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Demography, Credit and Institutions in a Globalizing World

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DEDICATION

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CONTENTS

Part I

Introduction

This thesis analyzes the impact of the interaction between demographic differences and capital market imperfections in explaining patterns in international capital movements. More specifically, this thesis derives theoretical implications from the interaction between asymmetric fertility shocks and two different types of exogenous capital market imperfections. Two simple open-economy overlapping generations models are developed. The theoretical implications of those models are then tested empirically.

Different regions of the world are at different stages of a global aging phenomenon named demographic transition. More advanced countries in the demographic transition face a high old-age dependency ratio and the prospect of a labor force shortage. Less advanced countries are experiencing a relatively lower old age dependency ratio and an increasing labor force population. According to the United Nations [13], demographic differences are likely to remain important in the future. In a two-country framework, under standard neoclassical assumptions, a partial equilibrium implication of the life-cycle hypothesis is that the bulk of the saving supply triggered by the rapidly aging country should flow to the slower aging country where capital is relatively scarce and where labor is relatively abundant. This prediction matches the past decades surge in capital inflows to younger/poorer countries following their capital markets liberalization. However, Lucas [10] claimed that those international capital flows appear to be limited compared to what neoclassical theory would predict. Indeed, several capital market imperfections are likely to impede aging differences to foster international capital flows. In addition, those capital inflows are unevenly distributed across younger/poorer countries as documented in Prasad et al. [11]. The younger/poorer economies receiving the least capital inflows are often plagued by poor rule of law and underdeveloped domestic credit markets.[1] These stylized facts suggest a role for the interaction between demographic differences and various capital market imperfections in explaining those important patterns of international capital movements.

The theoretical literature has been relatively scarce on the relevance of such interaction but abundant on the closed-economy consequences of aging. This literature is often related to the analysis of pay-as-you-go system unsustainability. Indeed Auerbach and Kotlikoff [3] have initiated a wide strand of literature on the consequences of social security reform in aging economies. Both theoretical and empirical results, based on the life-cycle hypothesis, suggest that aging, through its impact on the labor market, increases capital labor intensity.

A recent literature has been addressing the economic consequences of aging differences in

[1] Capital market imperfections are treated as exogenous phenomena. Indeed, in this dissertation, I do not intend to explain how those phenomenons arise. I also do not intend to explain fertility choices. However, I will further discuss the existing literature on the consequences of capital market imperfections and public pension coverage on fertility choices and on household saving.

an open-economy perspective using large scale simulation models. Among others, Attanasio and Violante [2] and Brooks [5] simulation results point to a significant role being played by demographic differences in explaining capital flow from fast aging OECD countries to slower aging emerging markets. Brooks [5] also predict a future reversal in the direction of international capital flows. Indeed, Brooks [5] suggest that capital will flow from currently younger countries to currently older countries as the former enter into the fast aging stage of the demographic transition. There is, however, an important caveat to this recent literature. These studies assume the absence of capital market imperfections.

In the present thesis, I claim that the interaction between demographic differences and capital market imperfection can help explain both the timing, the magnitude and the distribution of international capital flows across receiving countries. I focus on two different types of capital market imperfections. Distinguishing between **external** and **internal** capital imperfections is relevant, as the channel through which those imperfections interact with demography is different. First, **external** capital imperfection is likely to impede capital flows triggered by demographic differences through the investment channel. Indeed, Lucas [10] emphasizes the role of external capital imperfections/political risk in explaining the lack of capital flow from capital abundant to capital scarce countries. More recently, Shleifer and Wolfenzon [12] model how agency costs stemming from inefficient corporate governance and law enforcement mechanisms impede foreign capital from flowing to capital-scarce countries. Their results suggest that poorer/younger countries receive substantially less foreign investment. Second, **internal** capital market imperfection/credit market imperfections are likely to impede international capital flows triggered by demographic differences through the saving channel. Japelli and Pagano [8] provide theoretical and empirical evidence that exogenous liquidity constraints, in a closed economy, (through redistribution from young/borrower individuals to middle age/saver individuals) tend to raise national saving and thus capital labor ratio. In contrast, De Gregorio [6] provides evidence that liquidity constraints impede investment in human capital thus reducing capital accumulation. However, to the extent of my knowledge, no-one has investigated the interaction between demographic differences and the receiving country's degree of liquidity constraints in explaining international capital flows. In the present thesis, I show that the latter interaction can help determine international capital flows through its impact on national saving.

There are few empirical studies focusing on the relevance of the interaction between demographic differences and capital imperfections to explain international capital movements. Among the few of them, Higgins [7] estimates a reduced form model to quantify the impact of age structure differences on international capital flows. Drawing from data for up to 100 countries over the period 1950 to 1989, Higgins' results point to the significant impact that changes in population age structure have on saving. Results also point to a differentiated impact of age structure on saving and investment, opening the scope for international borrowing and lending. Bosworth and Keys [4], replicating Higgins study, use a larger sample period covering the period 1950 to 2000 and seem to confirm Higgins results. However, Bosworth and Keys [4] argue that their results are not robust and driven by South East Asian countries. The latter findings seem to suggest that the role of demographic differences in driving international capital flows needs to be considered together with its interaction with capital market imperfections. Indeed, Alfaro et al. [1], using cross country data, show empirically the importance of institutional factors in determining international capital inflows to emerging countries.[2] To the extent of my knowledge, there are no empirical studies that test the relevance of the interaction between age structure differences and capital market imperfections in explaining international capital flows.

The main points of this thesis are the following. First, if the degree of external capital imperfection is not too high, capital flows from older to younger countries. Second, less stringent borrowing constraints in the younger country magnifies the impact of countries demographic differences on saving/investment imbalances. To make those claims precise, two open economy overlapping generations models are developped with asymmetric fertility shocks in presence of either external or internal capital market imperfections. Third, I provide empirical evidence that good institutions and higher credit availability magnify the impact of age structure differences in affecting current account positions.

In chapter 1, a simple small open economy Diamond-type overlapping-generations model with an external capital market imperfection is developped. The capital market imperfection is modelled through a symmetric wedge between foreign investor and domestic investor return on capital likely to arise when property rights are not enforced. The consequences of an asymmetric fertility shock on capital formation, saving/investment imbalance, and welfare are investigated. The shock is transmitted to the small open economy depending on whether the wedge is below a given threshold. If the wedge is not too high, capital first flows into the small open economy in order to exploit the difference in returns on capital. After the shock has occurred, capital is repatriated in order to finance old-aged consumption of the rest of the world investors. If capital flows internationally, lifetime utility in the small open economy decreases unambiguously for individuals born one period before the shock occured. Provided that the small open economy is initially below its golden

[2]The finance literature has provided empirical (see for instance La Porta et al. [9]) and theoretical evidence on the importance of a country's legal system in determining their level of financial development.

rule, individuals born after the time the shock occurred experience an increase in their lifetime utility. The model can explain the observed timing and magnitude of capital flows from older/richer to younger/poorer countries. Furthermore the model can explain the distribution of capital inflows to younger/poorer countries through the foreign investment channel. Several extensions are discussed. For example, within this framework, introducing a pay-as-you-go system can deliver interesting insights on the consequences of fast aging OECD countries pension reforms on capital movements to younger/poorer countries and welfare.

In Chapter 2, a simple small open economy three period lived overlapping-generations model with internal capital market imperfection is developped. The internal capital market is modelled through an exogenous (binding) borrowing constraints on young age individuals' consumption. The consequences of an asymmetric fertility shock on saving, international capital flows and welfare are investigated. The consequences of a rest of the world negative fertility shock on the small open economy national saving and capital flows are distributed in an hump shaped fashion over time. Capital first flows into the small open economy to exploit the difference in returns on capital and to finance the small open economy young-aged individuals increased borrowing. After the shock has occurred, capital is repatriated to finance the rest of the world old age consumption investors. Looser liquidity constraints magnify the consequence of such an asymmetric fertility shock on the small open economy national saving and current account position. In the small open economy, lifetime utility decreases unambiguously for individuals born one period before the shock occurred. Provided that the small open economy is below its golden rule (without imperfection), individuals born after the shock has occurred experience an increase in their lifetime utility is independent of the small open economy degree of liquidity constraint. The model can explain the observed timing and magnitude of capital flows from older/richer to younger/poorer countries. Furthermore the model can explain the distribution of capital inflows to younger/poorer countries through the saving channel. Several extensions are discussed. For example, within the context of a two country model, investigating the interaction of an asymmetric fertility shock and the degree of liquidity constraints can deliver interesting results on the consequences of fast aging OECD countries credit market reforms on capital movements to younger/poorer countries and welfare. Indeed, in this framework, different degrees of liquidity constraints will affect both saving and capital formation.

In Chapter 3, I use a reduced form model estimation to test empirically the validity of the latter chapters' theoretical implications. At first, I present some stylized facts on age structure differences and cross-correlations between saving, investment and population age structure. Then I discuss the empirical specification. I estimate a variety of individual regressions for saving, investment and current account position, drawing from data for up to 115 countries over the period 1970 to 2000. Results indicate the existence of a differentiated effect in the relationship between age structure and international capital flows. Good institutions allow for a differentiated impact of age structure on saving and investment opening the scope for an impact of demographic differences in driving international capital flows. In contrast, bad institutions shut down the effect of age structure on international capital flows. Despite increased credit availability contributing to reduced aggregate saving, this will nevertheless magnify the role of the population age structure in driving international capital flows. Over the past three decades, I estimate that age structure changes have contributed to improving the current account balance position by five per cent of GDP in more advanced aging countries. I also presents out of sample projections of the consequences of age structure differences on international capital flows. Around the year 2020, age structure changes are projected to deteriorate the current account position in the latter countries, which will experience a drop in saving. In other regions, the faster the current aging process, the sharper the projected improvement in the current account position. This improvement is projected to reverse itself, at a later stage in time in regions with a slower aging process. Different scenarios of both internal and external capital market imperfections reveal that the scope for international capital flows is reduced when imperfections are high though through different channels.

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Part II

Chapters

CHAPTER 1

AGING AND EXTERNAL CAPITAL MARKET IMPERFECTIONS IN A GLOBALIZING WORLD: A SIMPLE MODEL

There exist important differences in the timing and the size of the aging phenomenon across regions of the world. These differences are likely to remain important in the future (see United Nations [24]). In a two country framework, under standard neoclassical assumptions, a partial equilibrium implication of the life cycle hypothesis is that the bulk of the saving supply triggered by the rapid aging country should flow to the slower aging country, where capital is relatively scarce and labor relatively abundant. This prediction matches with the past decades surge in capital flows to younger/poorer countries following their capital market liberalization. However, those international capital flows appear to be limited compared to what the neoclassical theory would predict, as claimed in Lucas [21]. Indeed, several capital market imperfections are likely to impede demographic differences from fostering international capital flows. In addition, those capital inflows have been unevenly distributed across younger/poorer countries. These stylized facts on capital movements, documented in Prasad and al. [23], suggest a role for the interaction between aging differences and capital market imperfections in explaining both the timing, the magnitude and the distribution of international capital flows across receiving countries. In the present framework, through introducing exogenous differences in fertility rates, I generate differences in capital returns between "source" (OECD) countries and "recipient" (small open emerging) countries that in turn explain the magnitude and the timing of the flows. Through introducing an external capital market imperfection, I provide an explanation for the uneven distribution of those flows across "recipient" countries.[1]

The literature has been relatively scarce on the relevance of such an interaction in explaining international capital movements but abundant on the closed economy consequences of aging.[2] This literature is often related to the analysis of pay-as-you-go systems sustainability. Indeed, Auerbach and Kotlikoff [3] have initiated a wide literature dealing with the

[1] My argument takes further the main insight of the "push and pull" literature initiated by Calvo et al. [8].

[2] Bosworth and al.[4] provide a useful survey on the financial and macroeconomic consequences of aging.

consequences of social security reforms in a context of aging economies. Both theoretical and empirical results, based on the life cycle hypothesis, suggest that aging increases capital intensity. The introduction of a pay-as-you-go system is shown to be associated with a decrease in capital intensity (see for instance Kotlikoff [19]). A recent literature has been addressing the economic consequences of aging differences in an open economy perspective using large scale simulation models.[3] Among others, Attanasio Violante [2] and Brooks [5] simulations results point to a significant role of population age structure differences in explaining capital flow from fast aging OECD countries to slower aging emerging markets. Brooks [5] also predict a future reversal in the direction of those international capital flows. Indeed, Brooks [5] suggest that capital will flow from currently younger countries to currently older ones as the former will enter into the fast aging stage of the demographic transition. There is however an important caveat to the literature that is being addressed in the present paper. To the extent of my knowledge, there is no study that analyzes the open economy adjustment to an asymmetric demographic shock in presence of capital market imperfections.[4] Chapter 3, building on Higgins [17], provides empirical evidence of the relevance of the interaction between population age structure differences and institutional quality in explaining current account position, using a panel of up to 115 countries over the period 1970 to 2000.

In this Chapter, I analyze the consequences of an asymmetric negative fertility shock on capital formation, saving/investment imbalance, and welfare. The framework of analysis is a Diamond-type overlapping-generations small open economy with external capital market imperfections. The rest of the chapter is organized as follows. Section 1.1 presents the model. Section 1.2 analyzes the consequence of a rest of the world negative fertility shock on capital formation, saving/investment imbalances and welfare. In section 1.2.1, I find that the rest of the world shock is transmitted to the small open economy, depending on whether the wedge between the domestic investor return and foreign investor return on capital is below a given threshold. In section 1.2.2, I find that if the wedge is not too high, capital first flows in the small open economy in order to exploit the differences in returns on capital. After the shock has occurred, capital is repatriated in order to finance old-aged consumption of rest of the world investors. In section 1.2.3, I find that if capital flows internationally, lifetime utility in the small open economy decreases unambiguously for individuals born one period before the shock occurred. Provided that the small open economy is initially below its golden rule of capital accumulation, individuals born after the shock has occured experience an increase

[3] Geide-Stevenson [15] and Groezen and Leers [16] focus on the open economy consequence of aging using Diamond type overlapping generations models in presence of various pension arrangements .

[4] Kenc and al. [18] developed a simulation model to analyze the consequence of aging in the European Union for Turkey, introducing imperfect capital mobility.

in their lifetime utility. Section 1.3 concludes.

1.1 The Model

The model consists of a small open economy and the rest of the world identical in every respect except in demographic patterns. Each country is represented by competitive output and factor markets, two overlapping generations (OLG), and an identical well-behaved constant returns to scale production function f, a model due to Diamond [12]. Labor is not mobile. Capital is perfectly mobile. The model is entirely standard except that I assume a symmetric wedge between domestic investor and foreign investor return on capital. The wedge is the result of iceberg costs on capital return repatriation, so that for each unit of capital invested abroad a lump sum amount τ of the return is lost in transit.

All variables associated with the small open economy with respect to the rest of the world are distinguished by the upper script SOE and by the upper script RW respectively on the relevant variables. The variables associated with the rest of the world are also distinguished by an upper bar that indicates their exogenous nature.

1.1.1 Notation

$c_{1,t}^{i}$ = consumption while young by an individual living at time t in country i ; $i \in \{SOE, RW\}$;

$c_{2,t+1}^{i}$ = consumption while old by an individual at time $t+1$ living in country i; $i \in \{SOE, RW\}$;

s_t^i = aggregate asset owned while young by an individual at time t living in country i; for $i \in \{SOE, RW\}$;

w_t^i = real wage at time t in country i; for $i \in \{SOE, RW\}$;

r_t^i = interest rate on country i individual assets carried from period $t-1$ into period t in country i; for $i \in \{SOE, RW\}$;

k_t^i = capital labor ratio in country i at time t; $i \in \{SOE, RW\}$;

n_t^i = rate of growth of population in country i from period $t-1$ into t; for $i \in \{SOE, RW\}$;

ρ = pure rate of time preference; $\rho > 0$;

τ = wedge between foreign investor and domestic investor return on capital.

1.1.2 Individuals

Individuals in both regions live two periods: they work in the first period of their lives, and retire in the second. During the first period of their life each individual supplies inelastically one unit of labor. The optimization problem for an individual living in country i is given by equations (1.1), (1.2) and (1.3). The utility of lifetime consumption is maximized subject to an intertemporal budget constraint given by (1.2). The properties on U^i ensure that the intertemporal budget constraint will hold with equality and that an interior solution will be obtained for $c^i_{1,t}, c^i_{2,t+1}$ for $i \in \{SOE, RW\}$.

$$\max_{c^i_{1,t}, c^i_{2,t+1}} U^i(c^i_{1,t}, c^i_{2,t+1}) = u(c^i_{1,t}) + \frac{1}{1+\rho} u(c^i_{2,t+1}) \tag{1.1}$$

$$c^i_{1,t} + \frac{c^i_{2,t+1}}{1+r^*_{t+1}} \leq w^i_t \tag{1.2}$$

$$c^i_{1,t},\ c^i_{2,t+1} \geq 0 \tag{1.3}$$

For simplicity, I assume that the utility function is time separable and that the subutility function, u, is logarithmic.[5] Thus the optimal saving of a young individual born at time t in country i is given by the following expression:

$$s^i_{1,t} = \frac{w^i_t}{2+\rho} \tag{1.4}$$

Optimal portfolio return namely r^* is the result of investors behavior analyzed in the following.

1.1.3 Firms

Firms located in region i maximize profits taking as given domestic factor prices. Equations (1.5) and (1.6) state that the capital rental market and labor market in region i are competitive.[6] I assume that capital fully depreciates over a period of time. Thus gross investment equals net investment.

$$r^i_t = f'(k^i_t) - 1 \tag{1.5}$$

$$w^i_t = f(k^i_t) - k^i_t f'(k^i_t) \tag{1.6}$$

[5] The main results of the paper hold when assuming that the expected utility function is twice differentiable, strictly quasi-concave, and increasing in c_1, c_2 and $\frac{\partial U}{\partial c_1}(0,c_2) = \frac{\partial U}{\partial c_2}(c_1,0) = +\infty$, $\frac{\partial U}{\partial c_1}(\infty,c_2) = \frac{\partial U}{\partial c_2}(c_1,\infty) = 0$.

[6] For $i \in \{SOE, RW\}$.

1.1.4 Investors

Given the presence of iceberg costs, the effective return associated with foreign investment equals domestic investor return minus a wedge, τ. Investors optimize the return on their portfolio taking as given returns in both locations. Optimization decision for a given investor i at period t is formally given by the following expression:[7]

$$r_t^* = \max(r_t^i,\ r_t^j - \tau) \tag{1.7}$$

1.1.5 Asset Allocation Equilibria

As a result of investors portfolio return optimization, the world economy can be at three different asset allocation equilibria:

1. At equilibrium of type 1, individuals located in both regions invest all their assets domestically. At this equilibrium, the rate of return on aggregate assets for an individual living in a given region equals her domestic return.

2. At equilibrium of type 2, small open economy individuals invest all their assets domestically and rest of the world individuals invest their assets in both locations. At this equilibrium, individuals living in the small open economy receive r^{SOE} as a return on their aggregate assets. Individuals living in the rest of the world receive $r^{SOE} - \tau$ as a return on their aggregate assets.

3. At equilibrium of type 3, small open economy individuals invest their assets in both locations and rest of the world individuals invest all their assets domestically. At this equilibrium, the small open economy individuals receive $\overline{r}^{RW} - \tau$ as a return on their aggregate assets. Individuals living in the rest of the world receive $\overline{r}^{RW}$ as a return on their aggregate assets.

For the purpose of realism, I am only interested in equilibria where in both regions individuals invest in the small open economy that corresponds to type 1 and 2 equilibria. At these two equilibria, an individual of a given region i born at time t receives her domestic return r^i as a return on her aggregate asset.[8]

[7] For i and $j \in \{SOE, RW\}$ with $i \neq j$.
[8] For $i \in \{SOE, RW\}$.

1.1.6 Equilibrium

Let us now collect the equations characterizing the equilibrium in both regions. In the following subsection, I also present the way I model the occurrence of an asymmetric negative fertility shock, whose consequences are analyzed in the following section.

1.1.6.1 Rest of the World

Whether the world economy is at type 1 or type 2 equilibrium does not affect the rest of the world economy. Indeed, given the small open economy assumption, the rest of the world economy is unaffected by changes affecting the small open economy. The dynamic equilibrium of the rest of the world economy, described in details in appendix 1.A, corresponds to the equilibrium of a standard closed economy OLG model.

