor pay-as-you-go systems". In her setting, there is no demographic transition. By contrast, in Bárány et al. (2015), the Social Security parameters adapt with demographic transition inducing an increase in contribution rates but a decrease (or at least no increase) in the replacement rate, meaning less generous pensions. In the long run, economic and social development makes the persistance of the lack of pension generosity in the South unlikely. In this perspective, we assert, as suggested by findings of Clements et al. (2011), that it is strongly relevant to deal with the issue of Social Security convergence in the emerging countries. Note that part of this literature has focused on global imbalances induced by differences in time preference (Aglietta et al, 2002 and 2007), in public expenditure (Eugeni, 2015) or in financial rigidities (Song et al., 2011; Coeurdacier et al., 2015). However, in this paper, we focus only in long run convergence by assuming that the worldwide financial market is fully integrated as soon as openness occurs. Moreover, we consider only regional private transfers, setting aside foreign transactions and public debts. Taking into account these two assumptions, as empirically shown by Reinhardt et al. (2013) and by Alfaro et al. (2014), the Lucas (1990) paradox disappears and the neoclassical framework proprieties apply.

The paper is organized as follows. Section 1 presents some data illustrating past and forthcoming trends about catching-up, aging and institutional convergence. Section 2 presents the model and the proprieties of the equilibrium in closed economy. Section 3 compares the equilibrium in open economy with the previous one. Section 4 investigates three types of convergence. First, we examine a technological catching-up process. Then, we suppose this process is completed by a demographic transition. Finally, institutional convergence in the pension scheme is added. Last section concludes.

1 Demographics, Economics and Social Security: Global Trends

The UN forecasts (table 1) show that the length of life expectancy at birth has increased, between 1960 and 2010, by 9 years in the North and 21 years in the South, dramatically crushing the North-South gap from 24 to 8 years. This trend illustrates a long run convergence process which is linked to economic growth (Aghion et al, 2010). Moreover, in the same period, the current fertility rate in the South lies just below that prevailing in the North in 1960, reducing the gap from 3 to 0.9. The microeconomic (Becker, 1991) and microdemographic (Caldwell, 1976) rationale for the average number of children per family focuses on the quality-quantity tradeoff. In this theoretical framework, the economic growth improves standards of living, putting pressure on the fertility rate by favouring quality over quantity. As to the resulting population growth, it has been strongly reduced (divided by 3.4) in the North but it stays at a positive rate because the lengthening of life expectancy has largely offset an insufficient fertility rate (1.64 instead of 2.1 for maintaining the 1:1 ratio between generations). In the South, the population growth has significantly reduced but it stays at a higher rate than the one observed in the North in 1960. Between 1960 and 2010, the share of the North in the world population has been roughly divided by two. In the future, if the South population growth rate does not converge towards that of the North, i.e. zero (if a stable population is assumed), the relation between economic growth and demographic evolution will be only explained by South characteristics.

	years	1950	1980	2010	2040	2070	2100
Life expectancy at birth	North	64.7	72.8	76.9	82.2	86	88.9
	South	41.6	60	67	73.9	78.1	80.8
	South (% of North)	64.4	82.3	87.1	90	90.8	90.9
Total fertility (children per woman)	North	2.83	1.84	1.66	1.85	1.91	1.93
	South	6.08	4.18	2.69	2.32	2.12	1.99
	South (% of North)	215	227	162	126	111	103
Annual population growth (%)	North	1.2	0.6	0.3	0.02	-0.03	-0.05
	South	2.06	2.15	1.33	0.68	0.3	0.13
	S-N	0.85	1.55	1.03	0.66	0.33	0.18

Table 1. Demographic transition (United Nations, 2013)

These demographic changes in both South and North took place along with an impressive economic growth. Since 1960, the GDP per capita has more than tripled in the North and increased fivefold in the South (Wang et al., 2011). The per capita wealth in the South has increased by about 50%, highlighting a fast technological catching-up. Considering as Wang et al. (2011) that this process will go on, the forecast South's GDP per capita is 25% of North's in 2040 against 12.7 in the 2000s (Table 2).

years	1980s	1990s	2000s	2010	2020	2030	2040[1]
North (average annual change, %)	2.3	1.6	0.6	NA	NA	NA	NA
South (level, % of North)	9.5	10.1	12.7	15.6	19.2	23.8	25

Table 2. GDP per capita: evolution and convergence (2005 PPP USD; source: OECD, Wang et al., 2011, based on World Development Indicators of the World Bank).

In the South, economic development and demographic transition are likely to modify the share of income between young and old. Otherwise, elderly people would benefit less from growth than young people. As can be seen in Table 3 based on Clements et al. (2011), the Social Security will continue to expand in the South with the catching-up and aging process. Therefore, the South's pension scheme size is expected to reach 82% of North's in 2050 against 51% in 2010.

years	1960	1980	2010	2020	2030	2040	2050
North	3.9	6.9	8.2	8.5	9.3	9.9	10
South	1.1	2.7	4.2	4.9	6.1	7.1	8.2
South (% of North)	28	39	51	58	66	72	82

Table 3. Public pension expenditures (% of GDP), (source: Clements et al, 2011 based on data from OECD, EC, ILO and IMF)

These convergence processes are concomitant and these changes will impact the net savings needs of each region. In a financially globalized world, identifying how each of these dynamics congervence contributes to global capital allocation is central. To this effect, we propose in the following a structural model of the world economy.

2 The Model

The world is divided into 2 regions, one developed and called the North, the other emerging and called the South. Each region hosts three categories of economic agents: the households, the firms, and a public sector.

[1]Following Wang et al. (2011), we forecast the year 2040 by assuming all gaps continue to narrow at the same average speed as between 1990 and 2010.

Households are composed of two adults of the same generation. Their life spans over two periods. In the first period, each household works, consumes, saves and does not value leisure. The second period breaks into two subperiods. The first subperiod is dedicated to work and consumption while the second subperiod is retirement time when they consume their savings and their pension income. Households are supposed to maximize life-cycle utility. Their savings are invested into one financial asset, which is an ownership title in the firms' productive capital.

The productive sector is modeled as a set of perfectly competitive firms which produce a single good relying on a technology combining capital and labor. It can be consumed or invested. At the optimum of production, the factors of production are remunerated at their marginal productivity. The good and the financial assets are freely traded on perfectly competitive markets.

The public sector is reduced to an unfunded pension scheme which finances pension benefits of retired people by taxing earnings of contemporaneous workers.

2.1 Households

Each household lives for two periods respectively denoted "young" and "old". At each period t and for a given region i, growth in the number of young is characterized by:

$$\frac{N_{i,t}}{N_{i,t-1}} = G_{i,t} \tag{1}$$

where $N_{i,t}$ denotes the corresponding number of young people in t. Besides, old people live only a fraction of the second period (life expectancy) denoted $\rho_{i,t+1}$. Note that, in order to avoid the annuity puzzle, we have modeled without loss of generality the length of life as a deterministic process.

When young in t, they work, consume and save income for the second period of their life. In addition, they contribute to a PAYG retirement system. Their first period budget constraint is then:

$$C_{i,t} + S_{i,t} = (1 - \tau_{i,t}) \cdot w_{i,t} \tag{2}$$

where $C_{i,t}$ denotes consumption when young, $S_{i,t}$ the savings, $w_{i,t}$ the wage and $\tau_{i,t}$ the contribution rate.

When old in $t+1$, they go on working a fraction $l_{i,t+1}$ of their second life period (mandatory length of work and/or legal age of retirement) and they consume all their income which corresponds to their savings with interest, their net wage during the period they work and their due pension for the rest of their life. The second period budget constraint is then:

$$\rho_{i,t+1} \cdot Z_{i,t+1} = (1-\tau_{i,t+1}) \cdot w_{i,t+1} \cdot l_{i,t+1} + R_{i,t+1} \cdot S_{i,t} + \left(\rho_{i,t+1} - l_{i,t+1}\right) \cdot P_{i,t+1} \qquad (3)$$

where $Z_{i,t+1}$ denotes the consumption when old in $t+1$, $R_{i,t+1}$ the interest factor, $P_{i,t+1}$ the pension and $l_{i,t+1} \leq \rho_{i,t+1}$.

Young individuals in t are characterized by the following lifetime utility function:

$$\ln C_{i,t} + \beta \cdot \rho_{i,t+1} \cdot \ln Z_{i,t+1} \qquad (4)$$

where $\beta < 1$ denotes the discount factor.
Let us consider:

$$\Omega_{i,t} = (1-\tau_{i,t}) \cdot w_{i,t} + (1-\tau_{i,t+1}) \cdot l_{i,t+1} \cdot \tfrac{w_{i,t+1}}{R_{i,t+1}} + \left(\rho_{i,t+1} - l_{i,t+1}\right) \cdot \tfrac{P_{i,t+1}}{R_{t+1}} \qquad (5)$$

the lifetime income of young. Their consumption obtained by maximizing utility (4) under constraints (2) and (3) is then characterized by $C_t = \frac{\Omega_{i,t}}{1+\beta \cdot \rho_{i,t+1}}$. It yields according to eq. (5) that savings can be expressed as:

$$\begin{aligned} S_{i,t} &= (1-\tau_{i,t}) \cdot w_{i,t} - \tfrac{\Omega_{i,t}}{1+\beta \cdot \rho_{i,t+1}} \qquad (6) \\ &= s_{i,t} \cdot (1-\tau_{i,t}) \cdot w_{i,t} - (1-s_{i,t}) \cdot \tfrac{(1-\tau_{i,t+1}) \cdot l_{i,t+1} \cdot w_{i,t+1} + \left(\rho_{i,t+1} - l_{i,t+1}\right) \cdot P_{i,t+1}}{R_{i,t+1}} \end{aligned}$$

where $s_{i,t} = \frac{\beta \cdot \rho_{i,t+1}}{1+\beta \cdot \rho_{i,t+1}}$ denotes the marginal propensity to save the current income and $(1-s_{i,t})$ the marginal propensity to consume the future income. Note that marginal propensity to save is an increasing function of life expectancy and interest rate.

2.2 PAYG retirement system

Assuming that the budget of the retirement system is balanced at each period, it follows that:

$$(N_{i,t} + N_{i,t-1} \cdot l_{i,t}) \cdot \tau_{i,t} \cdot w_{i,t} = \left(\rho_{i,t} - l_{i,t}\right) \cdot N_{i,t-1} \cdot P_{i,t}.$$

When considering the population evolution process characterized by eq. (1) and Social Security's balanced budget, the pension is defined as:

$$P_{i,t} = \theta_{i,t} \cdot w_{i,t}. \tag{7}$$

where $\theta_{i,t} = \frac{G_{i,t}+l_{i,t}}{\rho_{i,t}-l_{i,t}} \cdot \tau_{i,t}$ is the replacement rate.

2.3 Firms

There is a single homogenous good in the world produced by firms in each region according to a Cobb-Douglas technology $Y_{i,t} = A_{i,t} \cdot K_{i,t}^{\alpha} \cdot L_{i,t}^{1-\alpha}$, where $Y_{i,t}$ denotes the output, $A_{i,t}$ the total factor productivity (TFP), $K_{i,t}$ the capital stock and $L_{i,t}$ the labor. Assuming total depletion of capital over the period and perfectly competitive production sector, profit maximisation yields:

$$w_{i,t} = A_{i,t} \cdot (1-\alpha) \cdot k_{i,t}^{\alpha} \tag{8}$$

$$R_{i,t} = A_{i,t} \cdot \alpha \cdot k_{i,t}^{\alpha-1} \tag{9}$$

where $k_{i,t} = \frac{K_{i,t}}{L_{i,t}}$ denotes capital per worker.

2.4 Closed-economy equilibrium

Considering closed economies, in each region and at each period, labor markets must clear at equilibrium:

$$L_{i,t} = N_{i,t} + N_{i,t-1} \cdot l_{i,t} = (G_{i,t} + l_{i,t}) \cdot N_{i,t}, \forall i, \forall t \tag{10}$$

as also must financial markets:

$$K_{i,t+1} = N_{i,t} \cdot S_{i,t}, \forall i, \forall t. \tag{11}$$

From eqs. (1) and (6) – (11) we can then show that in each region the dynamic general equilibrium is characterized by:

$$R_{i,t+1} = R_{i,t}^{\alpha} \cdot \Phi_{i,t}^{1-\alpha}, \ \forall i \text{ and } \forall t \tag{12}$$

where $\Phi_{i,t} = \left[\frac{\left(1+\hat{A}_{i,t+1}\right) \cdot [\alpha \cdot (G_{i,t+1}+l_{i,t+1})+(1-\alpha)\cdot(1-s_{i,t})\cdot(l_{i,t+1}+G_{i,t+1}\cdot\tau_{i,t+1})]}{(1-\alpha)\cdot s_{i,t}\cdot(1-\tau_{i,t})} \right]$ and $\frac{A_{i,t+1}}{A_{i,t}} = \left(1+\hat{A}_{i,t+1}\right)^{1-\alpha}$.

$\Phi_{i,t}$ captures the regional relative tension between demand (numerator) and supply (denominator) of capital.

At the steady state, we have:

$$R_i = \left(1+\hat{A}_i\right) \cdot \frac{[\alpha \cdot (G_i + l_i) + (1-\alpha) \cdot (1-s_i) \cdot (l_i + G_i \cdot \tau_i)]}{(1-\alpha) \cdot s_i \cdot (1-\tau_i)}, \ \forall i. \tag{13}$$

To calculate the steady state interest rates in the closed economies, let us assume that a period spreads over 30 years. If we assume that individuals enter the job market at 18 and, following demographic features of 2010, we set $\rho_N = 1$ in the North, which corresponds to a 60-year lifespan at age 18 (United Nations, 2013). Thereafter, as life expectancy at age 18 is 55 years in the South, we set $\frac{1+\rho_S}{2} = \frac{55}{60}$, then $\rho_S = 0.83$. From the United Nations (2013), the world population's share of people between age 18 and 47 in the South is 83.47% in 2010. Accordingly, at the initial period, we set $N_{N,0} = 20$ and $N_{S,0} = 101$. Fixing from the beginning a stable population in the North implies $G_N = 1$ and its size is then always equal to $2 \cdot N_{N,0}$. Conversely, the number of living people in the South depends on the demographic transition and, at any date t, evolves as follows:

$$N_{S,t} + \rho_{S,t} \cdot N_{S,t-1} = N_{S,t} \cdot \left(1 + \frac{\rho_{S,t}}{G_{S,t}}\right). \tag{14}$$

Finally, to complete the mimicking of the structure of the world population in 2010, we set $G_{S,0}$ such that $\frac{101\cdot\left(1+\frac{0.83}{G_{S,0}}\right)}{101\cdot\left(1+\frac{0.83}{G_{S,0}}\right)+2\cdot 20} = 78.94\%$, and then $G_{S,0} = 1.715$.

Besides the demographic factors, we assume an annual discount time factor equal to 0.98, so that $\beta = 0.98^{30} \approx 0.55$. As usual we set the capital's share in output to $\alpha = 0.3$. We then consider the Social Security expenditures towards elderly in 2010. Following Table 3, in the North they amount to 8.2% of GDP, i.e. $\frac{8.2}{1-\alpha}$% of the wage bill: $\tau_{N,0} = 11.7\%$. In the South, they amount to 4.2% of GDP. Accordingly, $\tau_{S,0} = 6\%$. We consider the legal retirement age equal to 65 years both in the North and in the South, implying $l_N = l_S = \frac{17}{30} = 0.57$.

In case there is no technological innovation in the North and no technological convergence of the South with the North, the interest factor is equal to 3.56 in the North and 4.89 in the South, which corresponds respectively to an annual rate of 4.3% and 5.4%.

	α	β	ρ	G	N_0	τ (%)	l	$\hat{A}$
North (N)	0.3	0.55	1	1	20	11.7	0.57	0
South (S)	0.3	0.55	0.83	1.715	101	6	0.57	0

Table 3. Calibration parameters

Considering this calibration with stationary technology ($\hat{A} = 0$), both North and South's computed interest rates are higher than the economic growth rate, reflecting dynamic efficiency. This is obvious for the North. As we consider no technological growth and no population growth, the economic growth is nil. As for the South, it has no technological growth, but its population is growing. On a steady state basis, the economic growth is then equal to the population growth, $\frac{Y_S}{Y_{S,-1}} - 1 = 1.715\%$, which is lower than the interest rate: $r_{S,annual} = 5.4\% > g_{S,annual} = 1.8\%$. As we will see, this feature is central to analyse the impact of openness on both economies.

3 Openness and globalized finance

We now contemplate a financial globalized economy. The good and the financial asset are freely traded on perfectly competitive world markets. There are no money and no non-tradable local good. The PPP condition is satisfied. Workers are immobile making both labor markets local. The capital market must clear at each date at equilibrium such as:

$$\sum_i K_{i,t+1} = \sum_i N_{i,t} \cdot S_{i,t}, \forall t. \tag{15}$$

In a two-country world model, this equilibrium condition can be rewritten as a capital flow from the North (excess of savings: $N_{N,t} \cdot S_{N,t} - K_{N,t}$) towards the South to satisfy an excess of capital demand ($K_{S,t} - N_{S,t} \cdot S_{S,t}$):

$$N_{N,t} \cdot S_{N,t} - K_{N,t} = K_{S,t} - N_{S,t} \cdot S_{S,t}, \forall t.$$

From eqs. (1), (6) – (10) and (15), we show that the world dynamic general equilibrium yields an equilibrium world interest rate denoted R_t.

Proposition 1: *At the general equilibrium, the world interest factor can write as a geometric average of the past interest factor and the weighted arithmetic average of the regional tension between demand and supply of capital:*

$$R_{t+1} = R_t^{\alpha} \cdot \Phi_t^{1-\alpha} \tag{16}$$

where $\Phi_t = (\varphi_t \cdot \Phi_{N,t} + (1-\varphi_t) \cdot \Phi_{S,t})\,, \varphi_t = \frac{s_{N,t} \cdot \left(1-\tau_{N,t}\right) \cdot \lambda_{N,t} \cdot A_{N,t}^{\frac{1}{1-\alpha}}}{\sum_i s_{i,t} \cdot (1-\tau_{i,t}) \cdot \lambda_{i,t} \cdot A_{i,t}^{\frac{1}{1-\alpha}}} \in (0,1]$ *and* $\lambda_{i,t} = \frac{N_{i,t}}{\sum_i N_{i,t}}$ *is the share of region* i *in the world young population.*

Φ_t captures the international tension between demand and supply of capital which expresses as a convex combination of the two regional tensions.