Further assuming that the production function f is twice differentiable and follows the Inada conditions, I obtain a first order difference equation in k_t^{RW} that describes the evolution of the model from arbitrary initial conditions given by the following expression:[9]

$$k_{t+1}^{RW}\left[(1+n_{t+1}^{RW})\right]-\left[\frac{f(k_t^{RW})-k_t^{RW}f'(k_t^{RW})}{2+\rho}\right]=0 \tag{1.8}$$

I assume that the rest of the world is subject to a fertility shock. γ^{RW} denotes the size of the shock and h^{RW} denotes the time pattern of the shock.[10] The fertility rate of the rest of the world economy at time t, n_t^{RW} is assumed to be equal to the sum of its steady state value n_{ss}^{RW} (being further normalized to zero) and its deviation from the steady state given by $\gamma^{RW}h_t^{RW}$ as described in expression (1.9). The variables evaluated at the economy steady state are distinguished by a lower index ss.

$$n_t^{RW}=n_{ss}^{RW}+\gamma^{RW}h_t^{RW} \tag{1.9}$$

I characterize the steady state of the rest of the world economy through formally giving the expression of its domestic returns at the steady state:

$$\overline{r}_{ss}^{RW}=f'(\overline{k}_{ss}^{RW})-1 \tag{1.10}$$

with $\overline{k}_{ss}^{RW}$ corresponding to the fix point solution of the difference equation (1.8).

[9]The Inada formally rewrites $f(0)=0$; $f'\succ 0$; $f'(0)=+\infty$ and $f'(0)=0$.
[10]In the case of a one period shock, h_t^{RW} takes the form: {0 at $t=0$, ..., 0 at $t=t_0-1$, -1 at $t=t_0$, 0 at t =
with t_0 denoting the time at which the shock occurs.

1.1.6.2 Small Open Economy

As stated before, I am only interested in equilibria where individuals living in both regions invest in the small open economy. I therefore describe the dynamic equilibrium of the small open economy for type 1 and type 2 equilibria where the small open economy individuals receive r^{SOE} as a return on their aggregate assets invested. I assume that the small open economy is not subject to any fertility shock. Thus its fertility rate at any period t, n_t^{SOE}, is at its steady state value (being further normalized to zero).

At the equilibrium of type 1, the small open economy is as if it were in autarky. The dynamic equilibrium of the small open economy from initial conditions guaranteeing equilibrium of type 1, corresponds to the equilibrium of a standard closed economy OLG model.

At the equilibrium of type 2, rest of the world individuals invest in the small open economy. The small open economy dynamic equilibrium is affected by changes in the rest of the world economy. At this equilibrium the no arbitrage condition between rest of world investors return on domestic investment and their effective return on investment in the small open economy is now binding. Thus the domestic return in the small open economy is pinned down by the rest of the world domestic return. The dynamic equilibrium of capital labor ratio at equilibrium of type 2 in the small open economy is formally determined by the following expression:

$$k_t^{SOE} = f'^{-1}(\overline{r}_t^{RW} + 1 + \tau) \tag{1.11}$$

At the steady state, the small open economy is identical to rest of the world economy in per capita terms.

1.2 Consequences of a Rest of the World Fertility Shock

In this section, I analyze the consequences of a rest of the world negative fertility shock on capital formation, saving/investment imbalances and welfare for both regions. I assume that the initial conditions in both regions are such that the world is at type 1 equilibrium. Depending on whether the wedge is below a given threshold, the occurrence of a shock is likely to drive the world economy to an equilibrium of type 2.

1.2.1 Capital Formation

The consequences of an asymmetric fertility shock on capital formation are analyzed first in the rest of the world economy. Then I explore the transmission of the consequences of such an asymmetric shock to the small open economy.

1.2.1.1 Rest of the World

I assume that the rest of the world is subject to a transitory negative fertility shock.[11] [12] To study the consequences of such a shock on the rest of the world economy, I differentiate (1.8) with respect to n_t^{RW} around the economy steady state. I obtain the following expression:

$$\frac{d\bar{k}_{t+1}^{RW}}{d\gamma^{RW}}(1+n_{ss}^{RW}) = \left[\frac{-k_{ss}^{RW} f''(k_{ss}^{RW})}{2+\rho}\right] \frac{d\bar{k}_t^{RW}}{d\gamma^{RW}} - k_{ss}^{RW} h_{t+1}^{RW} \tag{1.12}$$

To ensure local stability of the system described by equation (1.12), I assume that $\frac{d\bar{k}_{t+1}^{RW}}{d\bar{k}_t^{RW}} < 1$ that is equivalent to $\left[\frac{-k_{ss}^{RW} f''(k_{ss}^{RW})}{(2+\rho)(1+n_{ss}^{RW})}\right] < 1$.

At time t_0, a decline in the fertility rate mechanically increases the capital labor ratio through a reduction in the capital required to endow new workers. Formally, the short term impact of a negative fertility shock occurring at time t_0 on fertility is given by $\frac{-\bar{k}h_{t_0}}{(1+n_{ss}^{RW})} > 0$. After period t_0, a higher capital labor ratio leads to a higher real wage and saving rate. Indeed, the competitive labor market condition (1.6) implies that a lower employment level translates into a wage increase, thus increasing individual lifetime resources. Given that consumption at both ages are not inferior goods, consumptions in both periods are an increasing function of labor income. Consumption of the working age individuals increases but by less than their real wages, so that their saving increases, thus increasing the capital labor ratio (and so on and so forth).

Given the transitory nature of the shock and the stability condition imposed on the system, the effect of the shock vanishes over time. A transitory fertility shock has therefore no persistent impact on the rest of the world capital labor ratio. Only a permanent fertility shock has a long run impact on the rest of the world capital labor ratio. Formally, the long run effect of a permanent fertility shock, $\frac{dk^{RW}}{d\gamma^{RW}}$, is given by the fixed point solution to equation (1.12):[13]

$$\frac{dk^{RW}}{d\gamma^{RW}} = \frac{-k_{ss}^{RW} h^{RW}}{(1+n_{ss}^{RW}) + \frac{k_{ss}^{RW} f''(k_{ss}^{RW})}{2+\rho}} > 0 \tag{1.13}$$

The stability condition suffices to ensure that the long run effect of a permanent fertility shock is positive.

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[11] I only consider a one period shock for expositional purpose. My main results are qualitatively similar in the case of a multi-period shock.

[12] Given the specific form of the utility function, whether the shock is anticipated or not does not affect individuals behavior.

[13] The time pattern of a permanent negative shock occurring at time t_0, h^{RW}, takes the form: $\{0 \text{ at } t = 0, ..., 0 \text{ at } t = t_0 - 1, -1 \text{ at } t = t_0, -1 \text{ at } t = t_0 + 1, ...\}$.

The impact of an asymmetric transitory shock on the rest of the world interest rate is given by the following expression:

$$\frac{d\bar{r}_t^{RW}}{d\gamma^{RW}} = f''(k_{ss}^{RW})\frac{d\bar{k}_t^{RW}}{d\gamma^{RW}} \leq 0 \tag{1.14}$$

I now establish a proposition on the consequences of an asymmetric demographic shock on capital formation in the small open economy.

1.2.1.2 Small Open Economy

Proposition 1.1 *A rest of the world negative fertility shock translates into an increase in the small open economy capital labor ratio if the wedge between domestic and foreign investor return on capital is lower than the exogenous short run impact of a negative fertility shock on the rest of the world interest rate.*

Proof. When one starts from steady state in both regions, if τ is higher than the short run difference between the two regions before any potential transmission that formally implies $\tau \geq \left|\frac{d\bar{r}_{t_0}^{RW}}{d\gamma^{RW}}\right|$, the world economy is at the equilibrium of type 1 at time t_0. Given the stability condition imposed on (1.12), the world economy remains at the equilibrium of type 1 for all $t > t_0$. Thus there is no effect on capital formation in the small open economy that formally implies $\frac{dk_t^{SOE}}{d\gamma^{RW}} = 0$ for all t if $\tau \geq \left|\frac{dr_{t_0}^{RW}}{d\gamma^{RW}}\right|$.

When one starts from steady state in both regions, if τ is smaller than the short run difference between the two regions before any potential transmission that formally implies $\tau < \left|\frac{d\bar{r}_{t_0}^{RW}}{d\gamma^{RW}}\right|$, the world economy jumps at the equilibrium of type 2 at time t_0. For all $t > t_0$ for which $\tau < \left|\frac{d\bar{r}_t^{RW}}{d\gamma^{RW}}\right|$, the world economy is at equilibrium of type 2. Given the stability condition on (1.12), for all $t \geq t^*$, with t^* such that $\tau \geq \left|\frac{d\bar{r}_{t^*}^{RW}}{d\gamma^{RW}}\right|$ the world economy is at equilibrium of type 1. Thus there is a positive impact of the rest of the world asymmetric shock on capital formation in the small open economy that formally implies $\frac{dk_t^{SOE}}{d\gamma^{RW}} > 0$ for all t such that $t_0 \geq t > t^*$. ∎

The impact of a rest of the world negative fertility shock on the small open economy capital formation is formally given by the following expression:[14] [15]

[14]Substituting $\frac{d\bar{k}_{t_0}^{RW}}{d\gamma^{RW}}$ in (1.14), I obtain $\left|\frac{d\bar{r}_{t_0}^{RW}}{d\gamma^{RW}}\right| = \frac{f''(k_{ss}^{RW})k_{ss}^{RW}}{(1+n_{ss}^{RW})}$.

[15]t_0 is such that $\tau < \left|\frac{d\bar{r}_{t_0}^{RW}}{d\gamma^{RW}}\right|$ and t^* is such that $\tau \geq \left|\frac{d\bar{r}_{t^*}^{RW}}{d\gamma^{RW}}\right|$.

$$\frac{dk_t^{SOE}}{d\gamma^{RW}} = \left[\frac{1}{f''(k_{ss}^{RW})}\right]\left(\frac{d\bar{r}_t^{RW}}{d\gamma^{RW}} + \tau\right) > 0 \text{ for } t^* > t \geq t_0 \quad (1.15)$$

$$= 0 \text{ otherwise} \quad (1.16)$$

Appendix 1.B formally describes the detail of the derivation that leads to the above expression.

The transmission mechanism is interpreted as follows. If the wedge level is below a certain threshold, a rest of the world negative fertility shock leads to a decrease in the return on capital in that region. Capital flows to the small open economy in order to exploit the difference in returns. The world economy reaches the equilibrium of type 2. Thus the small open economy capital labor ratio increases. As the shock vanishes in the rest of the world, small open economy capital inflows vanish over time too. Capital flows stop when the difference between domestic returns in both regions is lower than the wedge, so that there is no incentive to invest abroad. The world economy returns to the equilibrium of type 1. Thus there is no long term effect of a rest of the world transitory fertility shock on the small open economy capital formation.

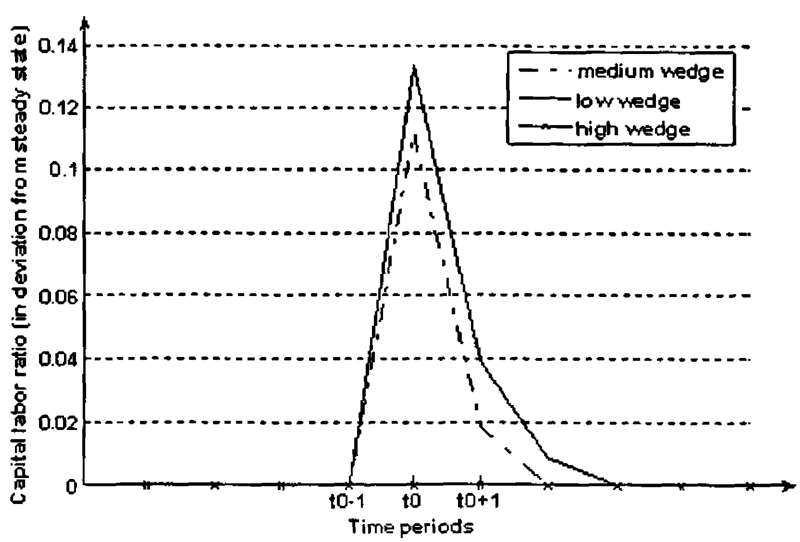

Figure 1.1: Evolution of Small Open Economy Capital Formation over Time

From (1.15), it is straightforward to show that given the assumption on diminishing returns, a marginally higher wedge limits the transmission of a rest of the world shock in terms of higher capital labor ratio. Indeed the equilibrium is reached through capital flowing to the small open economy, up to the point where there is no arbitrage between returns in the different locations. Thus a marginally higher wedge reduces the level of capital flows to the small open economy necessary to fulfill the no arbitrage condition between returns. Figure 1.1 displays the evolution over time of the small open economy capital formation for different degrees of external capital market imperfections.[16]

In the following subsection, I establish two propositions on the consequences of a rest of the world negative fertility shock on international capital movements.

1.2.2 Saving/Investment Imbalance

In the following, I analyze the consequences of an asymmetric shock both on the small open economy balance-of-trade surplus (deficit), B^{SOE} and on the current account surplus (deficit), G^{SOE}.

The small open economy balance-of-trade surplus at time t is the excess of **net** domestic product at time t, Y_t^{SOE}, over domestic absorption. Domestic absorption is the sum of aggregate consumption at time t, C_t^{SOE}, and domestic capital formation used in the production at time $t+1$, K_{t+1}^{SOE}:

$$B_t^{SOE} = Y_t^{SOE} - C_t^{SOE} - K_{t+1}^{SOE} \tag{1.17}$$

with

$$Y_t^{SOE} = F(K_t^{SOE}) - \tau_t(K_t^{SOE} - S_{t-1}^{SOE}) \tag{1.18}$$

with τ_t given by (1.37). In per capita terms the net production can be rewritten:

$$y_t^{SOE} = f(k_t^{SOE}) - \tau_t(k_t^{SOE} - \frac{s_{t-1}^{SOE}}{1+n_t^{SOE}}) \tag{1.19}$$

Indeed, in presence of iceberg costs the relevant measure of domestic production is domestic production net of transit losses.

Formally, the per capita balance-of-trade surplus of the small open economy is given by the following expression:

$$b_t^{SOE} = y_t^{SOE} - c_{1,t}^{SOE} - \frac{c_{2,t}^{SOE}}{(1+n_t^{SOE})} - k_{t+1}^{SOE}(1+n_{t+1}^{SOE}) \tag{1.20}$$

[16] The figures are based on the following Cobb-Douglas technology, $f(k) = k^{0.33}$. Further more $\rho = 0.5$ and the low, medium and high wedge levels correspond respectively to the following values of τ: $\tau_{low} = \frac{1}{20}\left(\frac{d\bar{r}_{t_0}^{RW}}{d\gamma^{RW}}\right)$, $\tau_{medium} = \frac{1}{5}\left(\frac{d\bar{r}_{t_0}^{RW}}{d\gamma^{RW}}\right)$, $\tau_{high} = \frac{d\bar{r}_{t_0}^{RW}}{d\gamma^{RW}}$.

Under the assumption that the technology is constant returns to scale, after some rearrangements, I obtain:

$$b_t^{SOE} = (1 + r_t^{SOE} - \tau_t)\left[k_t^{SOE} - \frac{s_{t-1}^{SOE}}{(1+n_t^{SOE})}\right] + s_t^{SOE} - k_{t+1}^{SOE}(1+n_{t+1}^{SOE}) \qquad (1.21)$$

The current account surplus is the excess of **net national** product over domestic absorption. Net national product equals net domestic product at time t, Y_t^{SOE}, plus net foreign investment income at time t that is formally given by $r_t^{SOE}(S_t^{SOE} - K_t^{SOE})$.[17] The small open economy current account surplus at time t is given by:

$$G_t^{SOE} = Y_t^{SOE} + r_t^{SOE}(S_t^{SOE} - K_t^{SOE}) - C_t^{SOE} - K_{t+1}^{SOE} \qquad (1.22)$$

In per capita terms, the current account surplus reduces to the following expression:

$$g_t^{SOE} = (1 - \tau_t)\left[k_t^{SOE} - \frac{s_{t-1}^{SOE}}{(1+n_t^{SOE})}\right] + s_t^{SOE} - k_{t+1}^{SOE}(1+n_{t+1}^{SOE}) \qquad (1.23)$$

At the steady state, the small open economy balance-of-trade and the current account equal zero, as the two regions become identical in every respect (in per capita terms). However, if the wedge is strictly below a certain threshold given by $\left|\frac{dr_{t_0}^{SOE}}{d\gamma^{RW}}\right|$, the occurrence of a rest of the world fertility shock is likely to impact upon the small open economy balance-of-trade and current account. To analyze the effect of an asymmetric demographic shock on saving/investment imbalance, I differentiate expressions (1.21) and (1.23) with respect to n_t^{RW}. Appendix 1.C presents the details of the linearization of those expressions.

I can now establish the following proposition on the consequences of a rest of the world negative fertility shock on saving/investment imbalance in the small open economy.

Proposition 1.2 *At the end of time $t_0 - 1$, capital flows into the small open economy, provided that the wedge between domestic and foreign investor return is lower than the exogenous short run impact of a negative fertility shock on the rest of the world interest rate. If the latter condition holds, at the end of time t_0 capital is repatriated in order to finance the old-aged consumption of rest of the world investors.*

[17] Net foreign investment income equals interest rate payments on the difference between the small open economy aggregate assets at time t minus domestic capital stock installed in the small open economy at time t. The economy being either at equilibrium of type 1 or 2, the interest rate received on small open economy individuals assets, r^{SOE}, equals the interest rate served on foreign investment in the small open economy (before transit losses occur).

Proof. see appendix 1.D. ■

At the end of time $t_0 - 1$, capital flows to the small open economy in order to exploit differences in returns, provided that the wedge is below a given threshold. The deviation from steady state of the current account position of the small open economy at time $t_0 - 1$ is given by the following expression:

$$\frac{dg_{t_0-1}^{SOE}}{d\gamma} = -\frac{dk_{t_0}^{SOE}}{d\gamma^{RW}} \leq 0 \tag{1.24}$$

At time t_0, capital flows out of the small open economy. Indeed, capital is repatriated to the rest of the world in order to finance old-aged investors' consumption. Formally, this is described by the following expression:

$$\frac{dg_{t_0}^{SOE}}{d\gamma} = \left[1 + \frac{-k_{ss}^{SOE} f''(k_{ss}^{SOE})}{2+\rho}\right] \frac{dk_{t_0}^{SOE}}{d\gamma^{RW}} - \frac{dk_{t_0+1}^{SOE}}{d\gamma^{RW}} > 0 \tag{1.25}$$

I establish another proposition as regards the capital movements resulting from a rest of the world asymmetric shock.

Proposition 1.3 *Provided that the wedge is below a certain threshold, a marginally higher wedge limits the magnitude of the small open economy capital inflows and ouflows resulting from of a rest of the world asymmetric fertility shock.*

Proof. For $t = t_0 - 1$, I combine (1.15) together with (1.24), and I then differentiate this combination with respect to τ. Using the fact that the rest of the world interest is exogenous, I obtain $\frac{d\left(\frac{dg_{t_0-1}^{SOE}}{d\gamma}\right)}{d\tau} = -\left[\frac{1}{f''(r_{ss}^{RW}+1)}\right] > 0$. A marginally higher wedge improves the small open economy current account position at time $t_0 - 1$.

For $t = t_0$, I combine (1.25) and (1.15), and then I differentiate this combination. It is then straightforward to show that $\frac{d\left(\frac{dg_{t_0}^{SOE}}{d\gamma}\right)}{d\tau} < 0$. A marginally higher wedge deteriorates the current account position at time t_0. ■

At the equilibrium, a marginally higher wedge requires that for a given rest of the world interest rate, the return in the small open economy will be higher. The diminishing returns assumption implies that the small open economy capital labor ratio should be lower for a given rest of the world interest rate. Thus less capital should flow to the small open economy to adjust for a rest of the world negative fertility shock. Figure 1.2 displays the evolution over time of the small open economy current account position for different degrees of external capital market imperfections.

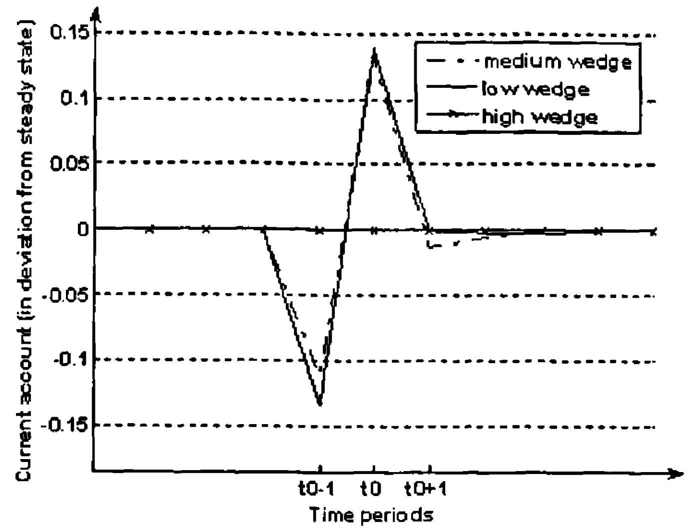

Figure 1.2: Evolution of Small Open Economy Current Account Position over Time

In the following subsection, I establish two propositions on the consequences of such an asymmetric shock on lifetime utility of individuals living in both regions.