Corollary 1: *Starting from closed-economy steady states,* ceteris paribus*, openness yields:*

$$\Phi_t = \varphi_t \cdot R_N + (1-\varphi_t) \cdot R_S \tag{17}$$

where R_N *and* R_S *denote respectively the closed-economy steady-states values of the interest factor in the North and in the South as defined in equation (13). In addition,*

$$R_0 = \left[\xi \cdot R_N^{\frac{1}{\alpha-1}} + (1-\xi) \cdot R_S^{\frac{1}{\alpha-1}}\right]^{\alpha-1} \tag{18}$$

where $\xi = \frac{(1+l_N) \cdot \lambda_{N,0}}{(1+l_N) \cdot \lambda_{N,0} + (G_S + l_S) \cdot \left(1-\lambda_{N,0}\right) \cdot A_{S,0}^{\frac{1}{1-\alpha}}} \in [0,1]$*,* $A_{N,0} = 1$ *and* $A_{S,0} \leq A_N$*. The dynamics of the world interest rate is then monotonous and such that* $R_t \in [R_N, R_S]\,, \forall t \geq 0$.

If variables in the model are fixed, i.e. $x_{i,t} = x_i \ \forall t$, where $x = G, l, s, \tau, A$, this dynamics rewrites as follows:

$$R_{t+1} = R_t^{\alpha} \cdot [\varphi_t \cdot R_N + (1-\varphi_t) \cdot R_S]^{1-\alpha} \tag{19}$$

As population is growing in the South while the North has already achieved its demographic transition characterized by a stable population, the limit case checks: $\lim_{t \to +\infty} \lambda_{N,t} = 0$ and $\lim_{t \to +\infty} \varphi_t = 0$.

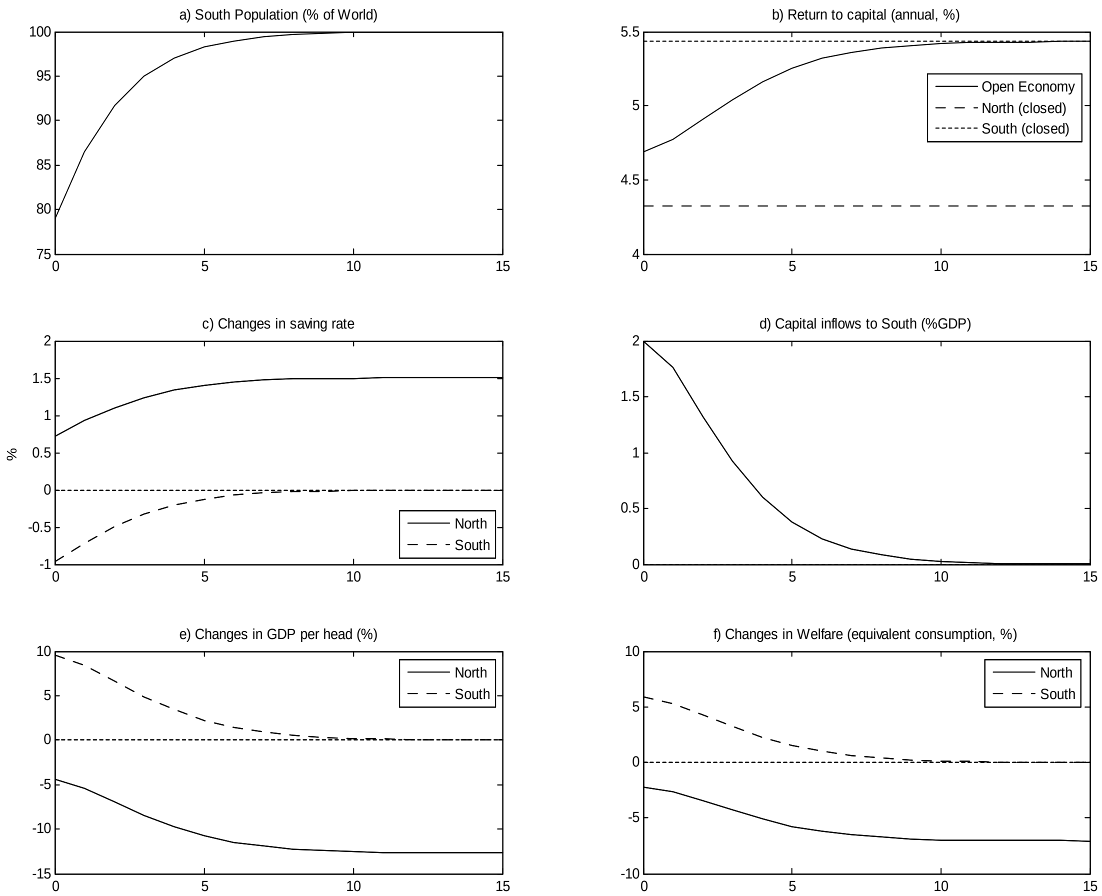

Figure 1: Openness without convergence (changes wrt the closed economy steady states)

To complete the calibration of the model with globalized finance, consider, to characterize the wealth gap, the relative GDP per capita in the South as compared to the North denoted Γ_t:

$$\Gamma_t = \frac{\frac{Y_{S,t}}{Pop_{S,t}}}{\frac{Y_{N,t}}{Pop_N}} = \frac{A_{S,t}}{A_N} \frac{1+\frac{l_S}{G_{s,t}}}{1+l_N} \frac{1+\rho_N}{1+\frac{\rho_{S,t}}{G_{S,t}}} \tag{20}$$

An increase in Γ_t corresponds to a reduction of the wealth gap. Note that this ratio is independent of the pension contribution rates because their impact on savings has an impact on the global capital accumulation and not its sharing. At the initial period, $\Gamma_0 = \frac{A_{S,0}}{A_N} \frac{1+\frac{l_S}{G_{s,0}}}{1+l_N} \frac{1+\rho_N}{1+\frac{\rho_{S,0}}{G_{S,0}}}$, where $A_N = 1$, $l_N = l_S = 0.57$, $\rho_N = 1$, $\rho_S = 0.83$ and $G_S = 1.715$. As shown in Table 2, if considering the entire population, this ratio is equal to 15.6 in 2010. Considering now the population over 18 as in the model, we mark up this number to 16.2, setting the TFP in the South ($A_{S,0}$) to 25.5% of the TFP in the North (A_N).

In autarky, the domestic interest rate in the South is higher than in the North. Therefore, after financial globalization, equalization in regional returns yields capital flows from the North to the South to reach around 2% of South GDP as illustrated in Fig. 1. As a consequence, everything else being equal, the interest rates jump to the same intermediary level equal to 4.7% on an annual basis (Fig. 1b). It increases in the North, and decreases in the South. As both closed economies were dynamically efficient, it follows that the welfare in the South increases whereas it decreases in the North. It is worth noting that the welfare loss in the North could be mitigated by considering H.O. effects. However, as shown by Sayan (2005), the welfare gains from trade appears quite low compared to losses caused by capital flight. To assess the importance of the welfare change and avoid any scale effect, we compute the equivalent consumption $ec_{i,t}$ which is the equivalent constant consumption over life cycle when considering no life expectancy change: $ec_{i,t} = \exp\left(\frac{\ln C_{i,t} + \beta \cdot \rho_{i,t+1} \cdot \ln Z_{i,t+1}}{1+\beta \cdot \rho_{i,0}}\right), \forall t \geq 0$. We then observe on Fig 1f that the equivalent consumption at date 0 increases by 5.8% in the South and decreases by 2.2% in the North. As the share of the South in the world population is growing, if there is no technological growth and no institutional convergence, the world interest rate progressively increases until reaching the South's interest rate before openness. It follows from equation (19) and from our calibration that the world interest factor converges monotonously to the South's when closed: $R_\infty = R_S = 4.89$. Therefore, the positive effect of openness on the South's welfare decreases until reaching zero and the negative effect in the North goes on increasing until stabilizing at -7 percent of equivalent consumption.

However, reasonable doubts can be raised about the relevancy of such a scenario to describe the long term convergence of the world economy for at least three reasons.

Firstly, the world population and especially the South's is unlikely to grow indefinitely. Similarly, as exhibited in the United Nations (2013) projections, we have to consider the South's demographic transition.

Secondly, this scenario exhibits no wealth convergence of the South with the North. From eq. (20), we can check that, if considering that $A_{S,t} = A_S$, $G_{S,t} = G_S$ and $\rho_{S,t} = \rho_S$ $\forall t \geq 0$, the wealth gap is constant over time, $\Delta\Gamma_t = 0$, $\forall t \geq 1$, which yields the following proposition:

Proposition 2: *After openness has occured,* ceteris paribus*, there is no wealth convergence of the South with the North.*

As we can see on Figure 1e, after a first decrease in the gap between the GDP per head in the South and in the North directly due to openness (it increases by 9.6% in the South and decreases by 4.3% in the North), the relative gap stays put: the GDP per head in the South remains at 16.2% of the North's in the long run. Contrasting with this result, studies from Maddison (2008) and Wang et al. (2011) tend however to evidence South's wealth is catching up North's even after financial markets are integrated (see Table 2). The demographic transition is characterized with a decrease in G_S and an increase in ρ_s yields a decrease in the relative wealth of the South with respect to the North . As $\frac{\partial \Gamma_t}{\partial G_S} \geq 0$ and $\frac{\partial \Gamma_t}{\partial \rho_S} \leq 0$, it follows from eq. (20) that after openness, a technological catching-up is required in bridging the wealth gap between the South and the North.

Thirdly, there is no institutional convergence, $\tau_{S,t} = \tau_S, \forall t$. However, the study of Clement et al. (2011) tends again to support an institutional convergence (see Table 3).

In the following, we study the dynamics of the world economy considering the global convergence in its three relevant components: technological, demographic and institutional.

4 Global convergence

Assume now that openness goes with global convergence. If we assume that the North region has already converged to its final pattern of society, a global convergence means that the South region will converge towards the North pattern of society characterized by its technology, its population features (life expectancy and total fertility) and its Social Security here characterized by a PAYG pension scheme. From eq. (16) we can then observe that a global convergence is characterized by the North interest rate:

$$R = \frac{[\alpha \cdot (1 + l_N) + (1 - \alpha) \cdot (1 - s_N) \cdot (l_N + \tau_N)]}{(1 - \alpha) \cdot s_N \cdot (1 - \tau_N)} \tag{21}$$

and, as a consequence, in the long run it has no impact on the North welfare. In order to characterize the transition path from closed economies to fully converged economies, we then need to specifiy the different convergence processes linked to the technology, the demography and the Social Security.

4.1 Convergence speed

To characterize the technological catching-up, the North is assumed to be the technological leader whose economy's growth is stationary. In our calibration, we assumed that the North's TFP is $A_N = 1$, higher than the South's, A_S, when capital markets are opened, such that $\frac{A_{S,0}}{A_N} = 25.5\%$. We now assume that openness permits free technological transfers and, consequently, goes along with a technological catching-up of the South according to the following decreasing return process: $\frac{A_{S,t}}{A_{S,t-1}} = \left(\frac{A_N}{A_{S,t-1}}\right)^{\sigma_A}$ for $t \geq 1$ with $\sigma_A < 1$. Note that σ_A measures the speed of technological convergence. Following this process, the South's TFP converges progressively towards the North's. Similarly, to characterize the demographic transition in the South, we assume that both its mortality rate and its fertility converge towards those of the North which has already achieved its transition. Here, $G_{S,t}$ corresponds to half the fertility rate divided by two because each household is assumed to be composed of two parents, and $1 + \rho_{S,t}$ is the life expectancy (at 18). The increase in the South's life expectancy is then described by $\frac{\rho_{S,t}}{\rho_{S,t-1}} = \rho_{S,t-1}^{\sigma_\rho}$ and the decrease in its fertility rate evolves as follows: $\frac{G_{S,t}}{G_{S,t-1}} = G_{S,t-1}^{\sigma_G}$ for $t \geq 1$, σ_ρ and σ_G denoting respectively the convergence speed of life expectancy and fertility. Finally, we assume that the contribution rate converges to the North's and its dynamics is described by $\frac{\tau_{S,t}}{\tau_{S,t-1}} = \left(\frac{\tau_N}{\tau_{S,t-1}}\right)^{\sigma_\tau}$ with σ_τ denoting the speed of institutional convergence.

Starting at date $t = 0$, we first set $\sigma_G = 0.47$ to account for the world population's share of people between age 18 and 47 in the South as forecast by the United Nations (2013) up to 2100 (see Table 4). It will stabilize at 90.3%. We then set $\sigma_\rho = 0.01$ to account for the world population's share of people over 18 in the South. As it is obvious when considering stable populations, it will also stabilize at 90.3%. As already exhibited in Table 1, the demographic transition that mimics the UN population forecast is mainly characterized by fertility transition.

Years		2010 ($t = 0$)	2040 ($t = 1$)	2070 ($t = 2$)	2100 ($t = 3$)
World population's share of people aged between 18 and 47 in the South	model	83.5	87.1	88.7	89.4
	UN data	83.5	87.6	88.7	89.4
World population's share of people over 18 in the South	model	78.9	84.5	87.0	88.2
	UN data	78.9	84.2	86.7	87.8

Table 4. Calibration of the demographic transition

Afterward, following eq. (20), we calibrate the speed of technological convergence σ_A such that the relative GDP per capita in the South with respect to the North reaches 25.5% on the basis of the population over 18 (which corresponds to 25% as in Table 2 with the entire population). It gives $\sigma_A = 0.242$. Finally, the speed of institutional convergence is set to $\sigma_\tau = 0.5$ such that in 2040 the public pension expenditures in the South amount to 72% of the North's, as suggested in Table 3. This way, we obtain a transition path from closed economies towards fully open and converged economies. However, as this transition path results from the interaction of four distinct convergence processes, we assume a fictional convergence pattern such that the technological catching-up goes first, the demographic transition goes second and the institutional convergence goes third. Indeed, openness is first a sharing of ideas and knowledge bringing the South a technological catching-up through trade. Second, the technological catching-up allows a reduction in mortality rates through medecine improvement. It leads also to a reduction of the fertility which, along with the mortality reduction, characterizes the demographic transition. Finally, through urbanization and social pressure, social protection follows. By doing so, we can decompose the transition pattern starting from the technological catching-up.

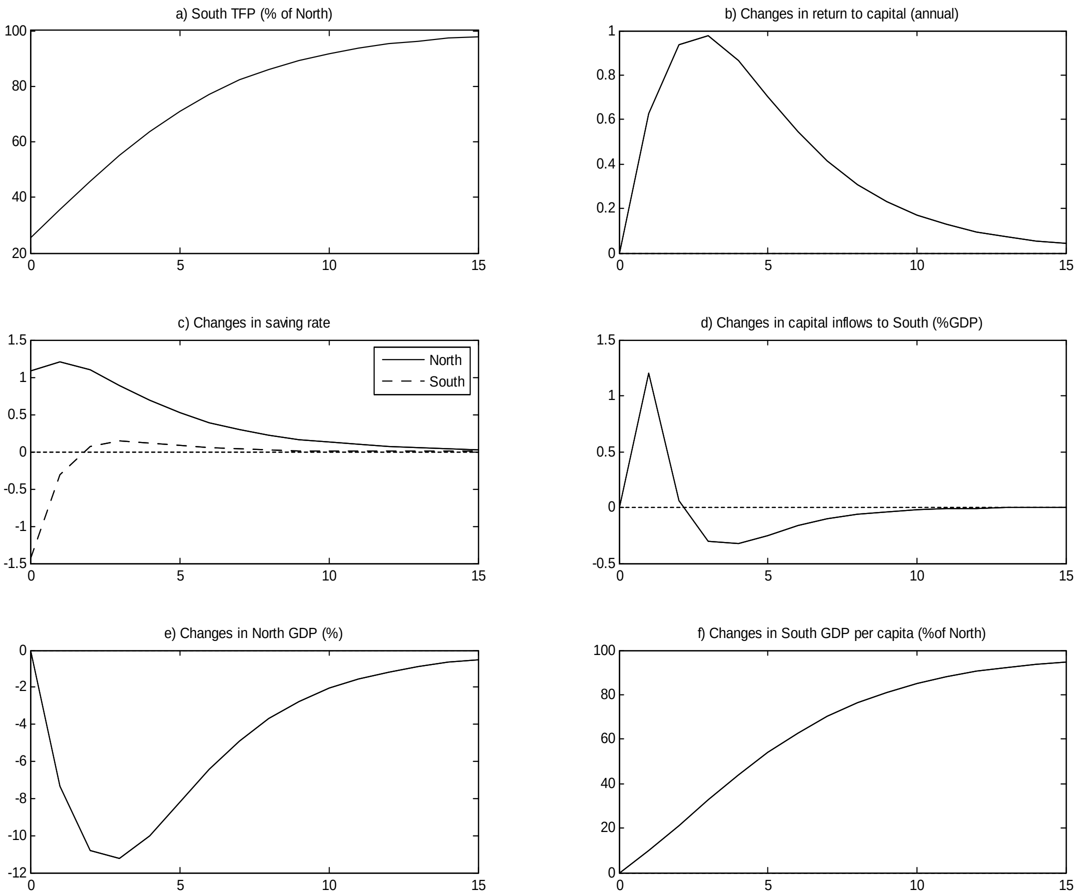

Figure 2: Technological catching-up (changes wrt the scenario with globalized finance)

4.2 Technological catching-up

Figure 2 presents the changes with respect to the simulations obtained in the economic openness configuration when no convergence of any type is assumed, i.e. only with globalized finance. Unsurprisingly, in such a scenario the increase in the TFP in the South boosts its demand for capital. As a consequence, the world interest rate (Fig. 2b) as well as the North's saving rate (Fig. 2c) increase. There are more capital flows from the North to the South (Fig. 2d). These effects are even first reinforced by a reduced South's saving rate. Indeed, as young workers in the South now anticipate the increase of their future income due to the stronger economic growth, they start with consuming more and save less as compared with the previous scenario (Fig. 2c). However, as the growth rate of the TFP in the South slows down during the technological catching-up process, an initially weaker saving rate in the South then grows and eventually converges to the same level as before. This higher saving rate in the South associated with the growing share of South in the world population explains why capital flows going from the South to the North is reduced and become even slightly negative (Fig. 2d). This also explains the shape of the GDP in the North (Fig. 2e). The more capital flows from the North to the South, the lower the North's GDP. Therefore, when the North-to-South capital flows are the first to increase, the wider the South-North GDP gap between the two scenarios - with and without catching-up -, while it narrows until vanishing when capital flows are reversed. Finally, when the relative population of the North becomes negligible, the world interest rate converges towards that of the South closed economy and capital flows as a percentage of the South production also become negligible.