1.2.3 Welfare Analysis

In order to evaluate the impact of a fertility shock on lifetime utility, I differentiate the lifetime utility function of individuals born at time t and living in region i with respect to n_t^{RW}.[18] The details of the linearization are shown in appendix 1.E.

In the following subsection, I establish a proposition on the impact of a rest of the world negative fertility shock on the lifetime utility of rest of the world individuals.

1.2.3.1 Rest of the World

Proposition 1.4 *Rest of the world individuals' lifetime utility decreases unambiguously for individuals born one period before the shock occurs. Under the assumption that the economy is initially below the golden rule, individuals born after the shock has occurred experience an increase in their lifetime utility.*

Proof. see the following. ■

Generations born before period $t_0 - 1$ do not experience any change in their lifetime utility. The generation born at time $t_0 - 1$ experiences an unambiguous decrease in its

[18] For $i \in \{SOE, RW\}$.

lifetime utility. Indeed, a negative fertility shock decreases this generation old-aged utility flow through lower interest rate payments. Formally, the deviation from steady state of the lifetime utility of rest of the world individuals born at time $t_0 - 1$ is given by the following expression:

$$\frac{dU_{t0-1}^{RW}}{d\gamma^{RW}} = \frac{1}{c_{2ss}^{RW}} \frac{1}{1+\rho} \frac{dc_{2,t0}^{RW}}{d\gamma} < 0 \tag{1.26}$$

with

$$\frac{dc_{2,t0}^{RW}}{d\gamma} = \left[\frac{w_{ss}^{RW}}{2+p}\right] \frac{d\overline{r}_{t0}^{RW}}{d\gamma^{RW}} < 0 \tag{1.27}$$

Using (1.14), it is straightforward to show that the impact on lifetime utility of generation born at time $t_0 - 1$ in the rest of the world is negative.

Generations born after $t_0 - 1$ experience an increase in their lifetime utility provided that the economy is below the golden rule. For individuals born after the shock has occurred, a negative fertility shock increases unambiguously their young-aged utility flow through an increase in their real wage. However, the effect of such a shock on old-aged utility flows is ambiguous. Indeed, there are two opposite effects resulting from a fertility rate shock on old-aged utility flows. First, a negative fertility shock tends to increase the amount of saving available at retirement age through a real wage increase. Second, a negative fertility shock tends to decrease old-aged wealth through a decrease in interest payments for a given real wage. The overall effect of a negative fertility shock on lifetime utility is positive if the rest of the world economy is initially below the golden rule of capital accumulation. Formally, the condition can be rewritten $n_{ss}^{RW} < r_{ss}^{RW}$. The details of the proof is provided in appendix 1.F. Indeed, if the rest of the world economy is initially below the golden rule, the economy is dynamically efficient. A negative fertility shock raising capital labor ratio further increases the economy efficiency.

I can now establish a proposition on the consequence of such an asymmetric shock on lifetime utility of an individual living in the small open economy.

1.2.3.2 Small Open Economy

Proposition 1.5 *If capital flows internationally, lifetime utility decreases unambiguously for small open economy individuals born one period before the shock occurs. Provided that the small open economy is initially below its golden rule, small open economy individuals born after the time the shock has occurred experience an increase in their lifetime welfare.*

Proof. I need to distinguish between two cases depending on whether or not capital flows internationally following a rest of the world negative fertility shock. If $\tau \geq \left|\frac{d\bar{r}_{t0}^{RW}}{d\gamma_{t0}^{RW}}\right|$, capital does not flow internationally following an asymmetric fertility shock. The world economy remains at capital equilibrium of type 1. Small open economy lifetime utility is not affected for all generations. If $\tau < \left|\frac{d\bar{r}_{t0}^{RW}}{d\gamma_{t0}^{RW}}\right|$, capital does flow internationally and the welfare of some generations living in the small open economy is affected. For small open economy individuals born before period $t_0 - 1$, there is no impact of an asymmetric shock on their lifetime utility. For individuals born at period $t_0 - 1$, lifetime utility decreases unambiguously for this generation. Provided that the economy is initially below the golden rule, a rest of the world negative fertility shock increases lifetime utility in the small open economy for the generation born after $t_0 - 1$. Formally, for individuals born after period $t_0 - 1$, lifetime utility increases if $n_{ss}^{SOE} < r_{ss}^{SOE}$.The details of the proof is provided in appendix 1.F. ■

These results are interpreted as follows. A small open economy aging slower than the rest of the world will experience change in welfare for some of its individuals provided that capital flows internationally. If the latter condition holds, the small open economy generation born one period before the shock occurs will unambiguously face a decrease in its lifetime utility. Generations born after the shock has occurred will experience an increase in welfare, provided that the small open economy is initially below the golden rule of capital accumulation. Figure 1.3 displays the evolution of small open economy individuals' lifetime utility over their birth periods for two different degrees of external capital market imperfections.

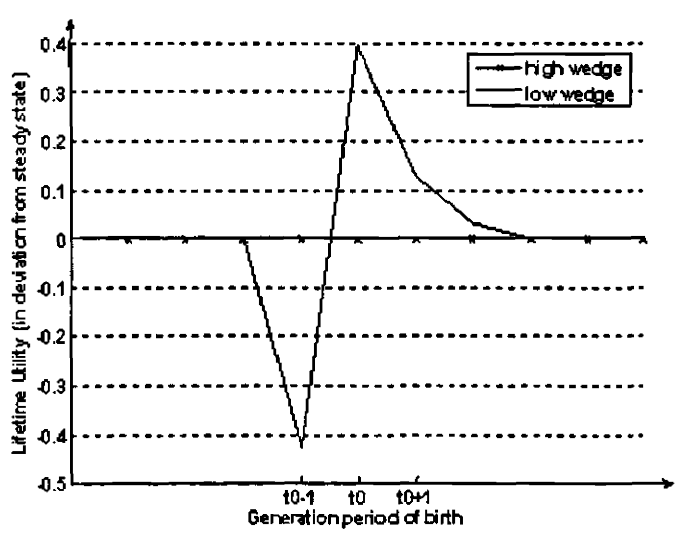

Figure 1.3: Evolution of Small Open Economy Individuals Lifetime Utility

1.3 Conclusion

Our objective in this paper has been to analyze the consequences of an asymmetric fertility shock on capital formation, saving/investment imbalance, and welfare. The framework of analysis is a Diamond-type overlapping-generations small open economy with external capital market imperfections. The external capital market imperfections is modelled through a symmetric wedge between foreign investor and domestic investor return on capital. A number of results are obtained. A rest of the world negative fertility shock is transmitted to the small open economy, depending on whether the wedge is below a given threshold. If the wedge is not too high, capital first flows into the small open economy to exploit the difference in returns on capital. After the shock has occurred, capital is repatriated in order to finance the old-aged consumption of rest of the world investors. If capital flows internationally, lifetime utility in the small open economy decreases unambiguously for individuals born one period before the shock occurs. Provided that the small open economy is below its golden rule, individuals born after the time the shock has occurred experience an increase in their lifetime utility.

The model can be extended in a number of directions. Within the context of our small open economy Diamond type model with external capital market imperfections, introducing a pay-as-you-go system can deliver interesting results on the consequence of fast aging OECD countries pension reforms on capital movements to younger emerging markets and welfare. The pension arrangements between the two regions can differ with respect to their generosity but can also differ in their nature (pay-as-you-go versus fully funded system). Another extension within this framework will analyze the adjustment of an asymmetric shock through labor mobility in the presence of transaction costs.[19] A welfare comparison on the adjustment to an asymmetric demographic shock through capital movement and labor movement can also be conducted. The scope for further development appears to be relevant and considerable.

So far, I have assumed that age structure was exogenous. There is, however, another theoretical and empirical literature where the age structure is endogenous. This other literature shows how a country's fertility rate is affected (along with the household saving rate) by capital market imperfections and more specifically by public pension system.[20] For instance, Cigno and Rosati [10] derive theoretical predictions from a model of endogenous fertility without altruism. The authors found that increasing public pension coverage both

[19] Galor [14] analyzes the welfare implications of international labor movement in a two-country overlapping generations framework, in presence of time preference rate differences.

[20] Cigno and Rosati [9], Cigno and Rosati [10], Cigno, Casolaro and Rosati [11], Ehrlich and Zhong [13] and, Zhang and Zhang [25] provide both theoretical and empirical investigations of the consequences of the expansion of social security coverage on the joint determination of household saving and fertility choice.

discourages fertility and increases household saving compared to a framework with exogenous fertility. This result is in contrast with life cycle or altruistic framework but is validated by Cigno and Rosati [10] empirical tests. Embedding Cigno and Rosati [10] theoretical framework in the context of a two regions model would tend to magnify the volume of international capital movements induced by differences in public pension coverage compared to models with exogenous fertility. Indeed, in the country with a lower social security coverage, fertility will be higher than in the other region. In addition, in the country with a lower social security coverage, household saving will be lower.[21] Overall, differences in capital labor ratios and returns on capital between the two regions will be magnified in the context of an endogenous fertility model compared to a framework where fertility is assumed to be exogenous. However, it should be noted that different assumptions on individual's degree of altruism (such as forward or backward altruism) will lead to different conclusions.

[21] On the one hand, a lower social security coverage will encourage saving by existing savers. On the other hand, a lower social security will decrease the number of savers. The latter effect dominates the former.

Appendices

1.A Rest of the World Dynamic Equilibrium

Individuals optimization problem

$$\max_{c_{1,t}^{RW},c_{2,t+1}^{RW}} U(c_{1,t}^{RW}, c_{2,t+1}^{RW}) = u(c_{1,t}^{RW}) + \frac{1}{1+\rho} u(c_{2,t+1}^{RW}) \tag{1.28}$$

$$c_{1,t}^{RW} + \frac{c_{2,t+1}^{RW}}{1+r_{t+1}^{RW}} \leq w_t^{RW} \tag{1.29}$$

$$c_{1,t}^{RW}, c_{2,t+1}^{RW} \geq 0 \tag{1.30}$$

Firms optimization problem

$$r_t^{RW} = f'(k_t^{RW}) - 1 \tag{1.31}$$

$$w_t^{RW} = f(k_t^{RW}) - k_t^{RW} f'(k_t^{RW}) \tag{1.32}$$

Capital market equilibrium condition

$$s_{1,t}^{RW} = k_{t+1}^{RW}(1+n_{t+1}^{RW}) \tag{1.33}$$

$$k_t^{RW} \geq 0 \tag{1.34}$$

The first order difference equation in k_t^{RW} that describes the evolution of the model from arbitrary initial conditions is given by the following expression:

$$k_{t+1}^{RW}\left[(1+n_{t+1}^{RW})\right] - \left[\frac{f(k_t^{RW}) - k_t^{RW} f'(k_t^{RW})}{2+\rho}\right] = 0 \tag{1.35}$$

1.B Capital Formation

For t such that $t < t_0$, that is before the shock occurs, a rest of the world negative fertility shock has no impact on the small open economy capital formation.

For t such that $t \geq t_0$, I formally derive the consequences of a rest of the world negative fertility shock on the small open economy interest rate through differentiating the following expression with respect to n_t^{RW} around the world economy steady state.

$$r_t^{SOE} - \tau_t = \overline{r}_t^{RW} \tag{1.36}$$

with τ_t such that

$$\begin{aligned} \tau_t &= \tau \text{ for all } t \text{ such that } \tau < \left| \frac{d\overline{r}_t^{RW}}{d\gamma^{RW}} \right| && (1.37) \\ &= 0 \text{ otherwise} && (1.38) \end{aligned}$$

Note first that for all t for which $\left| \frac{d\overline{r}_t^{RW}}{d\gamma^{RW}} \right| > \tau$, the rest of the world investor no arbitrage condition, that is formally given by $\overline{r}_t^{RW} = r_t^{SOE} - \tau$, is binding and the world economy is at equilibrium of type 2.

After differentiating (1.37), the following expression then holds:

$$\begin{aligned} \frac{d\tau_t}{d\gamma^{RW}} &= \tau \text{ for all } t \text{ such that } \tau < \left| \frac{d\overline{r}_t^{RW}}{d\gamma^{RW}} \right| \\ &= 0 \text{ otherwise} && (1.39) \end{aligned}$$

After differentiating expression (1.36), I formally have that:[22]

$$\begin{aligned} \frac{dr_t^{SOE}}{d\gamma^{RW}} &= \frac{d\overline{r}_t^{RW}}{d\gamma^{RW}} + \tau \text{ for all } t \text{ such that } \tau < \left| \frac{d\overline{r}_t^{RW}}{d\gamma^{RW}} \right| && (1.40) \\ &= 0 \text{ otherwise} && (1.41) \end{aligned}$$

To determine the effect of a fertility shock on the small open economy capital formation, I differentiate the following expression with respect to n_t^{RW} around the small open economy steady state.

[22]Note that if the condition $\left| \frac{d\overline{r}_t^{RW}}{d\gamma^{RW}} \right| \geqslant \tau$ holds, it is as if the wedge variable, τ_t, is subject to a shock of intensity τ, simultaneous to the fertility shock and that lasts until the above condition holds.

$$k_t^{SOE} = f'^{-1}(\overline{r}_t^{RW} + \tau_t + 1) \tag{1.42}$$

That reduces to the following expression:

$$\begin{aligned} \frac{dk_t^{SOE}}{d\gamma^{RW}} &= \left[\frac{1}{f''(k_{ss}^{RW})}\right]\left(\frac{d\overline{r}_t^{RW}}{d\gamma^{RW}} + \tau\right) > 0 \ \forall t \text{ such that } \tau < \left|\frac{d\overline{r}_t^{RW}}{d\gamma^{RW}}\right| \\ &= 0 \text{ otherwise} \end{aligned} \tag{1.43}$$

1.C Current Account Expression Linearization

To determine the effect of a rest of the world shock on the small open economy balance-of-trade, I differentiate the balance-of-trade expression namely equation (1.21) with respect to n_t^{RW} around the small open economy steady state. Formally, I obtain the following expression:[23]

$$\frac{db_t^{SOE}}{d\gamma^{RW}} = (1 + r_{ss}^{SOE})\left[\frac{dk_t^{SOE}}{d\gamma^{RW}} - \frac{ds_{t-1}^{SOE}}{d\gamma^{RW}}\right] + \frac{ds_t^{SOE}}{d\gamma^{RW}} - \frac{dk_{t+1}^{SOE}}{d\gamma^{RW}} \tag{1.44}$$

After some substitutions, I obtain the deviation from steady state equilibrium of the small open economy balance-of-trade.

$$\frac{db_t^{SOE}}{d\gamma} = \left[(1 + r_{ss}^{SOE})\frac{k_{ss}^{SOE} f''(k_{ss}^{SOE})}{2+\rho}\right]\frac{dk_{t-1}^{SOE}}{d\gamma^{RW}} + \tag{1.45}$$

$$\left[(1 + r_{ss}^{SOE}) + \frac{-k_{ss}^{SOE} f''(k_{ss}^{SOE})}{2+\rho}\right]\frac{dk_t^{SOE}}{d\gamma^{RW}} - \frac{dk_{t+1}^{SOE}}{d\gamma^{RW}} \tag{1.46}$$

In order to determine the effect of such an asymmetric shock on the small open economy current account, I differentiate (1.23) with respect to n_t^{RW} around the small economy steady state. Formally, I obtain the following expression:

$$\frac{dg_t^{SOE}}{d\gamma} = \frac{ds_{1,t}^{SOE}}{d\gamma} - \frac{d\left(\frac{s_{1,t-1}^{SOE}}{(1+n_t^{SOE})}\right)}{d\gamma} + \frac{dk_t^{SOE}}{d\gamma} - \frac{d(k_{t+1}^{SOE}(1+n_{t+1}^{SOE}))}{d\gamma} \tag{1.47}$$

[23]Note that at the steady state equilibrium, the world economy is at capital ownership of type 1. Thus $\tau > \left|\frac{d\overline{r}_t^{RW}}{d\gamma^{RW}}\right|$, so that $\tau_t = \tau_{ss} = 0$, for all t such that the small open economy balance of trade and current account position equal zero.at steady state.

After some substitutions, I obtain the small open economy current account deviation from steady state:

$$\frac{dg_t^{SOE}}{d\gamma^{RW}} = \left[\frac{dk_t^{SOE}}{d\gamma^{RW}} - \frac{ds_{t-1}^{SOE}}{d\gamma^{RW}}\right] + \frac{ds_t^{SOE}}{d\gamma^{RW}} - \frac{dk_{t+1}^{SOE}}{d\gamma^{RW}} \tag{1.48}$$

After some manipulations, I finally get:

$$\frac{dg_t^{SOE}}{d\gamma} = \left[\frac{k_{ss}^{SOE} f''(k_{ss}^{SOE})}{2+\rho}\right]\frac{dk_{t-1}^{SOE}}{d\gamma^{RW}} + \left[1 + \frac{-k_{ss}^{SOE} f''(k_{ss}^{SOE})}{2+\rho}\right]\frac{dk_t^{SOE}}{d\gamma^{RW}} - \frac{dk_{t+1}^{SOE}}{d\gamma^{RW}} \tag{1.49}$$

1.D Saving/Investment Imbalance

In the following section, I investigate the sign of a rest of the world negative fertility shock on both the balance-of-trade and the current account position, using the differential expressions presented in appendix 1.C.

I need to distinguish between two cases, depending on whether or not the transmission of the shock operates.

If $\tau \geq \left|\frac{dr_{t_0}^{RW}}{d\gamma_t^{RW}}\right|$, for all time periods the world economy remains at equilibrium of type 1. A rest of the world negative fertility shock has no impact either on the small open economy balance-of-trade and the current account position.

If $\tau < \left|\frac{dr_{t_0}^{RW}}{d\gamma_{t_0}^{RW}}\right|$, a rest of the world negative fertility shock affects the small open economy balance-of-trade and the current account position. Assuming the world economy is initially at its steady state, before the end of $t_0 - 1$, the balance-of-trade and the current account are not affected by a rest of the world shock. At the time period the shock occurs, that is between $t_0 - 1$ and t_0, the small open economy experiences capital inflows. Saving from the rest of the world is flowing into the small open economy in order to finance capital which will be used in the production at time t. Using (1.45) and (1.49), the small open economy deviation from steady state of the trade balance and the current account position at the end of time $t_0 - 1$ is given by the following expression:

$$\frac{db_{t_0-1}^{SOE}}{d\gamma} = \frac{dg_{t_0-1}^{SOE}}{d\gamma} = -\frac{dk_{t_0}^{SOE}}{d\gamma^{RW}} < 0 \tag{1.50}$$

Indeed, in presence of diminishing returns, capital flows from the rest of the world to the small open economy to exploit the difference in returns resulting from the rest of the world fertility shock.

At the end of time t_0, the capital flows out of the small open economy as capital is repatriated to the rest of the world in order to finance old-aged investor consumption that formally rewrites $\frac{dg_t^{SOE}}{d\gamma} > 0$ for $t = t_0$. Indeed, I have formally that:

$$\frac{dg_{t_0}^{SOE}}{d\gamma} = \left[1 + \frac{-k_{ss}^{SOE} f''(k_{ss}^{SOE})}{2+\rho}\right] \frac{dk_{t_0}^{SOE}}{d\gamma^{RW}} - \frac{dk_{t_0+1}^{SOE}}{d\gamma^{RW}} \tag{1.51}$$

Note that from (1.15) and (1.14) I have $\frac{dg_t^{SOE}}{d\gamma} > 0$ if :

$$\left[1 + \frac{-k_{ss}^{SOE} f''(k_{ss}^{SOE})}{2+\rho}\right] \frac{dr_{t_0}^{RW}}{d\gamma^{RW}} - \frac{dr_{t_0+1}^{RW}}{d\gamma^{RW}} < 0 \tag{1.52}$$

so that it reduces to:

$$\left[1 + \frac{-k_{ss}^{SOE} f''(k_{ss}^{SOE})}{2+\rho}\right] > \frac{dk_{t_0+1}^{RW}}{dk_{t_0}^{RW}} \tag{1.53}$$

From (1.12), I have that $\frac{dg_{t_0}^{SOE}}{d\gamma} > 0$. At period t_0 capital flows out of the small open economy in order to finance the rest of the world individuals old-aged consumption. It is also straightforward to show that at time t_0, a rest of the world shock has a positive impact on the small open economy balance-of-trade.

For $t \geq t_0 + 1$, given the transitory nature of the shock it can be shown that there are no capital flows from the rest of the world to the small open economy.