4.3 Demographic transition

4.3.1 Mortality reduction

Now, we assume the technological diffusion results in a medical progress which yields a reduction in the South's mortality rate. However, to replicate the structure of the world population as forecasted by the United Nations (2013), the North-South mortality rate convergence is assumed to be very slow. Hence, σ_ρ is set to 0.01. Therefore, only light effects should be initially expected from this convergence. To characterize the evolutions observed from the first simulated periods until the long run, the Figure 3 presents the steady steate values obtained when the complete mortality convergence is achieved. As evidenced by our simulations, people in the South save more with respect to the previous case with economic openness and technological catching-up because they tend to live longer (Fig. 3d). Indeed, they need to finance a longer period with no activity, knowing that pensions are very low. On the world capital market, as the supply of capital increases, this effect has a negative impact on the interest rate (Fig. 3c). In return, people in the North save less. Obviously, the capital flows to the South are firstly reduced (Fig. 3e) as compared with the previous scenario with no mortality reduction in the South. However, for the same reason as in the previous section, when the relative population of the North becomes negligible, capital flows as a percentage of the South production become also

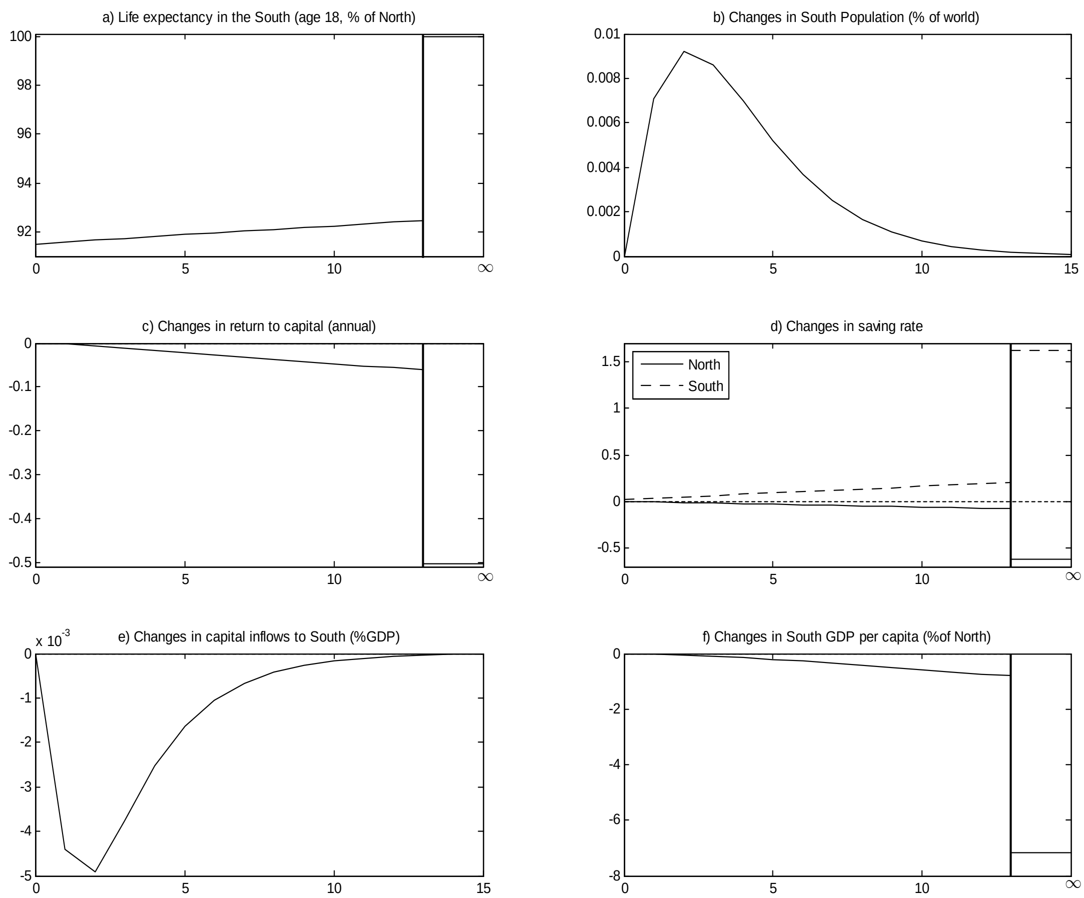

Figure 3: Mortality transition (changes wrt the scenario with technological catching-up)

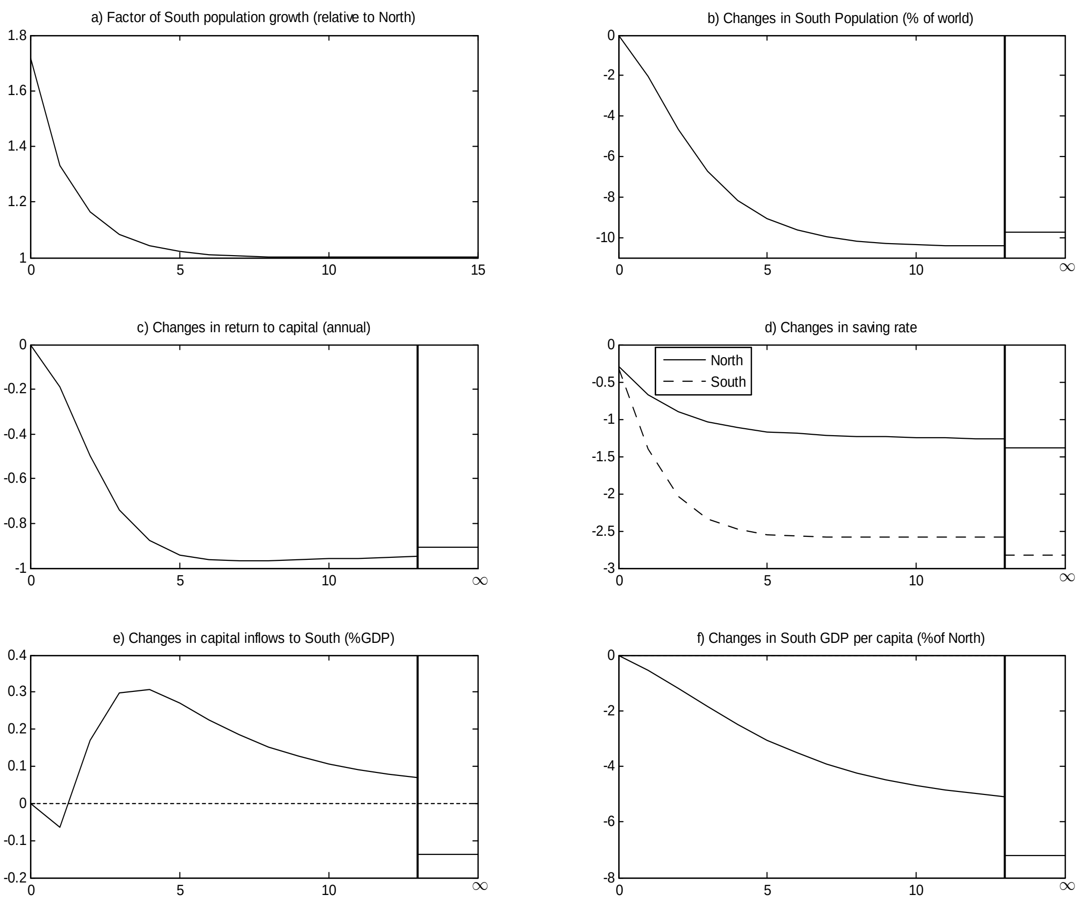

Figure 4: Fertility transition (changes wrt to the scenario with technological catching-up and mortality transition)

negligible. As Social Security is less developed in the South, the interest rate converges to an intermediate level between South and North closed economies equal to 4.9% on an annual basis, i.e. minus approximatively 0.5 percentage point with respect to the previous scenario. Observe also that, as exhibited in equation (20), as the proportion of people with no productive activity increases in the South, the North-South wealth gap widens so that Γ is reduced until reaching -7% in the long run relatively to the no-mortality-reduction scenario (Fig. 3f).

4.3.2 Fertility transition

Let us now assume that the technological diffusion results also in a "higher" individual education level which allows a better birth control, hence to a reduction in fertility rate.

This phenomenon associated with the mortality reduction illustrates the concept of demographic transition. Assuming $\sigma_G = 0.47$, we observe that fertility in the South reaches its steady state level after 15 periods (Fig 4a). Compared with the previous scenario, we observe that at steady state the share of South in the world population (over 18) is approximately 10 percentage points lower (Fig 4b), which corresponds to slightly more than 90% of the world population in the very long term. Note that, as fertility convergence is much faster than the mortality's, the evolution of the South's share in the world population is slightly non monotonous. The decrease due to this quick fertility reduction leads, during the process of demographic transition, to a lower share than its steady state value. That is why it slightly increases after period 15, due to mortality decreases, to reach its steady state value. From an economic perspective, as the growth of the working population in the South is reduced, the demand for capital there is weaker. The interest rate decreases to stabilize at 4% per year, i.e. approximatively 0.9 percentage point lower as compared with the previous scenario (Fig 4c) and lower than the North autarky economy's. Indeed, in this scenario, everything converges except Social Security. Therefore, compared with the North's closed economy, this world economy has, on average, a lower Social Security size and then more savings. As a consequence of the weaker demand for capital in the south and the decrease in the world interest rate, both saving rates in the North and in the South decrease (Fig 4d). Despite the weaker demand for capital in the South, we observe that capital inflows to South as percentage of GDP increase after period 1 (Fig 4e). However, it only characterizes a more intense decrease in GDP due to the decrease of the labor force than in capital inflows. Indeed, at steady state, as the South is characterized by a higher saving rate due to its lower Social Security size, the capital flows in percentage of GDP go well from the South to the North. Finally, following eq. (20), the decrease in the working population share in the South results in less wealth convergence such that the GDP per capita in the South is more than 7% lower compared with the North GDP per capita in the previous scenario at steady state (Fig 4f).

4.4 Institutional convergence

Finally, we add to the previous economic development (technological progress and demographic transition) a social pressure for a fairer share of income between young and old because, otherwise, the latter would benefit less from growth than the former. A

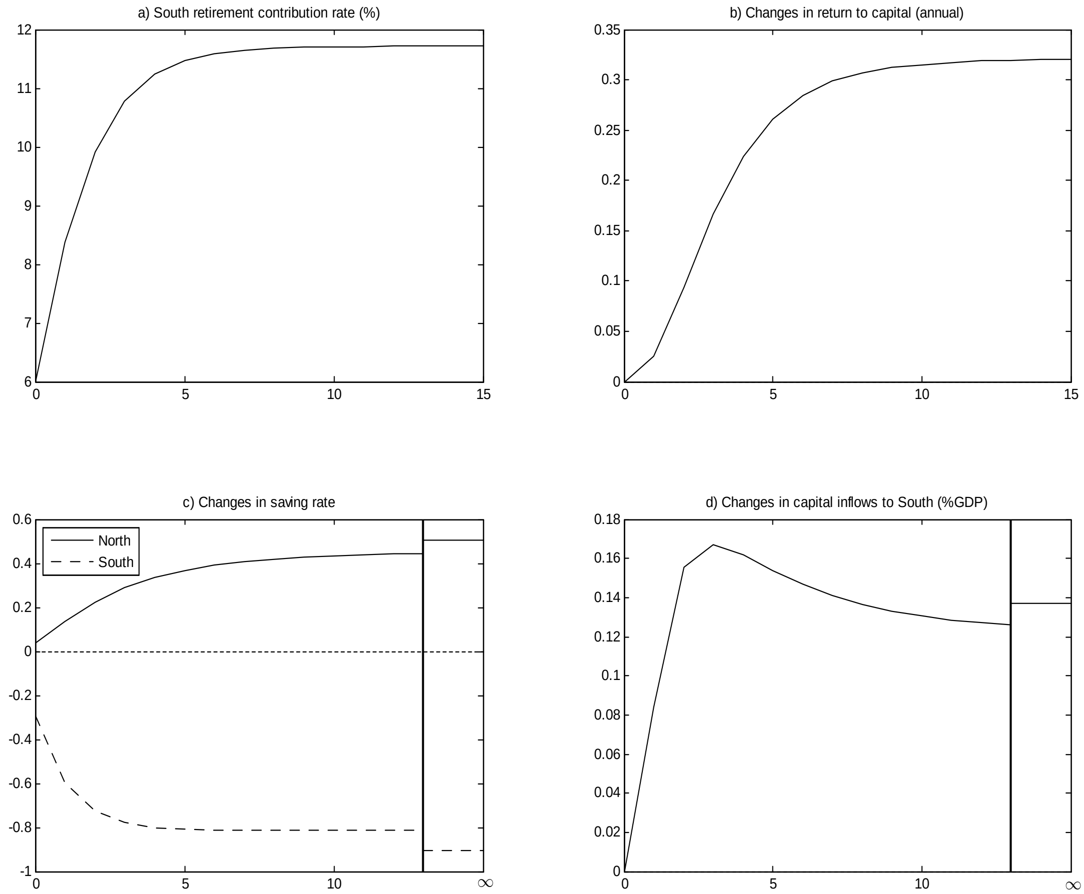

Figure 5: Institutional convergence (changes wrt the scenario with technological catching-up and demographic transition)

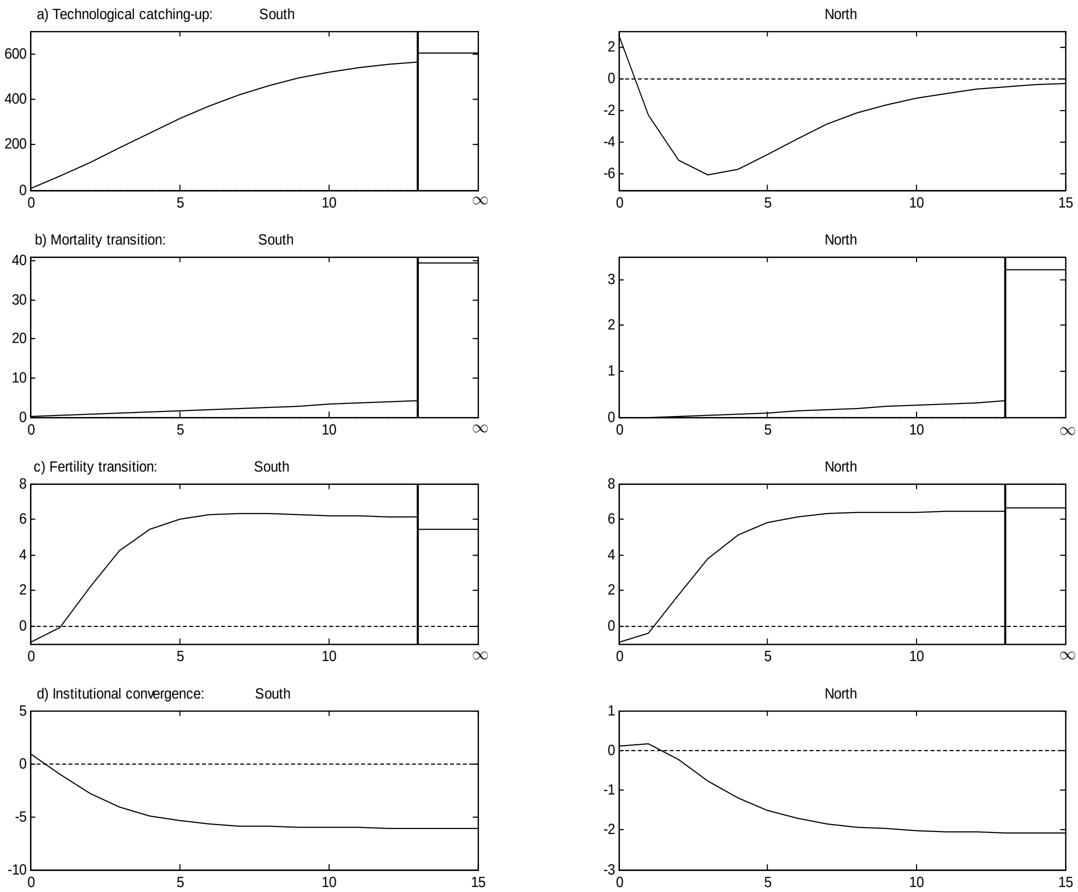

Figure 6: Welfare analysis

higher Social Security size (via a higher contribution rate as illustrated in Fig. 5a) reduces the savings in the South with respect to the previous scenario (Fig. 5c). This reduction is intended to mimic the progressive increase of Social Security. It follows that the net demand for capital is higher in the South. On the world capital market, the interest rate is pushed up and people in the North save more (Figs. 5b and c). As a result, capital flows from the North to the South are higher (Fig. 5d).

5 Welfare analysis

One important consequence of the economic openness is its impact on each generation's welfare. Figure 6 presents, for the North and the South, the changes in the time path of their respective welfare (valued by the equivalent consumption as described in section 3) with respect to their corresponding level in the scenario above.

The gross effect when we suppose no convergence is negative in the North due to dynamic efficiency.

When openness is assumed to generate positive externalities on TFP growth in the South through for instance technological transfers, the global impact could be positive during the first periods of the transition path whenever a higher interest rate generates a strong positive income effect for elderly. It is the case with our parameters but only in period 0 (Fig. 6a). Afterward, as a higher TFP in the South attracts more capital from the North, weakening production in the North (2e), a negative effect is exerted on the North's welfare that reaches a minimum of -6% in period 3. After period 3, this negative effect gradually slackens as the GDP in the North recovers, until finally cancelling at steady state. In the South, an improved labor productivity unambiguously leads to higher welfare.

In addition, if a demographic transition towards a stationary population with higher life expectancy is triggered, the direction of the net flows of capital reverses so that, finally, the North benefits from capital transfers from the South as compared to previous scenarios. Consequently, a positive welfare gain is observed immediately following the mortality convergence, after 2 periods with the fertility convergence. Of course, as people in the South are less numerous than in a context of growing population and live longer, they benefit from a higher welfare.