Substituting (1.15) into (1.49) gives $\frac{dg_t^{SOE}}{d\gamma} = 0$. Indeed, the details of substitution are as follows:

$$\left[\frac{k_{ss}^{SOE} f''(k_{ss}^{SOE})}{2+\rho}\right] \frac{d\overline{r}_{t-1}^{RW}}{d\gamma^{RW}} - \frac{d\overline{r}_{t+1}^{RW}}{d\gamma^{RW}} = -\left[1 + \frac{-k_{ss}^{SOE} f''(k_{ss}^{SOE})}{2+\rho}\right] \frac{d\overline{r}_t^{RW}}{d\gamma^{RW}} \tag{1.54}$$

Using (1.14) I obtain the following expression:

$$\left[\frac{k_{ss}^{SOE} f''(k_{ss}^{SOE})}{2+\rho}\right] \frac{d\overline{k}_{t-1}^{RW}}{d\gamma^{RW}} - \frac{d\overline{k}_{t+1}^{RW}}{d\gamma^{RW}} = -\left[1 + \frac{-k_{ss}^{SOE} f''(k_{ss}^{SOE})}{2+\rho}\right] \frac{d\overline{k}_t^{RW}}{d\gamma^{RW}} \tag{1.55}$$

Dividing (1.55) by $\frac{dk_t^{RW}}{d\gamma^{RW}}$, I obtain the following expression:

$$\left[\frac{k_{ss}^{SOE} f''(k_{ss}^{SOE})}{2+\rho}\right] \frac{d\overline{k}_{t-1}^{RW}}{dk_t^{RW}} - \frac{d\overline{k}_{t+1}^{RW}}{d\overline{k}_t^{RW}} = -\left[1 + \frac{-k_{ss}^{SOE} f''(k_{ss}^{SOE})}{2+\rho}\right] \tag{1.56}$$

Recall that from (1.12), I have for $t > t_0$:

$$\frac{d\overline{k}_{t+1}^{RW}}{d\overline{k}_t^{RW}} = \frac{-k_{ss}^{SOE} f''(k_{ss}^{SOE})}{2+\rho} \tag{1.57}$$

so that I obtain the following valid identity:

$$-1-\frac{-k_{ss}^{SOE}f''(k_{ss}^{SOE})}{2+\rho}=\left[-1-\frac{-k_{ss}^{SOE}f''(k_{ss}^{SOE})}{2+\rho}\right] \quad (1.58)$$

Similarly, it is also straightforward to show that for $t \geq t_0$, there is no effect of a rest of the world shock on the small open economy balance-of-trade.

As perfect capital mobility is assumed, the adjustment occurs instantaneously at the end of period t_0-1 (when capital flows into the small open economy) and at the end of time t_0 (when capital is repatriated in order to finance old-aged consumption of individuals living in the rest of the world).

1.E Lifetime Utility Function Linearization

Let U_t^i describe the lifetime utility of individuals born at time t living in region i for $i=\{SOE; RW\}$. Formally, U_t^i is given by the following expression:

$$U_t^i = u(c_{1,t}^i)+\frac{u(c_{2,t+1}^i)}{1+\rho} \quad (1.59)$$

with $c_{1,t}^i$ and $c_{2,t+1}^i$ given by:

$$c_{1,t}^i = w_t^i\left(\frac{1+\rho}{2+p}\right) \quad (1.60)$$

$$c_{2,t+1}^i = \left(\frac{w_t^i}{2+p}\right)(1+r_{t+1}^i) \quad (1.61)$$

Differentiating (1.59) with respect to n_t^{RW} around the economy steady state gives the following expression:

$$\frac{dU_t^i}{d\gamma^{RW}} = u'(c_{1,ss}^i)\frac{dc_{1,t}^i}{d\gamma^{RW}}+u'(c_{2,ss}^i)\frac{1}{1+\rho}\frac{dc_{2,t+1}^i}{d\gamma^{RW}} \quad (1.62)$$

with the corresponding consumption profile at steady state:

$$c_{1,ss}^i = w_{ss}^i\left[\frac{1+\rho}{2+p}\right] \quad (1.63)$$

$$c_{2,ss}^i = \left[\frac{w_{ss}^i}{2+p}\right](1+r_{ss}^i) \quad (1.64)$$

Factors prices deviation from steady state are given by the following expressions:

$$\frac{dw_t^i}{d\gamma^{RW}} = -k_{ss}^i f''(k_{ss}^i)\frac{dk_t^i}{d\gamma^{RW}} \quad (1.65)$$

$$\frac{dr_t^i}{d\gamma^{RW}} = f''(k_{ss}^i)\frac{dk_t^i}{d\gamma^{RW}} \quad (1.66)$$

Young and old-aged consumption deviations from steady state are given by:

$$\frac{dc_{1,t}^i}{d\gamma^{RW}} = \frac{dw_t^i}{d\gamma^{RW}}\left[\frac{1+\rho}{2+p}\right] \quad (1.67)$$

$$\frac{dc_{2,t+1}^i}{d\gamma^{RW}} = \frac{dw_t^i}{d\gamma^{RW}}\frac{1}{2+p}(1+r_{ss}^i) + \left[\frac{w_{ss}^i}{2+p}\right]\frac{dr_{t+1}^i}{d\gamma^{RW}} \quad (1.68)$$

Given the logarithmic utility assumption, the deviation from the steady state of the lifetime utility of an individual born at time t in region i reduces to the following expression:

$$\frac{dU_t^i}{d\gamma^{RW}} = \frac{1}{c_{1,ss}^i}\frac{dc_{1,t}^i}{d\gamma^{RW}} + \frac{1}{c_{2,ss}^i}\frac{1}{1+\rho}\frac{dc_{2,t+1}^i}{d\gamma^{RW}} \quad (1.69)$$

1.F Lifetime Utility

In the following, I prove that a negative fertility shock affects positively the lifetime welfare of an individual living in country i (for $i = \{SOE; RW\}$) provided that the economy i is below its golden rule of capital accumulation.

Combining (1.67) and (1.68) with (1.69), I obtain the following expression:

$$\frac{dU_t^i}{d\gamma^{RW}} = \frac{dw_t^i}{d\gamma^{RW}}\left[\frac{1}{c_{1,ss}^i}\left(\frac{1+\rho}{2+p}\right) + \frac{(1+r_{ss}^i)}{c_{2,ss}^i}\frac{1}{1+\rho}\frac{1}{2+p}\right] + \frac{dr_{t+1}^i}{d\gamma^{RW}}\left[\frac{1}{c_{2,ss}^i}\frac{1}{1+\rho}\left(\frac{w_{ss}^i}{2+p}\right)\right] \quad (1.70)$$

The impact of lifetime utility of an individual born after $t_0 - 1$ is positive if the following condition holds:

$$\frac{dw_t^i}{d\gamma^{RW}}(1+r_{ss}^i)\left[\frac{(2+\rho)}{w_{ss}^i}\right] > -\frac{dr_{t+1}^i}{d\gamma^{RW}} \quad (1.71)$$

using the above expression combined with (1.12), (1.65) and (1.66), I obtain the following condition:

$$\frac{(1+r_{ss}^i)}{(1+n_{ss}^i)} > \frac{dk_{t+1}^i}{dk_t^i} \quad (1.72)$$

Given the local stability condition, a sufficient condition for a negative fertility shock to affect positively the lifetime welfare of an individual living in country i is given by

$$r^i_{ss} > n^i_{ss} \tag{1.73}$$

If the economy is above the golden rule that formally rewrites, $r^i_{ss} < n^i_{ss}$, two cases need to be distinguished. First, if the following inequalities hold, then a negative fertility shock affects positively the lifetime welfare of an individual living in country i born after period t_0.

$$\frac{dk^i_{t+1}}{dk^i_t} < \frac{(1+r^i_{ss})}{(1+n^i_{ss})} < 1 \tag{1.74}$$

Second, if the following inequalities hold, then a negative fertility shock affects negatively the lifetime welfare of an individual living in country i born after period t_0.

$$\frac{(1+r^i_{ss})}{(1+n^i_{ss})} < \frac{dk^i_{t+1}}{dk^i_t} < 1 \tag{1.75}$$

Thus the economy being above the golden rule is a necessary but not sufficient condition for a negative fertility shock affect negatively the lifetime welfare of an individual living in country i born after period t_0.

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CHAPTER 2

AGING AND INTERNAL CAPITAL MARKET IMPERFECTIONS IN A GLOBALIZING WORLD: A SIMPLE MODEL

2.1 Introduction

There exist important differences in the timing and the size of the aging phenomenon across regions of the world. These differences are likely to remain important in the future (see United Nations [21]). In a two country framework, a partial equilibrium implication of the life cycle hypothesis is that the bulk of the saving supply triggered by the rapid aging country should flow to the slower aging country, where capital is relatively scarce and labor relatively abundant. This prediction matches with the past decades surge' in capital flows to younger/poorer countries following their capital market liberalization as shown in Prasad et al. [19].

However, those international capital flows appear to be limited compared to what the neoclassical theory would predict, as claimed in Lucas [17]. External capital market imperfections/political risk resulting from poor institutional arrangements has been put forward as an explanation of what is now called the Lucas' paradox.[1] Chapter 1 has analyzed the role of the interaction between demographic differences and **external** capital market imperfections in explaining the distribution of capital flows to younger/poorer countries through the foreign investment channel.

In the present chapter, I focus on the interaction between demographic differences and **internal** capital market imperfections/credit market imperfections in explaining distribution of capital flows to younger/poorer countries through the national saving channel. Japelli and Pagano [12] provide theoretical evidence that exogenous liquidity constraints, in a closed economy, (through redistributing from young/borrower individuals to middle age/saver individuals) tends to raise national saving and thus capital labor ratio. These authors provide empirical evidence that the loosening of liquidity constraints on households had a negative

[1] Alfaro et al. [1] have provided empirical evidence in that direction. Shleifer and Wolfenzon [20] model how agency costs stemming from inefficient corporate governance and law enforcement mechanisms impede foreign capital from flowing to capital-scarce countries.

impact on the national saving rate in OECD countries during the 1980s. In contrast, De Gregorio [7], introducing human capital to the latter theoretical framework, provides evidence that liquidity constraints (through impeding investment in human capital) reduce capital accumulation. In the present framework, through considering a small open economy framework with an asymmetric fertility shock, I shut down the channel through which liquidity constraints affect capital accumulation. However, in the latter framework, an asymmetric fertility shock interacts with the degree of liquidity constraints to determine national saving, and thus international capital movements.

The literature has been relatively scarce of the relevance on such an interaction in explaining international capital movements but abundant on the closed economy consequences of aging.[2] This literature is often related to the analysis of pay-as-you-go systems sustainability. Indeed, Auerbach and Kotlikoff [3] have initiated a wide strand of the literature on the consequence of social security reform in a context of aging economies. Both theoretical and empirical results, based on the life cycle hypothesis, suggest that aging increases capital intensity. The introduction of pay-as-you-go system is shown to be associated with a decrease in capital intensity (see for instance Kotlikoff [16]). A recent literature addresses the economic consequences of aging differences in an open economy framework using a large scale simulation models.[3] The simulations results of Attanasio and Violante [2] and Brooks [5], among others, point to a significant role of population age structure differences in explaining capital flows from fast aging OECD countries to slower aging emerging markets. Brooks [5] also predict a future reversal in the direction of international capital flows. Indeed, Brooks predictions suggest that capital will flow from currently younger countries to currently older ones as the former will enter into the fast aging stage of the demographic transition. There is however an important caveat to the literature which is addressed in the present chapter. To the extent of my knowledge, there is no study that analyzes the open economy adjustment to an asymmetric demographic shock in presence of internal capital market imperfections.[4] Chapter 3, building on Higgins [11], using panel data covering the period 1970 to 2000 for up to 115 countries, examines the role of age structure differences and their interaction with various capital imperfections in driving international capital flows in an empirical framework. In that chapter, I find that despite increased credit availability contributing to reduced aggregate saving, this will nevertheless magnify the role of the population age structure differences in driving international capital flows. These empirical

[2]Bosworth and al.[4] provide a useful survey on the financial and macroeconomic consequences of aging.

[3]Geide-Stevenson [9] and Groezen and Leers [10] focus on the open economy consequence of aging in presence of various pension arrangements.

[4]Kenc and al. [15] developed a simulation model to analyze the consequence of aging in the European Union for Turkey, introducing imperfect capital mobility.

results are consistent with the present chapter's theoretical findings.

This chapter examines the consequences of an asymmetric negative fertility shock on national saving rate, international capital flows and welfare. The framework is an overlapping-generations small open economy with internal capital market imperfections. The internal capital market imperfection is modelled through exogenous borrowing constraints on young-aged individuals' consumption. The rest of the chapter is organized as follows. Section 2.2 presents the model. Section 2.3 analyzes the consequence of a rest of the world asymmetric negative fertility shock on the small open economy in the presence of liquidity constraints. In section 2.3.2.2, I find that the consequences of a rest of the world negative fertility rate shock on small open economy's national saving are distributed in an hump-shaped fashion over time. I also find that looser liquidity constraints magnify the consequence of such asymmetric shock on the small open economy national saving. In section 2.3.2.3, I find that capital first flows into the small open economy to exploit the difference in returns on capital and to finance the small open economy young-aged individuals' increased borrowing. After the shock has occurred, I find that capital is repatriated to finance the old-aged consumption of the rest of the world investors. I also find that looser liquidity constraints magnify the consequence of such an asymmetric shock on the small open economy current account position. In section 2.3.2.4, I find that small open economy individuals' lifetime utility decreases unambiguously for individuals born one period before the shock has occurred. Provided that the small open economy is below its golden rule (without imperfections), individuals born after the shock has occurred experience an increase in their lifetime utility. I also find that the consequences of an asymmetric shock on the small open economy individuals' lifetime utility is independent of the small open economy's degree of liquidity constraints. Section 2.4 concludes and suggests an agenda for future research.

2.2 A Simple Model

The model consists of a small open economy and the rest of the world which are identical in every respect except in demographic patterns and in degrees of liquidity constraints. Each country is represented by competitive output and factor markets, overlapping generations, and an identical well-behaved constant returns to scale production f. Labor is not mobile. Capital is perfectly mobile. The model is standard except that I assume the presence of liquidity constraints in an open economy framework.

Individuals in both regions live for three periods. I assume that they earn labor income only in the second period of their life. This provides an incentive for intergenerational borrowing. Young-aged individuals are constrained in their borrowing caused by the presence of exogenous internal capital market imperfections/credit market imperfections. In order to capture the idea that credit markets are imperfect and that labor income (through common knowledge) is partly inalienable, I assume an exogenous borrowing limit of the form that young individuals can only borrow at most a fraction ϕ of the present value of their lifetime income. This modelling strategy follows Japelli and Pagano [12].[5] [6]

Preferences of an individual born at time t are given by

$$U^i(c^i_{1,t}, c^i_{2,t+1}, c^i_{3,t+2}) = \ln(c^i_{1,t}) + \beta \ln(c^i_{2,t+1}) + \beta^2 \ln(c^i_{3,t+2}) \tag{2.1}$$

where β is the discount factor and the first lower subscript indicates the life period, while the second lower subscript refers to the period at which consumption occurs. The upperscript i indicates individuals country of residence. With indices RW, SOE referring respectively to the rest of the world and the small open economy.

Households maximize utility subject to

$$c^i_{1,t} + \frac{c^i_{2,t+1}}{R^i_{t+1}} + \frac{c^i_{3,t+2}}{R^i_{t+1}R^i_{t+2}} \leqslant \frac{w^i_{t+1}}{R^i_{t+1}} \tag{2.2}$$

$$c^i_{1,t} \leqslant \phi^i \frac{w^i_{t+1}}{R^i_{t+1}} \tag{2.3}$$

where w^i_{t+1} is real labor earnings at time $t+1$, and R^i_{t+1} is the real interest factor between time t and $t+1$ in region i . Equation (2.2) is the intertemporal budget constraint. Equation (2.3) is a liquidity constraint. Two cases need to be distinguished depending on whether the liquidity constraint is binding or not.[7] First, if the liquidity constraint is not binding, the consumption of the young is

$$c^i_{1,t} = \eta \frac{w^i_{t+1}}{R^i_{t+1}} \tag{2.4}$$

where $\eta = 1/(1 + \beta + \beta^2)$. Second, if $\phi^i < \eta$, instead, the borrowing constraint is binding, and first-period consumption is equal to the limit (the righ hand side of (2.3)). Optimal consumption levels of middle-aged and old-aged individuals born at time t in region i are formally given by the following expression:

[5] De Gregorio [7], Buiter and Kletzer [6], and De Gregorio and Kim [8] have also made such an assumption to study the effect of borrowing limits in models where households have to finance their education.

[6] Obviously, the assumption of exogenous borrowing constraints is not fully satisfactory. Kehoe and Levine [14] developed a more realistic framework in which endogenous borrowing limits arises as the outcome of individual rationality constraints which prevent individuals from defaulting at equilibrium. For the purpose of tractability, I assume exogenous borrowing constraints in the present chapter.

[7] Throughout the chapter the expressions "credit constraints" and "liquidity constraints" are used equivalently.

$$c^i_{2,t+1} = \frac{1-\phi^i}{1+\beta^i} w^i_{t+1} \tag{2.5}$$

$$c^i_{3,t+2} = \frac{\beta^i(1-\phi^i)}{1+\beta^i} R^i_{t+2} w^i_{t+1} \tag{2.6}$$

In the following, I assume that the liquidity constraints are binding in both regions. Aggregate net wealth is given by the sum of middle-aged individuals wealth and the young-aged individuals debt:

$$A^i_t = (w^i_t - c^i_{2,t} - c^i_{1,t-1}R^i_t)L^i_{1,t-1} - c^i_{1,t}L^i_{1,t} \tag{2.7}$$

The above expression rewrites:

$$A^i_t = w^i_t \frac{\beta^i\left(1-\phi^i\right)}{1+\beta^i} L^i_{1,t-1} - \phi^i \frac{w^i_{t+1}}{R^i_{t+1}} L^i_{1,t} \tag{2.8}$$

Technology is identical across regions. f is assumed to be twice differentiable and to follow the Inada conditions.[8] It is summarized by the following aggregate production function:

$$Y^i_t = f(K^i_t, L^i_{2,t}) \tag{2.9}$$

where Y^i_t is aggregate output, K^i_t is the aggregate capital stock, and $L^i_{2,t}$ is the labor force which will vary in presence of fertility shocks assumed hereafter. Each middled-aged individual supplies inelastically one unit of labor. Capital is assumed to fully depreciate within one period. Firms located in region i maximize profits taking as given domestic factor prices. Equations (2.10) and (2.11) state that the capital rental market and labor market in region i are competitive.

$$R^i_t = f'(k^i_t) \tag{2.10}$$

$$w^i_t = f(k^i_t) - k^i_t f'(k^i_t) \tag{2.11}$$

where k^i_t is the capital labor ratio as given by

$$k^i_t = \frac{K^i_t}{L^i_{2,t}} \tag{2.12}$$

[8] Formally, the Inada conditions rewrite: $f(0) = 0$; $f' > 0$; $f'(0) = +\infty$ and $f'(0) = 0$.

2.2.1 Equilibrium

In this subsection, I characterize the equilibrium in both regions.

2.2.1.1 Rest of the World

The small open economy assumption implies that the rest of the world equilibrium is identical to the closed economy one. The capital market equilibrium condition in the rest of the world economy states that total wealth at time t is equal to capital stock at time $t+1$, that formally rewrites $A_t^{RW} = K_{t+1}^{RW}$. Substituting the expression for wealth (2.8) into the capital market equilibrium, one obtains a first order difference equation in capital labor ratio, k_t^{RW}, that describes the evolution of the model from arbitrary initial conditions given by the following expression:

$$k_{t+1}^{RW}(1+n_t^{RW}) = w_t^{RW}\frac{\beta\left(1-\phi^{RW}\right)}{1+\beta} - \frac{w_{t+1}^{RW}}{R_{t+1}^{RW}}\phi^{RW}(1+n_t^{RW}) \tag{2.13}$$

I assume that the rest of the world is subject to a negative fertility shock. γ^{RW} denotes the size of the shock and h^{RW} denotes the time pattern of the shock.[9] The rest of the world economy fertility rate at time t, n_t^{RW}, is assumed to be equal to the sum of its steady state value, n_{ss}^{RW}, and its deviation from the steady state, $\gamma^{RW}h_t^{RW}$, as described by the following expression:

$$n_t^{RW} = n_{ss}^{RW} + \gamma^{RW}h_t^{RW} \tag{2.14}$$

The variables evaluated at the steady state of economy are distinguished by a lower index ss. The steady state value of the capital labor ratio, k_{ss}^{RW}, corresponds to the fix point solution to the difference equation (2.13). Formally, the rest of the world capital labor ratio equals[10]

$$k_{ss}^{RW} = \left[\frac{(1-\alpha)\frac{\beta\left(1-\phi^{RW}\right)}{1+\beta}}{(1+n_{ss}^{RW})\left(1+\frac{(1-\alpha)}{\alpha}\phi^{RW}\right)}\right]^{\frac{1}{1-\alpha}} \tag{2.15}$$

[9] In the case of a one period shock, h_t^{RW} takes the form: $\{0 \text{ at } t=0,\dots, 0 \text{ at } t=t_0-1,\ -1 \text{ at } t=t_0,\ 0 \text{ at } t=t_0+1,\dots\}$ with t_0 denoting the time at which the shock occurs.

[10] It is straightforward to show that the rest of the world steady capital labor ratio is higher in an economy with more stringent (lower ϕ^{RW}) borrowing constraints.

2.2.1.2 Small Open Economy

The two regions are linked together in an international commodity and capital market. I make the assumption of perfect international mobility of financial capital. This means that the small open economy interest rate is equalized to the exogenous interest rate of the rest of the world:

$$R_t^{RW} = R_t^{SOE} \;\; \forall\, t \tag{2.16}$$

With international capital mobility, location and ownership of physical capital no longer coincide. From interest equalization, free trade in capital goods, and identical production functions, it follows that small open economy capital labor ratio and wage are pinned down by the rest of the world economy as formally given by the following expressions:

$$k_t^{RW} = k_t^{SOE} \tag{2.17}$$

$$w_t^{RW} = w_t^{SOE} \tag{2.18}$$

2.3 Consequences of an Asymmetric Fertility Shock

In this section, I analyze the consequences of a rest of the world negative fertility shock on small open economy national saving, current account position and welfare. To do so, I first identify the exogenous variation of the rest of the world capital labor ratio resulting from an asymmetric fertility shock.

2.3.1 Rest of the World

Indeed, in the present framework, the consequence of a rest of the world fertility shock on the small open economy capital labor ratio is pinned down by the exogenous variation in the rest of the world capital labor ratio. In contrast, chapter 1 shows that in a small open economy Diamond type Overlapping Generations framework with an exogenous external capital market imperfections, the transmission of an asymmetric fertility shock to the small open economy depends on the degree of external capital imperfections.

2.3.1.1 Capital Formation

I assume that the rest of the world is subject to a transitory negative fertility shock.[11] To study the consequences of such a shock on the rest of the world economy, I differentiate (2.13) with respect to n_t^{RW} around the rest of the world economy steady state. I obtain the following expression:[12]

$$\begin{aligned} & \frac{dk_{t+1}^{RW}}{d\gamma^{RW}}(1+n_{ss}^{RW})\left[1-\phi^{RW}\left(\frac{k_{ss}^{RW} f''(k_{ss}^{RW})}{R_{ss}^{RW}} + \frac{w_{ss}^{RW}}{R_{ss}^{RW\,2}} f''(k_{ss}^{RW})\right)\right] \\ = & -k_{ss}^{RW} f''(k_{ss}^{RW}) \frac{\beta\left(1-\phi^{RW}\right)}{1+\beta}\frac{dk_t^{RW}}{d\gamma} - h_t^{RW}\left[\phi^{RW}\frac{w_{ss}^{RW}}{R_{ss}^{RW}} + k_{ss}^{RW}\right] \end{aligned} \quad (2.19)$$

To ensure local stability of the system described by equation (2.19), I assume that $\frac{dk_{t+1}^{RW}}{dk_t^{RW}} < 1$ that is equivalent to $\frac{-k_{ss}^{RW} f''(k_{ss}^{RW})\frac{\beta\left(1-\phi^{RW}\right)}{1+\beta}}{(1+n_{ss}^{RW})\left[1-\phi^{RW}\left(\frac{k_{ss}^{RW} f''(k_{ss}^{RW})}{R_{ss}^{RW}} + \frac{w_{ss}^{RW}}{R_{ss}^{RW\,2}} f''(k_{ss}^{RW})\right)\right]} < 1$.[13]

Before the shock has occurred, that is formally for $t \leqslant t_0$, the fertility shock has no consequence on the capital labor ratio. Indeed, up to period t_0 (included), factor prices are predetermined variables. Given the logarithmic form of sub-utility function, whether the shock is anticipated or not, has no impact on the behavior of individuals born before the shock occurs.

A decline in the fertility rate occurring between period between $t_0 - 1$ and t_0, has a positive impact on the capital labor ratio at period t_0+1, as illustrated in Figure 2.1.[14] Two effects are at play. First, the decrease in the labor force (occurring at the period following the shock) requires less capital to endow new workers, thus capital labor ratio tends to rise. Second, the number of young-aged individuals decreases, so that the amount of borrowing is decreasing everything, else being equal. These two effects tend to raise capital labor ratio at the period following the shock. This increase in capital labor ratio at the next period tends to rise young-aged individuals borrowing at period t_0, anticipating a higher lifetime income. The latter feedback effect tends to reduce the increase in the capital labor ratio. Overall

[11] I only consider a one period shock for expositional purpose. My main results are qualitatively similar in the case of a multi-period shock.

[12] Note that the rest of the world degree of borrowing constraints affect the steady state world capital labor ratio.

[13] In the Cobb-Douglas case, the local stability condition reduces to $\frac{dk_{t+1}^{RW}}{dk_t^{RW}} = \alpha < 1$.

[14] The figure is based on the following Cobb-Douglas technology, $f(k) = k^{0.33}$. Further more $\beta = 0.9$, $\phi^{RW} = \frac{4}{5}\eta$.

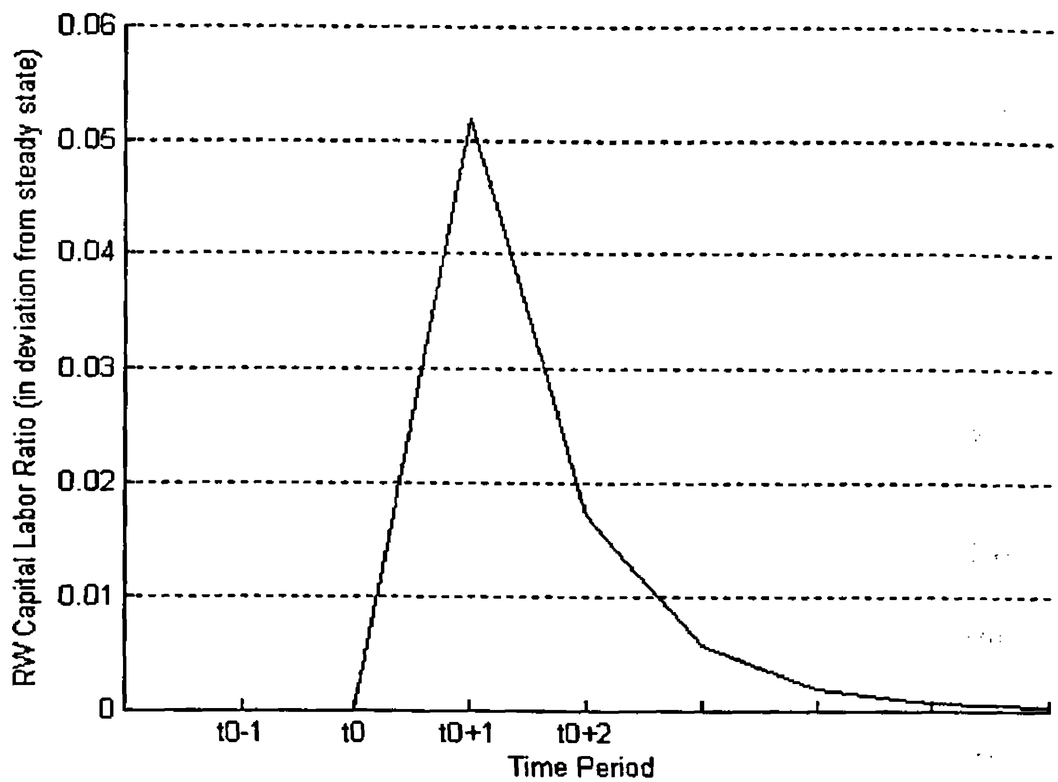

Figure 2.1: Evolution of the World Capital Formation over Time

capital labor ratio increases at the period following the shock, as formally given by

$$\frac{dk_{t_{0+1}}^{RW}}{d\gamma^{RW}} = \frac{\left(\phi^{RW}\frac{w_{ss}^{RW}}{R_{ss}^{RW}} + k_{ss}^{RW}\right)}{\left(1+n_{ss}^{RW}\right)\left[1-\phi^{RW}\left(\frac{k_{ss}^{RW} f"(k_{ss}^{RW})}{R_{ss}^{RW}} + \frac{w_{ss}^{RW}}{R_{ss2}^{RW\ 2}} f"(k_{ss}^{RW})\right)\right]} > 0 \tag{2.20}$$

After period t_0+1, a negative fertility rate shock has a positive impact on the capital labor ratio. The increase in middle-aged individuals' income translates into an increase in their saving (as their consumption increases but by less than their income given the homothetic utility function assumption) thus tending to raise total wealth and the capital labor ratio, everything else being equal. The feedback effect of the increase in the capital labor ratio resulting in increased borrowing by the currently young-aged individuals (anticipating that their lifetime income will increase) tends to decrease total wealth. Overall, the capital labor ratio increases. And so on and so forth, for the following periods. Given the local stability condition, the effect of the negative fertility shock vanishes over time.

$$\frac{dk_{t+1}^{RW}}{d\gamma^{RW}} = \frac{-k_{ss}^{RW} f''(k_{ss}^{RW}) \frac{\beta(1-\phi^{RW})}{1+\beta}}{(1+n_{ss}^{RW})\left[1-\phi^{RW}\left(\frac{k_{ss}^{RW} f''(k_{ss}^{RW})}{R_{ss}^{RW}} + \frac{w_{ss}^{RW}}{R_{ss}^{RW\,2}} f''(k_{ss2}^{RW})\right)\right]} \frac{dk_t^{RW}}{d\gamma^{RW}} > 0 \ \forall\, t \text{ such that } t \geqslant t_0+1 \tag{2.21}$$

Hereafter, I assume for simplicity that the production is Cobb-Douglas. The linearization of the expression characterizing the law of motion of the rest of the world capital labor ratio reduces to

$$\frac{dk_{t+1}^{RW}}{d\gamma^{RW}} = \alpha \frac{dk_t^{RW}}{d\gamma} - \frac{h_t^{RW}}{(1+n_{ss}^{RW})} k_{ss}^{RW} \tag{2.22}$$

Let's us investigate the consequences of such an asymmetric fertility rate shock on small open economy national saving, current account position and welfare.

2.3.2 Small Open Economy

2.3.2.1 Capital Labor Ratio

Recall that, in the present framework, the impact of a rest of the world fertility shock translates instantaneously into an increase in the small open economy capital labor ratio.

$$\frac{dk_t^{RW}}{d\gamma^{RW}} = \frac{dk_t^{SOE}}{d\gamma^{RW}} \tag{2.23}$$

Different degrees of liquidity constraints, in the small open economy, do not impact the small open economy capital labor ratio as the latter is pinned down by the rest of the world capital labor ratio.

2.3.2.2 Saving Rate

In the following, I analyze the consequences of the interaction between a rest of the world negative fertility shock and the small open economy degree of liquidity constraints on the small open economy national saving rate. I obtain two results. First, the consequences of a rest of the world negative fertility rate shock on the small open economy national saving are distributed in an hump-shaped fashion over time. Second, under a given parameters values condition, looser liquidity constraints magnify the consequences of such an asymmetric shock on the small open economy national saving. The results stated below are illustrated in Figure

2.2.[15]

In an open economy national saving rate at time t is equal to the variation in net assets between time t and $t-1$ divided by aggregate production at time t as formally given by

$$\frac{S_t^{SOE}}{Y_t^{SOE}} = \frac{A_t^{SOE} - A_{t-1}^{SOE}}{Y_t^{SOE}} \tag{2.24}$$

In order to investigate the consequences of an asymmetric shock on the small open economy national saving, I linearize the above expression with respect to n_t^{RW}. Appendix 2.A and 2.B provide the details of the linearization and the proof of the results stated below. In order to investigate the interaction between an asymmetric fertility shock and the small open economy degree of liquidity constraints, I resort to comparative static with respect to the small open economy degree of liquidity constraint as shown in Appendix 2.B.

- Before the asymmetric shock has occurred, that is before time t_0, small open economy national saving rate is not affected.

- At the time the shock has occurred, that is at time t_0, an asymmetric fertility shock decreases the small open economy national saving rate. Indeed, small open economy national saving rate at time t_0 is only affected by the asymmetric fertility shock through the change in the behavior of small open economy young-aged individuals born at time t_0. Young-aged individuals born at time t_0 in the small open economy increase their borrowing, anticipating a higher lifetime income. This tends to decrease total wealth at time t_0 thus decreasing national saving, given that total wealth at time $t_0 - 1$ remains non affected.

  - Less stringent liquidity constraints appear to magnify the impact of an asymmetric shock on the small open economy national saving rate at time t_0. Indeed, less stringent liquidity constraints allow young-aged individuals to borrow a higher share of their increased lifetime income. This tends to strengthen the small open economy national saving rate decrease triggered by an asymmetric fertility shock.[16]

[15]The figures are based on the following Cobb-Douglas technology, $f(k) = k^{0.33}$. Further more $\beta = 0.9$, $\phi^{RW} = \frac{4}{5}\eta$ and the low and high constraints correspond respectively to the following values of ϕ^{SOE} : $\phi_{low}^{SOE} = \frac{3}{5}\eta$, $\phi_{high}^{SOE} = \frac{1}{5}\eta$.

[16]I assumed that the rest of the world degree of borrowing constraint is constant and different from the small open economy one. Thus there is no feedback effect of a different small open economy borrowing constraint on world capital labor ratio unlike in Japelli and Pagano [12] framework.

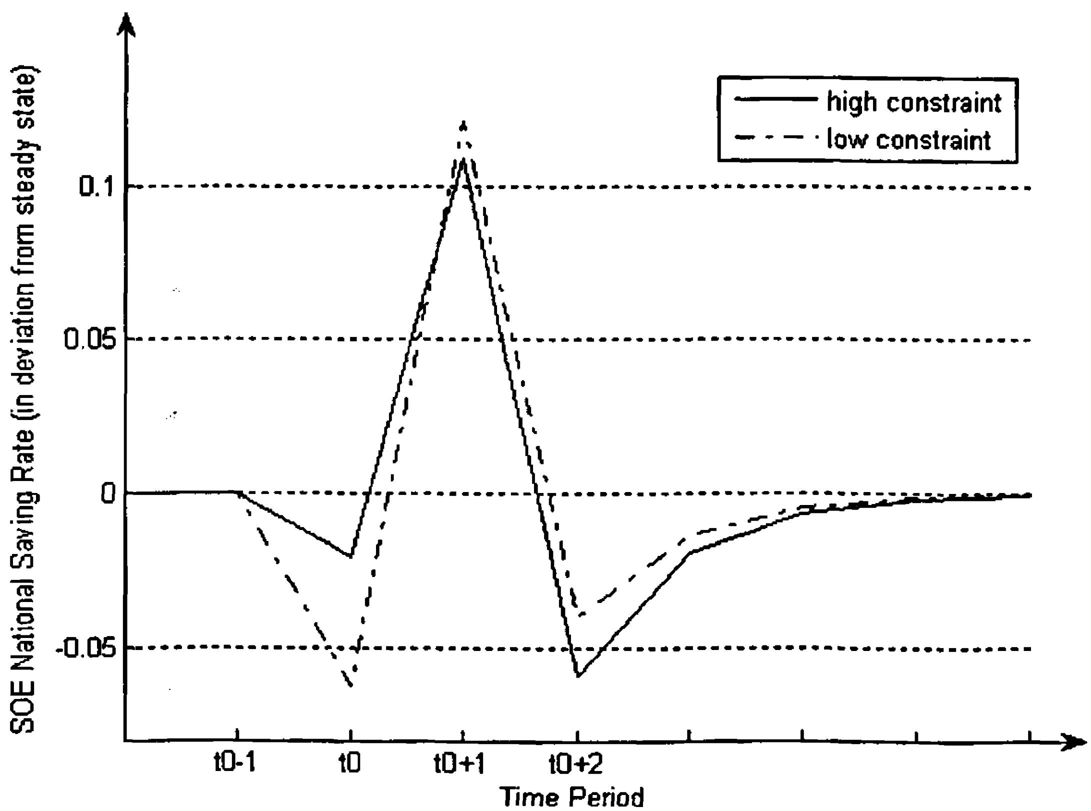

Figure 2.2: Evolution of Small Open Economy National Saving Rate over Time

- One period after the shock has occurred, that is at time t_0+1, an asymmetric fertility shock has a positive impact on the small open economy saving rate. Indeed, three effects are at play. First, a higher world capital labor ratio (through an increased borrowing of small open economy young-aged individuals born at time t_0) decreases small open economy total wealth at time t_0. This tends to raise national saving at time t_0+1. Second, the labor income increase triggered by an asymmetric fertility shock raises middle-aged individuals' saving at time t_0+1. Thus total wealth at time t_0+1 tends to increase. Third, a higher labor income increases the borrowing of young-aged individuals born at time t_0+1. This tends to decrease small open economy total wealth at time t_0+1, and thus to decrease national saving at time at time t_0+1. Given the local stability condition, the increased borrowing of young-aged individuals born at time t_0 is higher than the increased borrowing of young-aged individuals born at time t_0+1. Thus the first effect dominates the third effect. Overall, an asymmetric fertility shock occurring at time t_0 increases small open economy national saving at time t_0+1.

  - Less stringent liquidity constraints have an ambiguous effect on the impact of an asymmetric fertility shock on small open economy national saving rate at time t_0+1. Three effects are at play. First, less stringent liquidity constraints tend to increase borrowing of young-aged individuals born at time t_0 triggered by an asymmetric shock. This tends to boost the consequences of an asymmetric shock on national saving at time t_0+1. Second, less stringent liquidity constraints dampen middle-aged individuals' increased saving who are living at time t_0+1. This tends to reduce the consequences of an asymmetric fertility shock on national saving at time t_0. Third, less stringent liquidity constraints encourage increased young-aged individuals borrowing who are born at time t_0+1. This reduces the consequences of an asymmetric fertility shock on national saving at time t_0+1. Overall, which of the effect dominates depends on the rest of the world (constant) degree of liquidity constraints. If the rest of the world liquidity constraints are above a given threshold (see appendix 2.B), less stringent small open economy liquidity constraints magnify the impact of an asymmetric fertility shock on small open economy national saving after the period the shock has occurred.

- After period t_0+1, an asymmetric fertility shock has a negative impact on the small open economy national saving rate. Two opposing effects are at play on total wealth at time $t+1$ and t (for $t > t_0$). First, a higher lifetime income increases middle-aged individuals saving thus raising national wealth. Second, a higher capital labor ratio increases young-aged individuals lifetime income thus reducing total wealth. Overall, small open economy national wealth increases following an asymmetric fertility shock two periods after the shock has occurred and onwards[17]. However, under the local stability condition, total wealth increases but by less every period thus reducing national saving for $t > t_0 + 1$.

  - Less stringent borrowing constraints dampen the decrease in the small open economy national saving rate. Indeed, less stringent borrowing constraints through reducing middle-aged saving and increasing young age individual borrowing reduce total wealth. However, given local stability condition, this reduction of an asymmetric fertility shock impact on national wealth induced by higher liquidity constraints is decreasing over time, thus raising national saving rate. Overall, a higher degree of liquidity constraints reduces the impact of an asymmetric fertility shock after period $t_0 + 1$.

- Eventually, given the local stability condition, the effect of an asymmetric fertility shock on the small open economy vanishes over time.

2.3.2.3 International Capital Flows

In the following, I analyze the consequences of an asymmetric shock both on the small open economy balance-of-trade surplus (deficit), B^{SOE}, and on the current account surplus (deficit), G^{SOE}.

The small open economy balance-of-trade surplus at time t is the excess of domestic product at time t, Y_t^{SOE}, over domestic absorption. Domestic absorption is the sum of aggregate consumption at time t, C_t^{SOE}, and domestic capital formation used in the production at time $t+1$, K_{t+1}^{SOE}:

$$B_t^{SOE} = Y_t^{SOE} - C_t^{SOE} - K_{t+1}^{SOE} \tag{2.25}$$

Formally, the per capita balance-of-trade surplus of the small open economy, under the assumption that the technology is constants returns to scale, is given by

$$b_t^{SOE} = w_t^{SOE} + (R_t^{SOE} - 1)k_t^{SOE} - c_{1,t}^{SOE}(1 + n_t^{SOE}) + c_{2,t}^{SOE} + \frac{c_{3,t}^{SOE}}{(1 + n_{t-1}^{SOE})} - k_{t+1}^{SOE}(1 + n_t^{SOE}) \tag{2.26}$$

[17] This result holds under the assumption that the degree of borrowing constraints is lower in rest of the world than in the small open economy, that is $\phi^{RW} > \phi^{SOE}$.