Moreover, if the South adopts the North Social Security standards, it saves less and, globally, there is less productive capital both in the North and the South and consequently, in both regions, people endure a weaker welfare with respect to the previous scenario. In the long run, the welfare levels in the North and the South converge to the same level as the one observed in the North closed economy because the two regions are identical. Note that, due the steep evolution of the interest rate over time, people benefit, respectively, in period 0 in the South and in periods 0 and 1 in the North from the increase in Social Security size in the South.

Conclusion

This paper develops a tractable two-period two-region OLG model. It allows to detail the analytical solution of the dynamics of the world interest rate. This analytical approach exposes clearly the existing interactions between the different regional components of world equilibrium, contributing to a better understanding of the main mechanisms triggered by globalization.

This result is completed by numerical simulations. In a context of large domestic differences, our study permits to analyse global consequences from trade between the developed and emerging regions. The calibration set mimics the North-South differences as described by macroeconomic and demographic empirical data bases. More precisely, we investigate three types of convergence associated with economic openness. Our results show that the technological catching-up alone leads to the maximum welfare loss for the North. If we add to this first change a demographic transition, the welfare gain is maximum in the South and the North obtains positive welfare gain in a finite horizon. Lastly, an institutional convergence of the North-South pension schemes reduces saving rate in the South and induces a welfare loss in the North for any subsequent period.

The advantages of our approach rooted in an analytical framework are multifold. First, tractability allows to evidence clear-cut transitory dynamics. Second, it gives way to possible investigations of general analytical properties. Lastly, the following extensions may be contemplated: "true" spatial setting (several countries and/or regions more precisely and realistically differentiated) ; mobile workforce (migration) ; the implications of workers' skills and the link between development issues and economic geography literature (Krugman, 1991; Abdel-Rahman et al., 2005).

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Mathematical appendix and sensitivity analysis

From eqs. (9) and (10) we have:

$$\sum_i K_{i,t+1} = \sum_i (G_{i,t+1} + l_{i,t+1}) \cdot N_{i,t} \cdot k_{i,t+1}. \tag{22}$$

From (8) and (9), it follows that wage in each region depends on the world interest rate:

$$w_{i,t} = A_{i,t}^{\frac{1}{1-\alpha}} \cdot (1-\alpha) \cdot \alpha^{\frac{\alpha}{1-\alpha}} \cdot R_{i,t}^{\frac{\alpha}{\alpha-1}}. \tag{23}$$

From eqs. (6) and (7), we have:

$$S_{i,t} = s_{i,t} \cdot (1-\tau_{i,t}) \cdot w_{i,t} - (1-s_{i,t}) \cdot (l_{i,t+1} + G_{i,t+1} \cdot \tau_{i,t+1}) \cdot \frac{w_{i,t+1}}{R_{t+1}}. \tag{24}$$

From eq (23) it follows that:

$$S_{i,t} = s_{i,t} \cdot (1-\tau_{i,t}) \cdot w_{i,t} - (1-s_{i,t}) \cdot (l_{i,t+1} + G_{i,t+1} \cdot \tau_{i,t+1}) \cdot \tfrac{1-\alpha}{\alpha} \cdot k_{i,t+1}. \tag{25}$$

It follows that:

$$\begin{gathered} \textstyle\sum_i N_{i,t} \cdot S_{i,t} \\ = \\ \textstyle\sum_i N_{i,t} \cdot \left[s_{i,t} \cdot (1-\tau_{i,t}) \cdot w_{i,t} - (1-s_{i,t}) \cdot (l_{i,t+1} + G_{i,t+1} \cdot \tau_{i,t+1}) \cdot \tfrac{1-\alpha}{\alpha} \cdot k_{i,t+1}\right] \end{gathered}. \tag{26}$$

Following eqs. (11) and (9), the dynamic general equilibrium can be characterized by:

$$R_{t+1} = R_t^{\alpha} \cdot \left[\frac{\sum_i [\alpha \cdot (G_{i,t+1} + l_{i,t+1}) + (1-\alpha) \cdot (1-s_{i,t}) \cdot (l_{i,t+1} + G_{i,t+1} \cdot \tau_{i,t+1})] \cdot \lambda_{i,t} \cdot A_{i,t+1}^{\frac{1}{1-\alpha}}}{(1-\alpha) \cdot \sum_i s_{i,t} \cdot (1-\tau_{i,t}) \cdot \lambda_{i,t} \cdot A_{i,t}^{\frac{1}{1-\alpha}}}\right]^{1-\alpha} \tag{27}$$

and at the steady state, the interest factor is:

$$R = \frac{\sum_i [\alpha \cdot (G_i + l_i) + (1-\alpha) \cdot (1-s_i) \cdot (l_i + G_i \cdot \tau_i)] \cdot \lambda_i \cdot \sigma_i}{(1-\alpha) \cdot \sum_i s_i \cdot (1-\tau_i) \cdot \lambda_i \cdot \sigma_i} \tag{28}$$

with $\sigma_i = \left(\frac{A_i}{A_1}\right)^{\frac{1}{1-\alpha}}$.

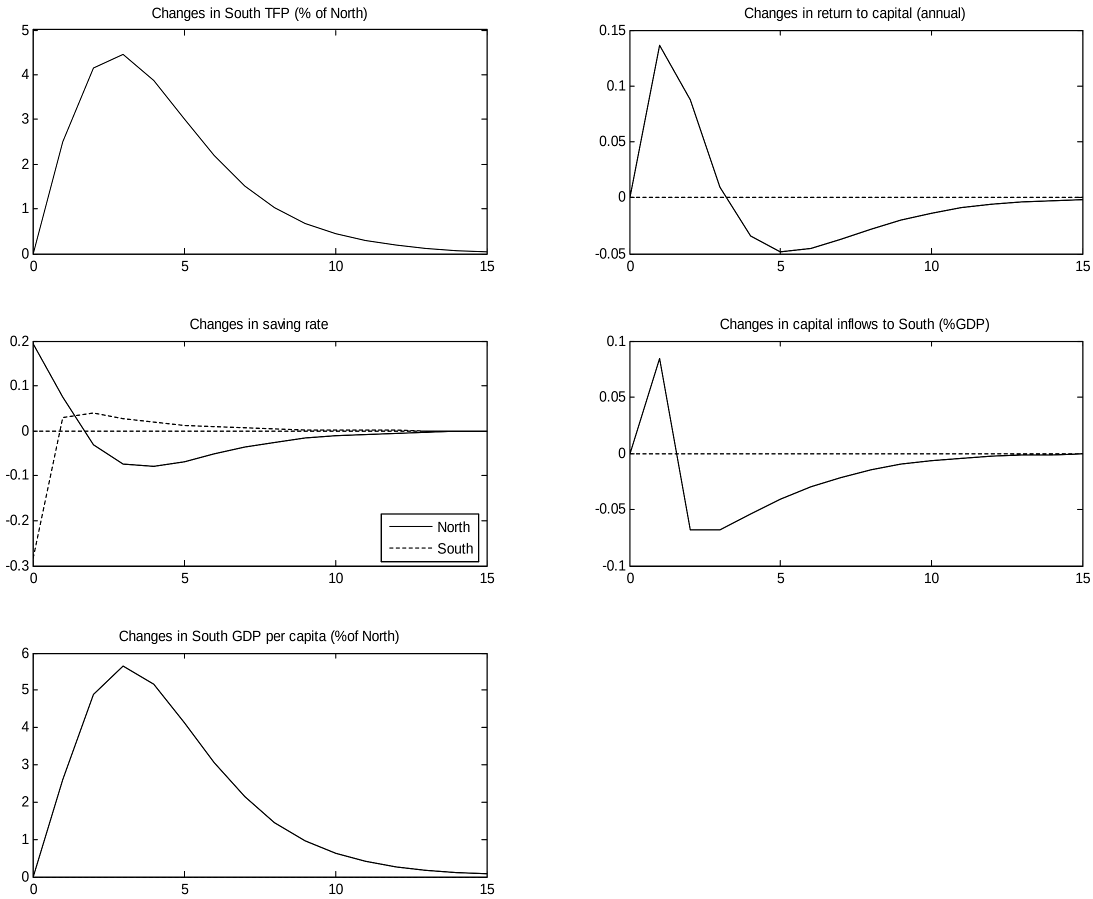

Figure 7: Sensitivity: faster TFP convergence ($\Delta\sigma_A = 0.01$)