The current account is the excess of national product over domestic absorption. Net national product equals domestic product at time t, Y_t^{SOE}, plus net foreign investment income at time t that is formally given by $(R_t^{SOE}-1)(A_t^{SOE}-K_t^{SOE})$. The small open economy current account surplus at time t is given by:

$$CAB_t^{SOE} = Y_t^{SOE} + (R_t^{SOE}-1)(A_t^{SOE}-K_t^{SOE}) - C_t^{SOE} - K_{t+1}^{SOE} \tag{2.27}$$

with

$$C_t^{SOE} = c_{1,t}^{SOE}L_{1,t}^{SOE} + c_{2,t}^{SOE}L_{1,t-1}^{SOE} + c_{3,t}^{SOE}L_{1,t-2}^{SOE} \tag{2.28}$$

Under the assumption that the technology is constant returns to scale, after some rearrangements, the small open economy current account surplus, in per (active population) capita terms is given by

$$\begin{aligned} cab_t^{SOE} \;=\;& R_t^{SOE}\left[w_t^{SOE} - c_{2,t}^{SOE} - (1+n_t^{SOE})\right] \qquad\qquad (2.29a)\\ & -(R_t^{SOE}-1)c_{1,t-1}^{SOE}R_t^{SOE} + k_t^{SOE} - \frac{c_{3,t}^{SOE}}{(1+n_{t-1})} - k_{t+1}^{SOE}(1+n_t^{SOE}) \end{aligned}$$

The occurrence of a rest of the world fertility shock is likely to impact the small open economy balance-of-trade and current account. To analyze the effect of an asymmetric fertility shock on saving/investment imbalance, I differentiate expressions (2.26) and (2.29a) with respect to n_t^{RW}. Appendix 2.C and 2.D present the details of the linearization of those expressions and the proof of the results stated below. Some results in this subsection are established through numerical simulations illustrated in Figure 2.3. Robustness checks over a wide range of parameters confirm the validity of the results stated below.[18]

- Before the period t_0, the small open economy current account position is not affected by a fertility shock occurring at period t_0.
- At the end of period t_0, capital flows into the small open economy in order to exploit the differences in returns, and to finance small open economy young-aged individuals' increased borrowing, as illustrated in Figure 2.3. The deviation from steady state of the small open economy current account position at time t_0 is given by expression (2.30). Two effects are at play. First, in presence of diminishing returns, capital flows from the rest of the world to the small open economy to exploit differences in returns resulting from a rest of the world fertility shock. This effect corresponds to

[18] Robutness checks are available upon request.

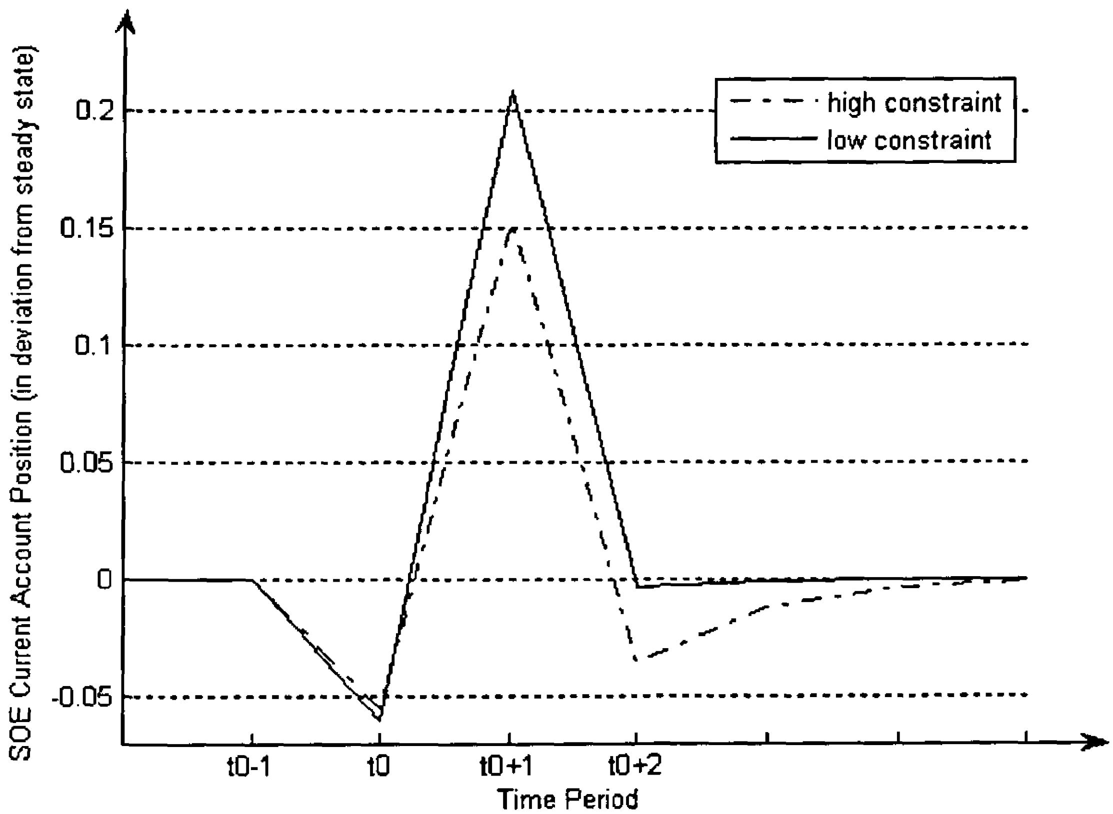

Figure 2.3: Evolution of the Small Open Economy CAB over Time

the first term on the right-hand side of expression (2.30). Second, small open economy young-aged individuals born at the time the shock occurs, anticipate that their lifetime income is increasing and thus increase their borrowing from the rest of the world. This effect corresponds to the second term on the right-hand side of expression (2.30). Both effects deteriorate unambiguously the small open economy balance-of-trade and the current account position.

- Less stringent borrowing constraints(in the case of a Cobb-Douglas), unambiguously magnify the impact on the volume of capital inflows induced by an asymmetric fertility shock occurring at time t_0. Indeed, less stringent borrowing constraints only affect the amount of increased borrowing triggered by the asymmetric fertility shock but do not impact the increased investment. Formally, the differential of the above expression with respect to ϕ^{SOE} is unambiguously negative as demonstrated in appendix 2.D.

$$\frac{dcab_{t_0}^{SOE}}{d\gamma^{RW}} = -\frac{dk_{t_0+1}}{d\gamma}(1+n_{ss}^{SOE}) + R_{ss}^{SOE}\left[-\frac{dc_{1,t_0}^{SOE}}{d\gamma}(1+n_{ss}^{SOE})\right] < 0 \qquad (2.30)$$

- At the end of time t_0+1, capital flows out of the small open economy in order to finance rest of the world old-aged investors' consumption. Indeed, at time t_0+1, there is a higher proportion of working age population (compared to the rest of the world) that tends to increase small open economy national saving (as shown in the above subsection) and which exceeds the increased investment. I resort to simulations to establish the present result. Indeed, numerical simulations, as illustrated in Figure 2.3, show that an asymmetric fertility shock lead to a small open economy current account surplus at period t_0+1.

  - Less stringent liquidity constraints magnify the current account surplus triggered by an asymmetric fertility shock as shown in Figure 2.3. Indeed, as shown in the above subsection, given that the rest of the world degree of liquidity constraints is below a given threshold, less stringent liquidity constraints strengthen the impact of an asymmetric fertility shock on national saving at the period after the shock has occurred. Given that the small open economy degree of liquidity constraints is not affecting the increased investment triggered by the shock, less stringent liquidity constraints magnify the impact of such an asymmetric shock on the small open economy current account surplus at period $t_0 + 1$. I also resort to numerical simulations, as illustrated in Figure 2.3, to establish this result.

- After period $t_0 + 1$, the small open economy experiences net capital inflows as established by numerical simulations. Indeed, old-aged individuals are in a higher proportion in the small open economy compared to the rest of the world. Thus the lack of saving in the small open economy translates into a current account deficit (in per capita terms) of that region. As shown in the above subsection, an asymmetric fertility shock has a negative impact on the small open economy national saving at period $t_0 + 2$.
  - Less stringent borrowing constraints reduce small open economy capital inflows triggered by such asymmetric fertility shock as established by numerical simulations. Indeed, less stringent liquidity constraints reduce the effect of an asymmetric fertility shock on small open economy national saving as shown in the above subsection. Given the small open economy assumption, increased investment triggered by an asymmetric fertility shock is independent of the small open economy degree of liquidity. Thus less stringent liquidity constraints reduce the current account deficit triggered by such an asymmetric fertility shock.
- Eventually, the impact of an asymmetric fertility shock on the small open economy current account position vanishes over time. Indeed, given the local stability condition, the impact of an asymmetric fertility shock on the world capital labor ratio decreases over time. Thus the impact on the small open economy national saving and investment also decreases over time.

How does an asymmetric fertility shock affect the welfare of individuals living in the small open economy? In this context, are individuals better off in presence of looser degrees of liquidity constraints?

2.3.2.4 Welfare

In order to evaluate the impact of a fertility rate decline on the small open economy individuals' lifetime utility in presence of liquidity constraints, I differentiate the lifetime utility of small open economy individuals born at time t with respect to n_t^{RW}. The details of the linearization is shown in Appendix 2.E.

In the following, I establish a number of results on the consequence of the interaction between an asymmetric fertility shock and the small open economy degree of liquidity constraints, on the small open economy individuals' lifetime utility.

- Generations born before the period $t_0 - 1$, do not experience any change in their lifetime utility.

- The generation born at time $t_0 - 1$, experiences an unambiguous decrease in its lifetime utility as illustrated in Figure 2.4. Indeed, a negative fertility shock reduces this old-aged generation utility flow through lowering interest rate payments. Formally, the deviation from the steady state of the lifetime utility of rest of the world individuals born at time $t_0 - 1$ is given by expression (2.31). From the latter expression, it is straightforward to show that diminishing returns on capital ensure that a fertility rate shock has a negative impact on lifetime utility of individuals born one period before the shock has occurred. Indeed, the rate of returns on the saving (accumulated in period t_0) received at period $t_0 - 1$ decreases. Thus the latter old-aged individuals' consumption decreases for a given (constant) real wage.

$$\frac{dU_{t_0-1}^{SOE}}{d\gamma^{RW}} = \beta^2 \frac{dR_{t_0+1}^{SOE}}{d\gamma^{RW}} \frac{w_{ss}^{SOE}}{w_{ss}^{SOE} R_{ss}^{SOE}} < 0 \tag{2.31}$$

  - Different degrees of liquidity constraints, in the case of a Cobb-Douglas case, do not modify the way a fertility rate decline affects the welfare of individuals born one period before the shock. There are two reasons for this. First, given the small open economy assumption, the small open economy degree of liquidity constraints does not affect the consequence of an asymmetric fertility shock on capital labor ratio and income levels. Second, there is no welfare loss resulting from the inability of old-aged individuals to smooth optimally the consequences of an asymmetric fertility shock on their consumption. Formally, Appendix 2.F shows that the above expression is independent of ϕ^{SOE} (in the case of a Cobb-Douglas).

- Generations born at the time the shock has occurred and onwards experience an increase in their lifetime utility provided that the economy is below the golden rule (without internal capital market imperfections) of capital accumulation. For individuals born after the shock has occurred, a negative fertility shock increases unambiguously their young-aged and middle-aged utility flows through an increase in lifetime income. However, the effect of such a shock on old-aged individuals utility flows is ambiguous. Indeed, there are two opposite effects resulting from a fertility rate shock on old-aged utility flows. First, a negative fertility shock tends to increase the amount of saving available at retirement age through a real wage increase. Second, a negative fertility shock tends to decrease old-aged wealth through a decrease in interest rate payments for a given real wage. The overall effect of a negative fertility shock on lifetime utility of individuals born at time t_0 and afterwards, is positive if the rest of the world economy is initially below the golden rule of capital accumulation (without internal capital market imperfections) as illustrated in Figure 2.4. The details of the proof are provided in Appendix 2.G. Indeed, if the rest of he world economy is initially below the golden rule, the economy is dynamically efficient. A negative fertility shock raising capital labor ratio further increases the economy's efficiency.

– Different degrees of borrowing constraints do not influence the impact of a fertility rate decline on the lifetime utility of individuals born after the shock has occurred as illustrated in Figure 2.4. Indeed, as shown in Appendix 2.G, the impact of a fertility rate on lifetime utility of individuals born after the shock is independent of the degree of liquidity constraints.[19] The independence of the impact of a fertility rate decline on welfare with respect to the small open economy degree of liquidity constraints should be distinguished from the Japelli and Pagano [13] results. The authors investigate specifically the consequence on welfare of a different degree of liquidity constraints in steady state and during the transition in presence of (exogenous and endogenous) economic growth. The authors find among other results, that if the economy is dynamically inefficient, the removal of liquidity constraints can enhance welfare through reducing the intertemporal distortion and by bringing the economy closer to the path that maximizes steady state consumption. In the present model, the world capital labor ratio is independent of the degree of liquidity constraint in the small open economy. In addition, different degree of liquidity constraints do not cause any welfare loss linked to the inability of small open economy individuals to smooth optimally the consequence of an asymmetric fertility shock on consumption. Indeed, in the present chapter, differences in degrees of liquidity constraints are relevant only through their interaction with an asymmetric fertility rate shock.

[19]Thus the consequences of a rest of the world fertility shock on individuals' lifetime utility born at a given time t are identical across regions.

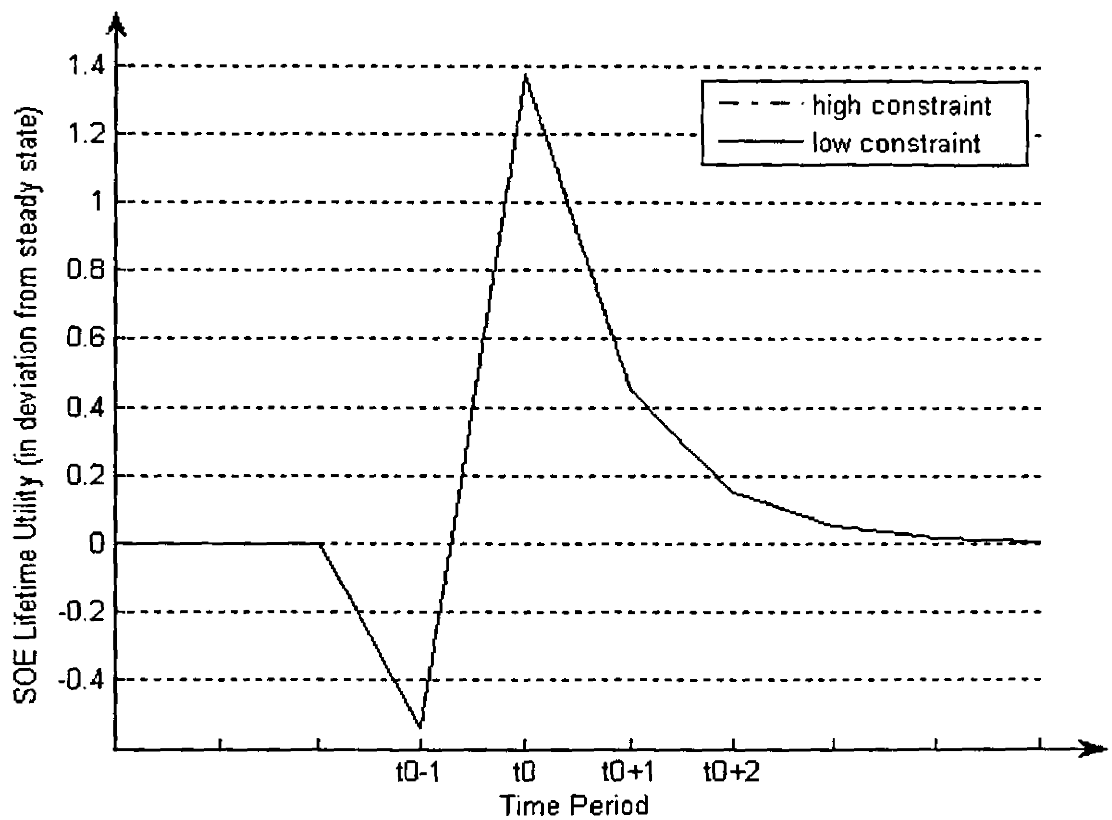

Figure 2.4: Evolution of SOE Individuals Lifetime Utility

2.4 Conclusion

Our objective in this chapter has been to analyze the consequences of an asymmetric fertility shock on saving, international capital flows and welfare in presence of internal capital market imperfections. The framework of analysis is an overlapping-generations small open economy with internal capital market imperfections. The internal capital market imperfection is modelled through exogenous liquidity constraints on young-aged consumption. I obtained a number of results. The consequences of a rest of the world negative fertility rate shock on the small open economy national saving and current account position are distributed in an hump-shaped fashion over time. Capital first flows into the small open economy to exploit the differences in returns on capital and to finance the small open economy young-aged individuals' increased borrowing. After the shock has occurred, capital is repatriated to finance the old-aged consumption of the rest of the world investors. Looser liquidity constraints magnify the consequences of such an asymmetric shock on the small open economy national saving and current account position. Small open economy individuals' lifetime utility decreases unambiguously for individuals born one period before the shock has occurred. Provided that the small open economy is below its golden rule (without imperfections), individuals born after the shock has occurred experience an increase in their lifetime utility. The consequence of an asymmetric shock on the small open economy lifetime utility is independent of the small open economy degree of liquidity constraints.

The model can be extended in a number of directions. Within the same framework, the consequence of an asymmetric life span lengthening shock on saving, international capital flows and welfare could be investigated with different scenarios of retirement age reforms. Another extension within the context of a two country model, investigating the interaction of an asymmetric fertility shock and the degree of liquidity constraints can deliver interesting insights on the consequences of fast aging OECD countries' credit market reforms on capital movements to younger emerging markets and welfare. Indeed, in this framework different degrees of liquidity constraints will affect both saving and capital formation.

Appendices

2.A National Saving Expression Linearization

National saving is defined as follows

$$S_t^{SOE} = A_t^{SOE} - A_{t-1}^{SOE} \tag{2.32}$$

After some substitutions, the above expression reduces to

$$\begin{aligned} S_t^{SOE} &= w_t^{SOE}\frac{\beta\left(1-\phi^{SOE}\right)}{1+\beta}L_{1,t-1}^{SOE} - \phi^{SOE}\frac{w_{t+1}^{SOE}}{R_{t+1}^{SOE}}L_{1,t}^{SOE} \\ &\quad - w_{t-1}^{SOE}\frac{\beta\left(1-\phi^{SOE}\right)}{1+\beta}L_{1,t-2}^{SOE} + \phi^{SOE}\frac{w_t^{SOE}}{R_t^{SOE}}L_{1,t-1}^{SOE} \end{aligned} \tag{2.33}$$

Dividing the above expression by total output, recalling that the small open economy is at its steady state of population growth rate for all t, national saving rate is given by

$$\begin{aligned} \frac{S_t^{SOE}}{Y_t^{SOE}} &= \frac{w_t^{SOE}}{y_t^{SOE}}\frac{\beta\left(1-\phi^{SOE}\right)}{1+\beta} - \phi^{SOE}\frac{w_{t+1}^{SOE}}{R_{t+1}^{SOE}y_t^{SOE}}\left(1+n_{ss}^{SOE}\right) \\ &\quad - \frac{w_{t-1}^{SOE}}{y_t^{SOE}}\frac{\beta\left(1-\phi^{SOE}\right)}{(1+\beta)(1+n_{ss}^{SOE})} + \phi^{SOE}\frac{w_t^{SOE}}{R_t^{SOE}y_t^{SOE}} \end{aligned} \tag{2.34}$$

In the Cobb-Douglas case, the above expression reduces to

$$\begin{aligned} \frac{S_t^{SOE}}{Y_t^{SOE}} &= (1-\alpha)\frac{\beta\left(1-\phi^{SOE}\right)}{1+\beta} - \phi^{SOE}\frac{(1-\alpha)k_{t+1}^{SOE}}{\alpha\left(k_t^{SOE}\right)^{\alpha}}\left(1+n_{ss}^{SOE}\right) \\ &\quad - \frac{(1-\alpha)\left(k_{t-1}^{SOE}\right)^{\alpha}}{\left(k_t^{SOE}\right)^{\alpha}}\frac{\beta\left(1-\phi^{SOE}\right)}{(1+\beta)(1+n_{ss}^{SOE})} + \phi^{SOE}\frac{(1-\alpha)\left(k_t^{SOE}\right)^{1-\alpha}}{\alpha} \end{aligned} \tag{2.35}$$

Linearizing the above expression with respect to n_t^{RW} gives

$$\frac{d\left(\frac{S_t^{SOE}}{Y_t^{SOE}}\right)}{d\gamma^{RW}} = \left[-\frac{(1-\alpha)\beta\left(1-\phi^{SOE}\right)\alpha}{(1+n_{ss}^{SOE})(1+\beta)k_{ss}^{SOE}}\right]\frac{dk_{t-1}^{SOE}}{d\gamma^{RW}}$$
$$+\left[\frac{(1-\alpha)\beta\left(1-\phi^{SOE}\right)\alpha}{(1+n_{ss}^{SOE})(1+\beta)k_{ss}^{SOE}}+\frac{\phi^{SOE}(1-\alpha)((1+n_{ss}^{SOE})+\frac{(1-\alpha)}{\alpha})}{(k_{ss}^{SOE})^{\alpha}}\right]\frac{dk_t^{SOE}}{d\gamma^{RW}} \quad (2.36)$$
$$+\left[-\phi^{SOE}\frac{(1-\alpha)}{\alpha}\frac{(1+n_{ss}^{SOE})}{(k_{ss}^{SOE})^{\alpha}}\right]\frac{dk_{t+1}^{SOE}}{d\gamma^{RW}} \quad (2.37)$$

2.B National Saving Rate

- At period $t < t_0$, the consequences of an asymmetric fertility shock on small open economy national saving are formally given by

$$\frac{d(\frac{S_t^{SOE}}{Y_t^{SOE}})}{d\gamma^{RW}} = 0$$

- At period $t = t_0$, the consequences of an asymmetric fertility shock on small open economy national saving are formally given by

$$\frac{d\left(\frac{S_{t_0}^{SOE}}{Y_{t_0}^{SOE}}\right)}{d\gamma^{RW}} = -\phi^{SOE}\frac{(1-\alpha)}{\alpha}\frac{(1+n_{ss}^{SOE})}{(k_{ss}^{SOE})^{\alpha}}\frac{dk_{t_0+1}^{SOE}}{d\gamma^{RW}} < 0 \quad (2.38)$$

  – At period $t = t_0$, differentiating the above expression with respect to ϕ^{SOE} gives

$$\frac{d\left[\frac{d\left(\frac{S_{t_0}^{SOE}}{Y_{t_0}^{SOE}}\right)}{d\gamma^{RW}}\right]}{d\phi^{SOE}} = -\frac{(1-\alpha)}{\alpha}\frac{(1+n_{ss}^{SOE})}{(k_{ss}^{SOE})^{\alpha}}\frac{dk_{t_0+1}^{SOE}}{d\gamma^{RW}} < 0 \quad (2.39)$$

- At period t_0+1, the consequences of an asymmetric fertility shock on small open economy national saving are formally given by

$$\frac{d\left(\frac{S_{t_0+1}^{SOE}}{Y_{t_0+1}^{SOE}}\right)}{d\gamma^{RW}} = \left[\phi^{SOE}\frac{(1-\alpha)^2}{\alpha\,(k_{ss}^{SOE})^{\alpha}}+\frac{(1-\alpha)\beta(1-\phi^{SOE})\alpha}{(1+\beta)(1+n_{ss}^{SOE})k_{ss}^{SOE}}\right]\frac{dk_{t_0+1}^{SOE}}{d\gamma^{RW}} > 0 \quad (2.40)$$

  – At period t_0+1, differentiating the above expression with respect to ϕ^{SOE} gives

$$\frac{d\frac{d\left(\frac{s^{SOE}_{t0+1}}{Y^{SOE}_{t0+1}}\right)}{d\gamma^{RW}}}{d\phi^{SOE}} = \left[\frac{(1-\alpha)^2}{\alpha\,(k^{SOE}_{ss})^{\alpha}} - \frac{(1-\alpha)\beta\alpha}{(1+\beta)(1+n^{SOE}_{ss})k^{SOE}_{ss}}\right]\frac{dk^{SOE}_{t0+1}}{d\gamma^{RW}} \tag{2.41}$$

$$k^{SOE}_{ss} > \left[\frac{\beta\alpha^2}{(1+\beta)(1-\alpha)(1+n^{SOE}_{ss})}\right]^{\frac{1}{1-\alpha}} \Rightarrow \frac{d\frac{d\left(\frac{s^{SOE}_{t0+1}}{Y^{SOE}_{t0+1}}\right)}{d\gamma^{RW}}}{d\phi^{SOE}} > 0 \tag{2.42}$$

with

$$k^{SOE}_{ss} = k^{RW}_{ss} \tag{2.43}$$

A necessary and sufficient condition to ensure that less stringent liquidity constraint magnifies the impact of an asymmetric fertility shock on small open economy saving

$$\text{if } \frac{1-2\alpha}{1-\alpha} > \phi^{RW} \Rightarrow \frac{d\frac{d\left(\frac{s^{SOE}_{t0+1}}{Y^{SOE}_{t0+1}}\right)}{d\gamma^{RW}}}{d\phi^{SOE}} > 0 \tag{2.44}$$

In contrast, a sufficient condition to insure that less stringent liquidity constraints reduce the impact of an asymmetric fertility shock on the small open economy national saving, as formally given by

$$\text{if } \alpha \geqslant \frac{1}{2} \Rightarrow \frac{d\frac{d\left(\frac{s^{SOE}_{t0+1}}{Y^{SOE}_{t0+1}}\right)}{d\gamma^{RW}}}{d\phi^{SOE}} < 0 \tag{2.45}$$

- At period $t \geqslant t_0 + 2$ and onwards, the consequences of an asymmetric fertility shock on the small open economy national saving are formally given by

$$\frac{d\left(\frac{S^{SOE}_t}{Y^{SOE}_t}\right)}{d\gamma^{RW}} = \frac{dk^{SOE}_{t-1}}{d\gamma^{RW}}\left[-\frac{(1-\alpha)\beta\left(1-\phi^{SOE}\right)\alpha(1-\alpha)}{(1+n^{SOE}_{ss})(1+\beta)k^{SOE}_{ss}} + \frac{\phi^{SOE}(1-\alpha)^2}{k^{\alpha}_{ss}}\right] \leqslant 0 \tag{2.46}$$

$$k^{SOE}_{ss} \leqslant \left[\frac{\beta\left(1-\phi^{SOE}\right)\alpha}{\phi^{SOE}(1+n^{SOE}_{ss})(1+\beta)}\right]^{\frac{1}{1-\alpha}} \Rightarrow \frac{d\left(\frac{S^{SOE}_t}{Y^{SOE}_t}\right)}{d\gamma^{RW}} \leqslant 0 \tag{2.47}$$

That is equivalent to

$$\left[\frac{(1-\phi^{RW})}{(1-\phi^{SOE})}\phi^{SOE}-\phi^{RW}\right]\leqslant\frac{\alpha}{(1-\alpha)}\Rightarrow\frac{d\left(\frac{S_t^{SOE}}{Y_t^{SOE}}\right)}{d\gamma^{RW}}\leqslant 0 \tag{2.48}$$

$$\left[\frac{(1-\phi^{RW})}{(1-\phi^{SOE})}\phi^{SOE}-\phi^{RW}\right]\leqslant 0\Longleftrightarrow\phi^{SOE}\leqslant\phi^{RW} \tag{2.49}$$

Thus $\phi^{SOE}\leqslant\phi^{RW}$ ensures that an asymmetric fertility shock boosts the small open economy national saving at period $t\geqslant t_0+2$ and onwards.

–At period $t\geqslant t_0+2$ and onwards, differentiating expression (2.46) with respect to ϕ^{SOE} gives

$$\frac{d\frac{d(\frac{S_t}{Y_t})}{d\gamma}}{d\phi^{SOE}}=\frac{dk_{t-1}^{SOE}}{d\gamma^{RW}}\left[+\frac{(1-\alpha)\beta\alpha(1-\alpha)}{(1+n_{ss}^{SOE})(1+\beta)k_{ss}^{SOE}}+\frac{(1-\alpha)^2}{k_{ss}^{\alpha\ SOE}}\right]>0 \tag{2.50}$$

At period $t\geqslant t_0+2$ and onwards, less stringent liquidity constraints unambiguously dampen the impact of an asymmetric fertility shock on small open economy saving

2.C Current Account Expression Linearization

To determine the effect of a rest of the world shock on the small open economy balance-of-trade, I differentiate the balance-of-trade expression namely expression (2.26) with respect to n_t^{RW} around the small open economy steady state. Formally, I obtain the following expression:

$$\begin{aligned}\frac{db_t^{SOE}}{d\gamma^{RW}} &= \frac{dw_t^{SOE}}{d\gamma^{RW}}+\frac{dR_t^{SOE}}{d\gamma^{RW}}k_{ss}^{SOE}+(R_{ss}^{SOE}-1)\frac{dk_t^{SOE}}{d\gamma^{RW}}-\frac{dc_{1,t}^{SOE}}{d\gamma^{RW}}(1+n_{ss}^{SOE})\\ &-\frac{dc_{2,t}^{SOE}}{d\gamma^{SOE}}-\frac{dc_{3,t}^{SOE}}{d\gamma^{SOE}}\frac{1}{(1+n_{ss}^{SOE})}-\frac{dk_{t+1}^{SOE}}{d\gamma^{SOE}}(1+n_{ss}^{SOE})\end{aligned} \tag{2.51}$$

In order to determine the effect of such an asymmetric shock on the small open economy current account position, I differentiate (2.29a) with respect to n_t^{RW} around the small open economy steady state. Formally, I obtain the following expression:

$$\begin{aligned} \frac{dcab_t^{SOE}}{d\gamma^{RW}} &= \frac{dR_t^{SOE}}{d\gamma}\left[w_{ss}^{SOE} - c_{2,ss}^{SOE} - c_{1,ss}^{SOE}(1+n_{ss}^{SOE})\right] \\ &+R_{ss}^{SOE}\left[\frac{dw_t^{SOE}}{d\gamma} - \frac{dc_{2,t}^{SOE}}{d\gamma} - \frac{dc_{1,t}^{SOE}}{d\gamma}(1+n_{ss}^{SOE})\right] \\ &-\frac{dR_t^{SOE}}{d\gamma}\phi^{SOE}w_{ss}^{SOE} + (R_{ss}^{SOE}-1)\phi^{SOE}\frac{dw_t^{SOE}}{d\gamma} \\ &+\frac{dk_t^{SOE}}{d\gamma} - \frac{dc_{3,t}^{SOE}}{d\gamma}\left[\frac{1}{1+n_{ss}^{SOE}}\right] - \frac{dk_{t+1}^{SOE}}{d\gamma}(1+n_{ss}^{SOE}) \end{aligned} \tag{2.52}$$

In the case of a Cobb-Douglas the expression reduces to

$$\frac{dcab_t^{SOE}}{d\gamma^{RW}} = \frac{dk_{t-1}^{SOE}}{d\gamma}A + \frac{dk_t^{SOE}}{d\gamma}B + \frac{dk_{t+1}}{d\gamma}C \tag{2.53}$$

with

$$A = \left[\frac{-\beta(1-\phi^{SOE})\alpha^2(1-\alpha)k_{ss}^{2\alpha-2}}{(1+\beta)(1+n_{ss}^{SOE})}\right] < 0 \tag{2.54}$$

$$\begin{aligned} B &= 1 + k_{ss}^{\alpha-1}\phi^{SOE}(1-\alpha)\left[(1-\alpha)(1+n_{ss}^{SOE}) - \alpha\right] \\ &+k_{ss}^{2\alpha-2}\left\{\alpha(1-\alpha)^2\beta(1-\phi^{SOE})\left[\frac{-n_{ss}^{SOE}}{(1+n_{ss}^{SOE})}\right] + \alpha^2(1-\alpha)\left[\frac{\beta+\phi^{SOE}}{1+\beta} + \phi^{SOE}\right]\right\} \end{aligned} \tag{2.55}$$

$$C = -(1+n_{ss}^{SOE})\left[1 + \phi^{SOE}(1-\alpha)k_{ss}^{\alpha-1}\right] < 0 \tag{2.56}$$

2.D Saving/Investment Imbalance

In the following, I investigate the sign of a rest of the world negative fertility shock on the small open economy balance-of-trade and the current account position, using the expressions derived in Appendix 2.C.

- Before period t_0, the balance-of-trade and the current account position are not affected by a fertility rate shock occurring at period t_0.
- At period t_0, at the period the shock has occurred the balance-of-trade and the current account position are deteriorating.

Using expressions (2.51) and (2.52), the deviations from steady state of the small open economy balance-of-trade and the current account position at the end of time t_0-1 are given by the following expressions

$$\frac{db_{t_0}^{SOE}}{d\gamma^{SOE}} = -\frac{dc_{1,t_0}^{SOE}}{d\gamma^{SOE}}(1+n_{ss}^{SOE}) - \frac{dk_{t_0+1}^{SOE}}{d\gamma^{SOE}}(1+n_{ss}^{SOE}) < 0 \tag{2.57}$$

$$\frac{dcab_{t_0}^{SOE}}{d\gamma^{RW}} = R_{ss}^{SOE}\left[-\frac{dc_{1,t_0}^{SOE}}{d\gamma^{RW}}(1+n_{ss}^{SOE})\right] - \frac{dk_{t_0+1}^{SOE}}{d\gamma^{RW}}(1+n_{ss}^{SOE}) < 0 \tag{2.58}$$

An asymmetric fertility shock deteriorates the current account position of the small open economy at time t_0.

Formally, the latter expression reduces to

$$\frac{dcab_{t_0}^{SOE}}{d\gamma^{RW}} = \left[-\left(\phi^{SOE}\frac{-k_{ss}^{SOE}f''(k_{ss}^{SOE})}{R_{ss}^{SOE}} - \phi^{SOE}\frac{w_{ss}^{SOE}}{R_{ss}^{2\ SOE}}f''(k_{ss}^{SOE})\right)R_{ss}^{SOE} - 1\right]\frac{dk_{t_0+1}^{SOE}}{d\gamma^{RW}}(1+n_{ss}^{SOE}) \tag{2.59}$$

–Let us now demonstrate that the differential of the impact of a rest of the world fertility rate on the current account position at time t_0 with respect to ϕ^{RW} is negative. In the context of a Cobb-Douglas, the differential of the above expression is given by

$$\frac{d\left(\frac{dcab_{t_0}^{SOE}}{d\gamma^{RW}}\right)}{d\phi^{SOE}} = -k_{ss}^{SOE\,\alpha}(1-\alpha) < 0 \tag{2.60}$$

Less stringent liquidity has an unambiguous negative impact on the consequence of an asymmetric fertility shock on the small open economy current account.

- At period t_0+1, the impact of an asymmetric fertility shock on the current account position is given by the following expression:

$$\frac{dcab_{t_0+1}^{SOE}}{d\gamma^{RW}} = \frac{dk_{t_0+1}^{SOE}}{d\gamma^{RW}}[B + C\alpha] \tag{2.61}$$

In the case of a Cobb-Douglas, numerical simulations, as illustrated in Figure 2.3, show for specific parameters values that the following expression holds

$$[B + C\alpha] > 0 \tag{2.62}$$

–Formally, the impact of the interaction between an asymmetric fertility shock and the small open economy degree of liquidity constraints on the small open economy current account position at time t_0+1 is given by

$$\frac{d\frac{dcab_{t_0+1}^{SOE}}{d\gamma^{RW}}}{d\phi^{SOE}} = \frac{dk_{t_0+1}^{SOE}}{d\gamma}\frac{d\left[B + C\alpha\right]}{d\phi^{SOE}} \tag{2.63}$$

I resorted to numerical simulations , as illustrated in Figure 2.3, to establish the sign of the above expression.

- After period $t_0 + 2$, the impact of an asymmetric fertility shock on the current account balance position is given by the following expression:

$$\frac{dcab_t^{SOE}}{d\gamma^{RW}} = \frac{dk_t^{SOE}}{d\gamma}\left[A + B\alpha + C\alpha^2\right] \tag{2.64}$$

In the case of a Cobb-Douglas, numerical simulations, as illustrated in Figure 2.3, show for specific parameters values that the following expression holds

$$\left[A + B\alpha + C\alpha^2\right] \geqslant 0 \tag{2.65}$$

–Formally, the interaction between an asymmetric fertility shock and the degree of liquidity constraints on the small open economy current account position after time $t_0 + 1$ is given by

$$\frac{d\frac{dcab_t^{SOE}}{d\gamma^{RW}}}{d\phi^{SOE}} = \frac{dk_t^{SOE}}{d\gamma}\frac{d\left[A + B\alpha + C\alpha^2\right]}{d\phi^{SOE}} \tag{2.66}$$

I resorted to numerical simulations to establish the sign of the above expression.

2.E Lifetime Utility Function Linearization

Let U_t^{SOE} describes the lifetime utility of individuals born at time t living in the small open economy. Formally, U_t^{SOE} is given by the following expression:

$$U_t^{SOE} = \ln(c_{1,t}^{SOE}) + \beta\ln(c_{2,t+1}^{SOE}) + \beta^2\ln(c_{3,t+2}^{SOE}) \tag{2.67}$$

with $c_{1,t}^{SOE}$, $c_{2,t+1}^{SOE}$ and $c_{3,t+2}^{SOE}$ are given by

$$c_{1,t}^{SOE} = \phi^{SOE}\frac{w_{t+1}^{SOE}}{R_{t+1}^{SOE}} \tag{2.68}$$

$$c_{2,t+1}^{SOE} = \frac{1 - \phi^{SOE}}{1 + \beta}w_{t+1}^{SOE} \tag{2.69}$$

$$c_{3,t+2}^{SOE} = \frac{\beta(1-\phi^{SOE})}{1+\beta} R_{t+2}^{SOE} w_{t+1}^{SOE} \tag{2.70}$$

Differentiating (2.67) with respect to n_t^{RW} around the small open economy steady state gives

$$\frac{dU_t^{SOE}}{d\gamma^{RW}} = \frac{1}{c_{1,ss}^{SOE}} \frac{dc_{1,t}^{SOE}}{d\gamma^{RW}} + \beta \frac{1}{c_{2,ss}^{SOE}} \frac{dc_{2,t+1}^{SOE}}{d\gamma^{RW}} + \beta^2 \frac{1}{c_{3,ss}^{SOE}} \frac{dc_{3,t+2}^{SOE}}{d\gamma^{RW}} \tag{2.71}$$

Factors prices deviation from steady state are given by

$$\frac{dw_{t+1}^{SOE}}{d\gamma^{RW}} = -k_{ss}^{SOE} f"(k_{ss}^{SOE}) \frac{dk_{t+1}^{SOE}}{d\gamma^{RW}} \geq 0 \tag{2.72}$$

$$\frac{dR_{t+1}^{SOE}}{d\gamma^{RW}} = f"(k_{ss}^{SOE}) \frac{dk_{t+1}^{SOE}}{d\gamma^{RW}} \leqslant 0 \tag{2.73}$$

Young-aged, middle-aged and old-aged consumptions deviations from steady state are given by

$$\frac{dc_{1,t}^{SOE}}{d\gamma^{RW}} = \phi^{SOE} \frac{1}{R_{ss}^{SOE}} \frac{dw_{t+1}^{SOE}}{d\gamma^{RW}} - \phi^{SOE} \frac{w_{ss}^{SOE}}{(R_{ss}^{SOE})^2} \frac{dR_{t+1}^{SOE}}{d\gamma^{RW}} \tag{2.74}$$

$$\frac{dc_{2,t+1}^{SOE}}{d\gamma^{RW}} = \frac{1-\phi^{SOE}}{1+\beta} \frac{dw_{t+1}^{SOE}}{d\gamma^{RW}} \tag{2.75}$$

$$\frac{dc_{3,t+2}^{SOE}}{d\gamma^{RW}} = \beta \frac{1-\phi^{SOE}}{1+\beta} \left(R_{ss}^{SOE} \frac{dw_{t+1}^{SOE}}{d\gamma^{RW}} + \frac{dR_{t+2}^{SOE}}{d\gamma^{RW}} w_{ss}^{SOE}\right) \tag{2.76}$$

Substituting factor prices and consumptions deviations in expression 2.71 gives

$$\frac{dU_t^{SOE}}{d\gamma^{RW}} = \frac{dk_{t+1}^{SOE}}{d\gamma^{RW}} \left[\frac{-k_{ss}^{SOE} f"(k_{ss}^{SOE})}{w_{ss}^{SOE}} \frac{1}{\eta} - \frac{1}{R_{ss}^{SOE}} f"(k_{ss}^{SOE})\right] + \frac{dk_{t+2}^{SOE}}{d\gamma^{RW}} \left[\frac{\beta^2}{R_{ss}^{SOE}} f"(k_{ss}^{SOE})\right] \tag{2.77}$$

2.F Lifetime Utility

In the Cobb-Douglas case, the deviation from steady state of the lifetime utility of individual born one period before the shock occurs reduces to

$$\frac{dU_{t_0-1}^{SOE}}{d\gamma^{RW}} = \beta^2(\alpha-1) \frac{1}{(1+n_{ss}^{SOE})} < 0 \tag{2.78}$$

The above expression is independent of ϕ^{SOE}. Thus different degrees of small open economy liquidity constraints do not affect the impact of an asymmetric fertility shock on lifetime utility of old age individuals born one period before the shock occurs.