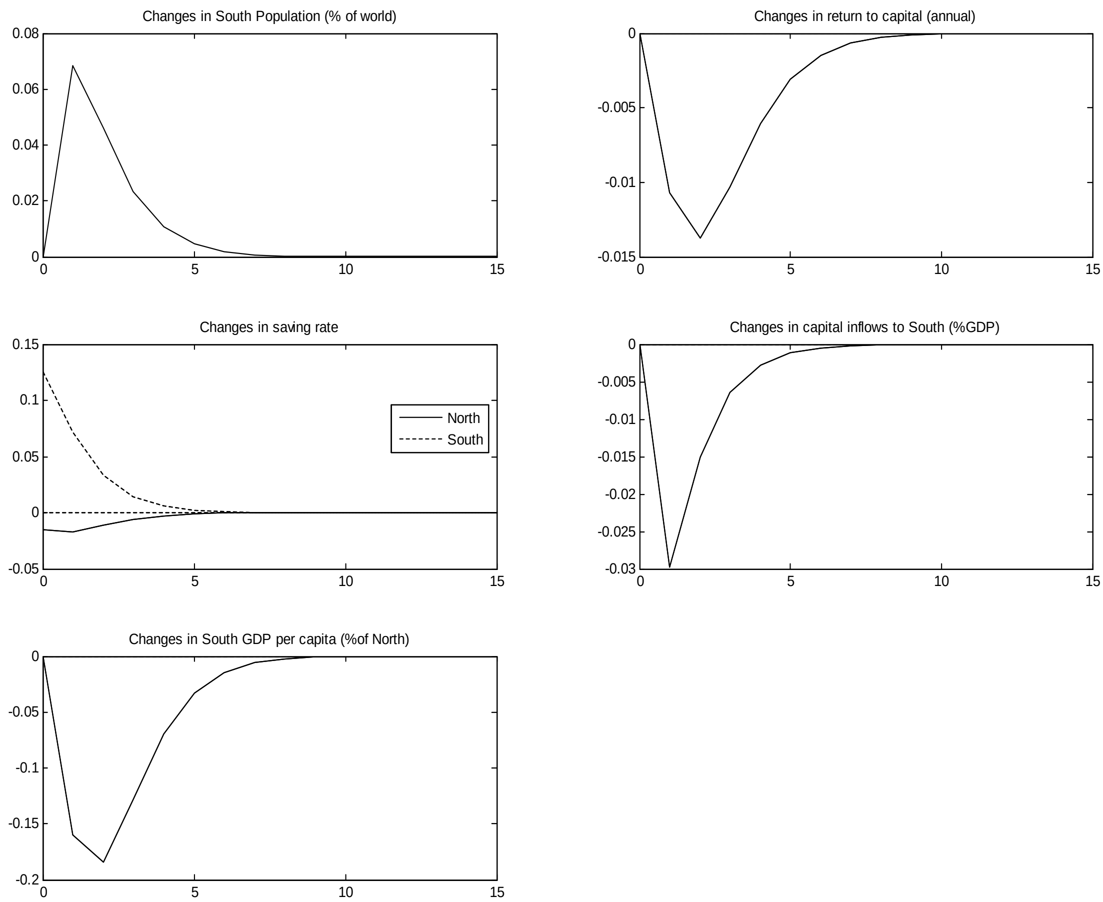

Figure 8: Sensitivity: faster mortality rate convergence ($\Delta\sigma_\rho = 0.01$)

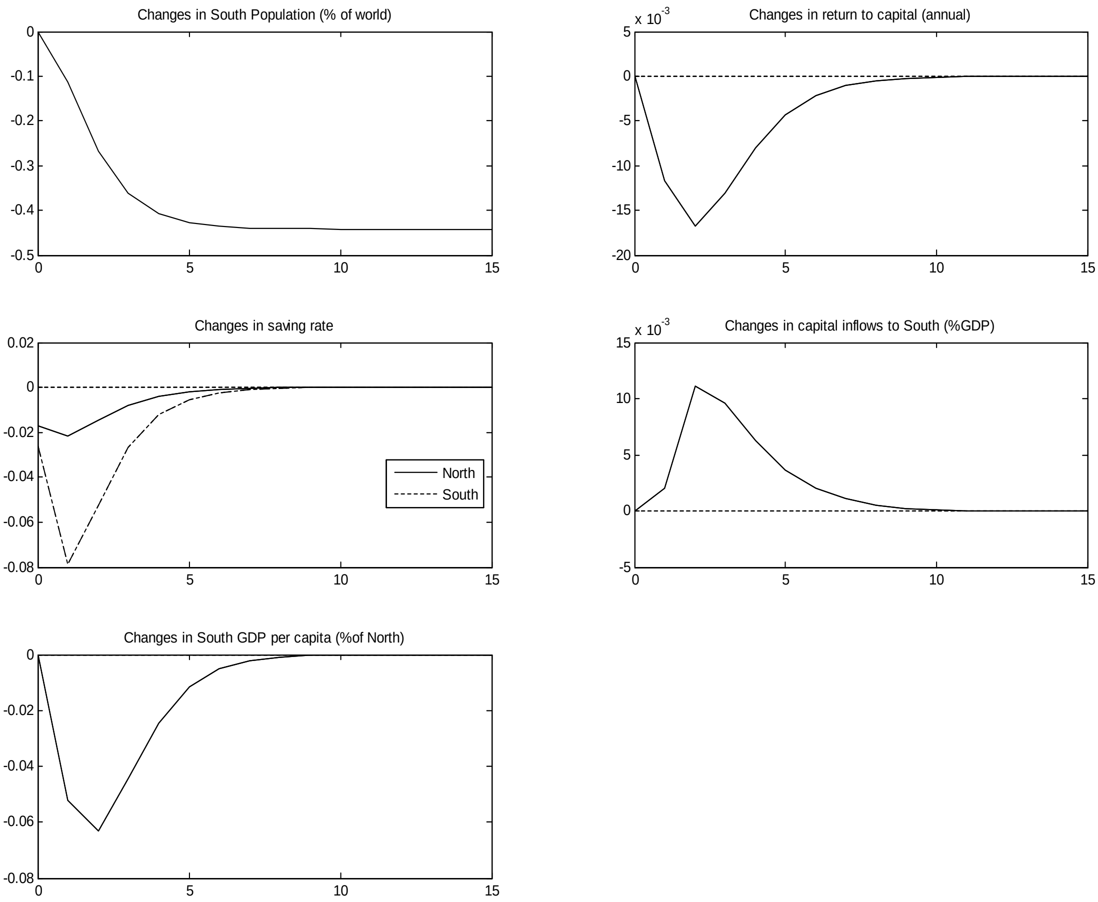

Figure 9: Sensitivity: faster fertility rate convergence ($\Delta\sigma_G = 0.01$)

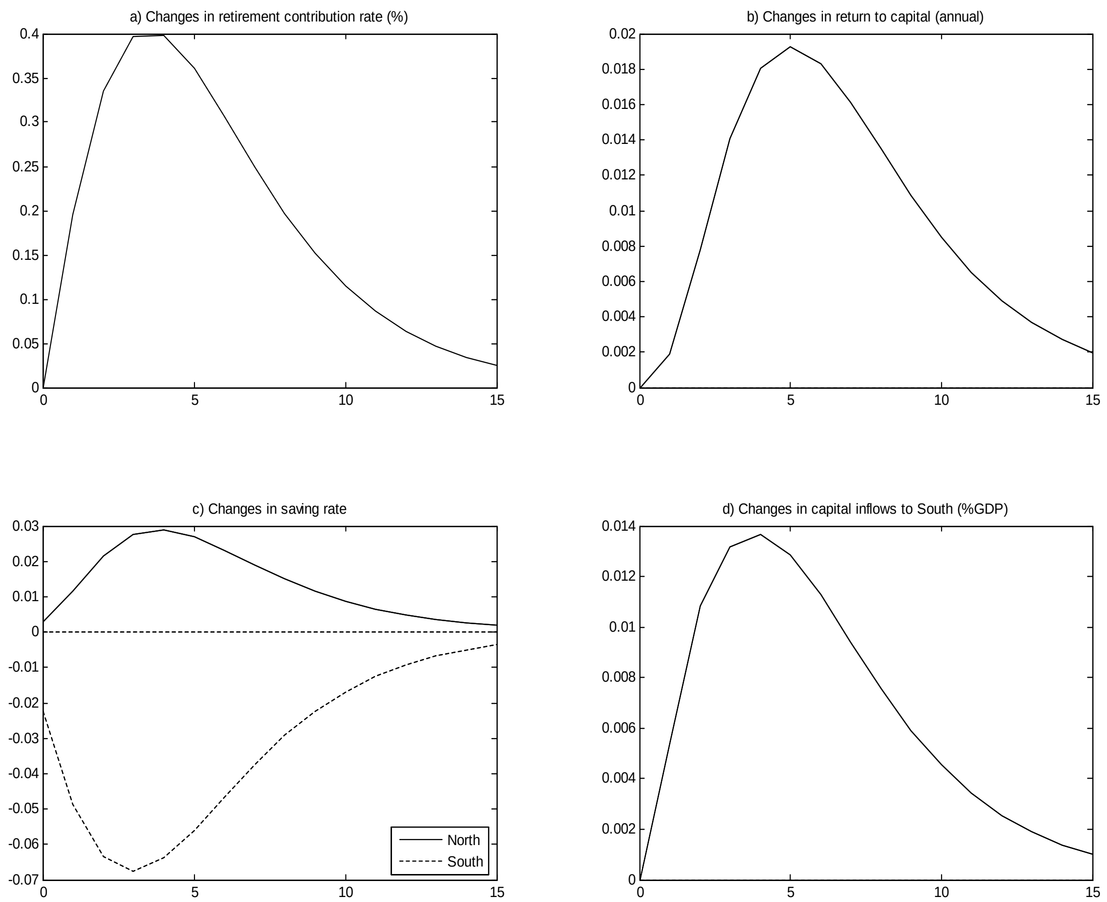

Figure 10: Sensitivity: faster Social Security (payroll tax rate) convergence ($\Delta\sigma_\tau = 0.01$)