2.G Lifetime Utility

In the following, I prove that a negative asymmetric fertility shock affects positively the lifetime utility of individuals born after the shock has occurred and living in the small open economy provided that the economy is initially below its golden rule of capital accumulation (without internal capital market imperfections).

Using expression (2.77), after some substitution, I obtain

$$\frac{dU_t^{SOE}}{d\gamma^{RW}} > 0 \Leftrightarrow \frac{dk_{t+2}^{RW}}{dk_{t+1}^{RW}} < \frac{1}{\beta^2} + \frac{k_{ss}^{RW} R_{ss}^{RW}}{w_{ss}^{RW} \beta^2 \eta}$$

using the local stability condition

$$\frac{dk_{t+2}^{RW}}{dk_{t+1}^{RW}} < 1 \text{ for } t > t_0$$

and using the expression implicitly characterizing the steady state capital labor ratio, that is

$$k_{ss}^{RW}(1 + n_{ss}^{RW}) = w_{ss}^{RW} \frac{\beta(1 - \phi^{RW})}{1 + \beta} - \frac{w_{ss}^{RW}}{R_{ss}^{RW}} \phi^{RW}(1 + n_{ss}^{RW}) \tag{2.79}$$

It is straigthtforward to show that a sufficient condition for a negative fertility rate to have a positive impact on lifetime utility is given by

$$\text{for } t > t_0, \; \frac{R_{ss}(1 - \phi^{RW})}{(1 + \beta)(1 + n_{ss})\beta\eta} + \frac{(\eta - \phi^{RW})}{\beta^2 \eta} > 1 \Rightarrow \frac{dU_t^{SOE}}{d\gamma^{RW}} > 0 \tag{2.80}$$

A necessary condition being for the consequences of a fertility rate shock to have a negative impact on the lifetime utility is formally given by

$$\frac{dU_t^{SOE}}{d\gamma^{RW}} < 0 \Rightarrow \frac{R_{ss}(1 - \phi^{RW})}{(1 + \beta)(1 + n_{ss})\beta\eta} + \frac{(\eta - \phi^{RW})}{\beta^2 \eta} < 1$$

Let's R_{ss}^{*} be the rest of the world steady return factor in the case without capital market imperfections (or non binding liquidity constraints). It is straightforward to show that

$$\text{if } \eta = \phi^{RW} \text{ for } t > t_0 \ \frac{dU_t^{SOE}}{d\gamma^{RW}} > 0 \Rightarrow R_{ss}^{*} > (1+n_{ss}) \tag{2.81}$$

$$\text{if } \eta < \phi^{RW} \text{ for } t > t_0 \ \frac{dU_t^{SOE}}{d\gamma^{RW}} > 0 \Rightarrow \frac{R_{ss}(1-\phi^{RW})}{(1+\beta)(1+n_{ss})\beta\eta} + \frac{(\eta-\phi^{RW})}{\beta^2\eta} > 1 \tag{2.82}$$

In the Cobb-Douglas case, it can be shown that the two above conditions are equivalent. Formally this reduces to

$$\begin{aligned} R_{ss}^{*} &> (1+n_{ss}) \Leftrightarrow \alpha > (1-\alpha)\eta\left[\beta^2-1\right] \\ \frac{R_{ss}(1-\phi^{RW})}{(1+\beta)(1+n_{ss})\beta\eta} + \frac{(\eta-\phi^{RW})}{\beta^2\eta} &> 1 \Leftrightarrow \alpha > (1-\alpha)\eta\left[\beta^2-1\right] \end{aligned}$$

In conclusion, in the presence of borrowing constraints an asymmetric fertility shock has a positive on the small open economy, if the economy is initially below its golden rule of capital accumulation without internal capital imperfections. The latter condition being independent of the degree of liquidity constraints, the impact of fertility rate on small open economy individuals lifetime utility is independent as well.

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CHAPTER 3

DEMOGRAPHY, CREDIT AND INSTITUTIONS IN A GLOBALIZING WORLD: AN EMPIRICAL PERSPECTIVE

3.1 Introduction

Different regions of the world are at different stages of a global aging phenomenon entitled "demographic transition". More advanced countries in this process face a high old-aged dependency ratio and the prospect of a labor force shortage. Less advanced countries are currently experiencing a relatively lower old-aged dependency ratio and an increasing labor force population. According to the United Nations [44] demographic differences are likely to remain important in the future.

Let us assume an overlapping-generations two country model where the two countries are identical in every respect except in fertility rates. Under the assumption of diminishing returns, an implication of the life-cycle hypothesis is that the bulk of saving supply triggered by the rapidly aging country should flow to the slower aging country where capital is relatively scarce and where labor is relatively abundant.

This prediction matches with the past decades' surge in capital inflows to younger/poorer countries following their capital markets' liberalization. However, those international capital flows appear to be limited compared to what neoclassical theory would predict as claimed in Lucas [29]. Indeed, capital market imperfections are likely to impede aging differences to foster international capital flows. Lucas [29] emphasizes the role of external capital market imperfections/political risk in explaining the lack of capital flow from capital-abundant to capital-scarce countries. More recently, Shleifer and Wolfenzon [42] model how agency costs stemming from inefficient corporate governance and law enforcement mechanisms impede foreign capital from flowing to capital-scarce countries. Alfaro et al. [3], using cross country data, show empirically the importance of institutional factors in determining international capital inflows to emerging countries.[1] In addition, capital inflows have been unevenly distributed across younger/poorer countries. These stylized facts on capital movements, documented in Prasad et al. [37], suggest a role for interaction between aging differences

[1]The finance literature has provided empirical (see for instance La Porta et al. [25]) and theoretical evidence on the importance of a country's legal system in determining their level of financial development.

and external capital market imperfections in explaining the timing, the magnitude and the distribution of international capital flows across receiving countries.

The theoretical literature has been relatively scarce on the relevance of such interaction in explaining international capital movements, but abundant on the closed economy consequences of aging. This literature is often related to the analysis of pay-as-you-go system sustainability. Indeed Auerbach and Kotlikoff [8] have initiated a wide strand of literature on the consequences of social security reforms in a context of aging economies. Both theoretical and empirical results, based on the life-cycle hypothesis, suggest that aging (through its impact on the labor market) increases capital labor intensity.

A recent literature has been addressing the economic consequences of aging differences in an open economy perspective using large scale simulation models. Simulation results of Attanasio and Violante [7], and Brooks [14], among others, point to a significant role being played by demographic differences in explaining capital flows from fast aging OECD countries to slower aging emerging markets. Brooks [14] simulation results also predict a future reversal in the direction of those international capital flows. Indeed, Brooks [14] predictions suggest that capital will flow from currently younger countries to currently older regions as the former will enter into the fast aging stage of the demographic transition. There is, however, an important caveat to this recent literature. These studies assume the absence of capital market imperfections, that are likely to explain the uneven distribution of capital inflows across younger/poorer countries. To remedy this caveat, Chapter 1 has analyzed the consequences of an asymmetric negative fertility shock on saving/investment imbalance in a Diamond-type overlapping-generations small open economy with **external** capital market imperfections. The external capital market imperfection is modelled through a symmetric wedge between foreign investor and domestic investor return on capital likely to arise when property rights are not enforced. The shock is transmitted to the small open economy, depending on whether the wedge is below a given threshold. If the wedge is not too high, capital first flows into the small open economy in order to exploit the difference in returns on capital. After the shock has occurred, capital is repatriated in order to finance old-aged consumption of the rest of the world investors. In addition, Chapter 2 has examined the consequences of an asymmetric fertility shock on saving and international capital flows in a three period lived overlapping-generations small open economy model with **internal** capital market imperfection. The internal capital market imperfection is modelled through exogenous (binding) borrowing constraints on young age individuals' consumption likely to occur in a context of low credit availability. The consequences of a rest of the world negative fertility rate shock on the small open economy national saving and capital flows are distributed in an hump-shaped fashion over time. Looser liquidity constraints magnify the consequences of such an asymmetric shock on national saving and current account position. Whether the capital market imperfection is external or internal influences the channel through which the capital market imperfection interacts with demographic shocks to determine international capital flows. Indeed, in the case of external capital imperfections, an asymmetric fertility shock affects international capital flows through the foreign investment channel. In the case of internal capital imperfections, an asymmetric fertility shock affects international capital flows through the saving channel. In the present chapter, I estimate a reduced form model to test empirically the validity of those theoretical results.

Empirically, Higgins [22] estimates a reduced form model to quantify the impact of age structure differences in explaining international capital flows. Drawing from data for up to 100 countries over the period 1950 to 1989, Higgins' results point to the significant impact that changes in population age structure have on saving. Results also point to a differentiated impact of age structure on saving and investment, opening the scope for international borrowing and lending. Bosworth and Keys [13], replicating Higgins study, use a larger sample period, covering the period 1950 to 2000, and seem to confirm Higgins results. However, Bosworth and Keys [13] claim that their results are not robust and are driven by South East Asian countries. The latter findings seem to suggest that the role of demographic differences in driving international capital flows needs to be considered together with their interaction with capital market imperfections, as suggested by chapter 1 and 2. To the extent of my knowledge, there are no empirical studies that test the relevance of the interaction between age structure differences and capital market imperfections in explaining international capital flows.

My objective in this chapter is to investigate the role of age structure and its interaction with both external and internal capital market imperfections in determining international capital flows, in a systematic empirical framework. To do so, I estimate a variety of reduced models for saving, investment and current account position, drawing from data for up to 115 countries over the period 1970 to 2000. Results indicate the existence of a differentiated effect of age structure on international capital flows. Good institutions allow for a differentiated impact of age structure on saving and investment, opening the scope for an impact of demographic differences in driving international capital flows. In contrast, bad institutions shut down the effect of age structure on international capital flows. Despite increased credit availability contributing to reduced aggregate saving, this will nevertheless magnify the role of the population age structure in driving international capital flows. Over the past three decades, I estimate that age structure changes have contributed to improving the current account balance position by five per cent of GDP in more advanced aging countries. However, around the year 2020, age structure changes are projected to deteriorate the current account position in the latter countries, which will experience a drop in saving. In other regions, the faster the current aging process, the sharper the projected improvement in the current account position. This improvement is projected to reverse itself, at a later stage in time in regions with a slower aging process. Different scenarios of both internal and external capital market imperfections reveal that the scope for international capital flows is reduced when imperfections are high though through different channels.

The rest of the paper is organized as follows. Section 3.2 presents some stylized facts on age structure differences and cross-correlations between saving, investment and population age structure. Section 3.3 presents the empirical analysis and results. Section 3.4 presents out of sample projections of the consequences of age structure differences on international capital flows. Section 3.5 concludes.

3.2 Stylized Facts

This section establishes some stylized facts on the world demographic transition. I also present cross-correlations between population age structure and saving, investment and the current account position over the period 1970 to 2000.

3.2.1 The Demographic Transition

The world as a whole is aging. This phenomenon has been formalized by demographers into a demographic transition model. Demographic transition is operating through fertility rate decline and life span lengthening. However, the timing of the decline in fertility rate is not synchronized with the timing of the decrease in death rates over the transition. Indeed, life span first increases, and is then followed by a decline in the fertility rate. As a result, one can distinguish four different stages in the demographic transition model, intrinsically linked to development stages, as described in Figure 3.1. The first stage corresponds to a pre-development phase and is characterized by high fertility and high death rates. The second stage is characterized by a rapid fall in the death rate due to improved living conditions, while the fertility rate remains high leading to high population growth. The third stage is characterized by a fall in the fertility rate, while the death rate remains stable, leading to a slowdown in population growth. The fourth stage is characterized by stabilized fertility and death rates, leading to a stationary population level.

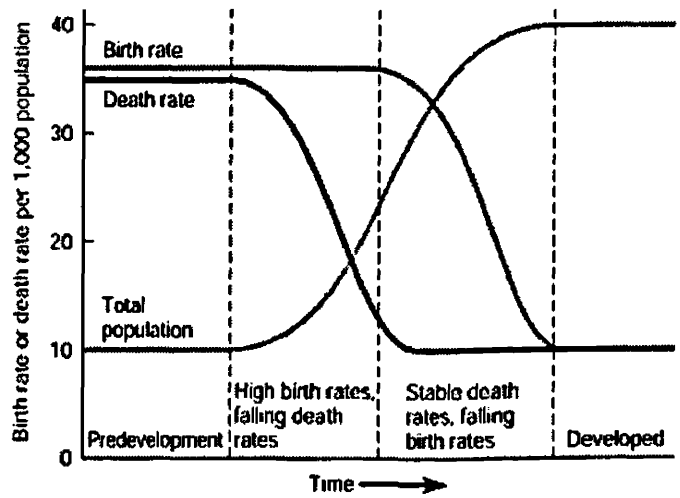

Figure 3.1: **Demographic Transition Model**

3.2.2 The Demographic Transition Around The World

Different regions of the world are at different stages of the demographic transition, resulting in important differences in population age structure across countries. Broadly speaking, these demographic differences are shaped along income level. Indeed, more developed countries are at a more advanced stage of the demographic transition than less developed countries. For instance, the median age in the year 2000 was about 37.3 years in more developed countries whereas it was only 24.1 years in less developed countries.[2] Moreover, these population age structure differences are projected to remain important over the next decades. Indeed, in the year 2050 median age is projected to reach 47.7 years in Europe and 27.5 years in Africa.

Important differences also exist between the pace of the aging process, as seen previously in the demographic transition model. Over the period 1975 to 2000, the median age in the least developed region has increased by less than a year, whereas in the more developed region the median age has increased by more than six years due to differential in fertility rates decline and in life expectancy lengthening.

In the following subsection, I investigate the cross-correlation between saving, investment, current account position and population age structure.

[2]The figures used in this subsection are drawn from United Nations [44].

3.2.3 Cross-Correlation between Saving, Investment, Current Account Position and Population Age structure

Saving rates are positively correlated with working age population share, and negatively correlated with young age share, as shown in Figure 3.2. These cross-correlations are in line with the life-cycle hypothesis. According to the latter hypothesis, individuals smooth the pattern of their consumption through their lifetime. Thus younger individuals tend to be net borrowers. Older individuals, at the peak of their earnings potential, tend to be high net savers. Contrary to what the life-cycle hypothesis predicts, the saving rate appears to be positively correlated with the elderly population share. Nonetheless, the cross-correlation between saving rate and old age share is lower than the cross-correlation between saving rate and working age share, as shown in Figure 3.2.[3] The empirical analysis will analyze further the impact of population age structure on national saving.

The cross-correlations between current account position, working age and elderly population shares are positive, as shown in Figure 3.2. However, the correlations presented appear to be low. Theoretically, chapter 1 has shown that capital should flow from fast aging to slower aging countries only if the degree of external capital market imperfections is not too high. In addition, chapter 2 has shown that looser internal capital imperfections magnify the impact of demographic differences on national saving and international capital movements. The empirical analysis will go further in investigating the impact of the interaction between population age structure and various capital market imperfections in determining international capital flows.

In the following sections, I will address questions such as: How does the population age structure interact with various capital market imperfections in explaining international capital movements? Will population age structure differences play an increasing role in shaping international capital flows in the future given specific scenarios on the degree of external and internal capital market imperfections?

3.3 Empirical Analysis

In this section, I test whether the interaction between age structure differences and external capital market imperfections proxied by institutional quality gives rise to a differentiated effect, as predicted in chapter 1. In addition, I also estimate the effect of the interaction between age structure differences and internal capital market imperfections on international

[3] An older population affects public saving (a component of national saving) through increased pay-as-you-go deficit and public health expenditures. This could also explain the relatively low correlation between elderly population share and national saving rate. (see Feldstein [21])

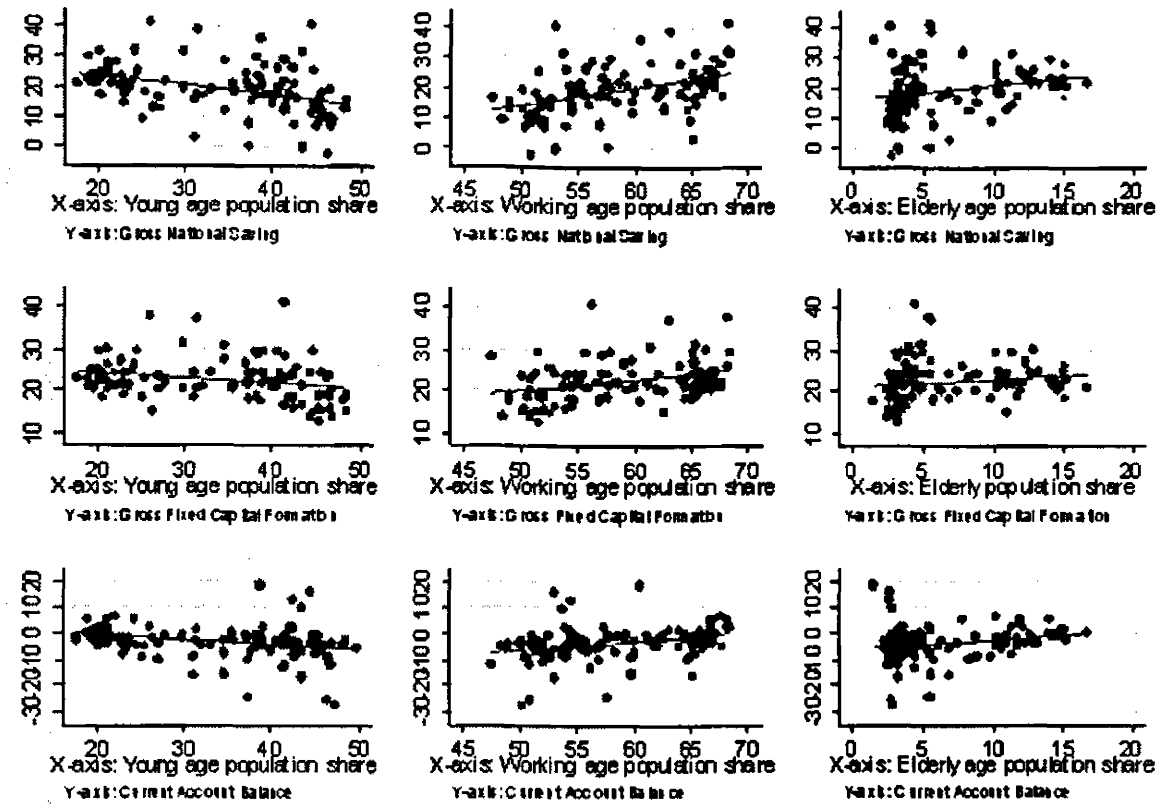

Figure 3.2: Economic Impact of Population Age Structure

capital flows.

3.3.1 Empirical Specification and Econometric Issues

The dependent variables are national saving rate proxied by the ratio of national saving to Gross Domestic Product (GDP), investment rate proxied by net fixed capital formation to GDP (including changes in inventory value) and current account position to GDP (CAB).[4]

I assume that each dependent variable follows the following data generating process:

[4]Current account position aggregate is built as the difference between national saving and fixed capital formation. Thus, one out of the three individual regressions will always be redundant. Concretely, in the following linear regressions, the estimated coefficients in the current account position individual regressions equal the difference between the estimated coefficients in the corresponding individual national saving and fixed capital formation regressions.

$$y_{i,t} = \beta_{0,i} + \beta_1' D_{it} + \beta_2' Interactive_{it} + \beta_3' X_{it} + u_{it} \quad i = 1,...,N \quad t = 1,...,T$$

$$Interactive_{it} = D_{it} Imper_{it} \quad with \quad Imper_{it} = \{INSTITUTION_{it}, CREDIT_{it}\}$$

where $y_{i,t}$ represents the dependent variable in country i at time t; $D_{i,t}$ refers to a vector of demographic variables; $Interactive_{i,t}$ is the vector of interactive terms between population age structure and both external and internal capital market imperfections described below, and $X_{i,t}$ represents a vector of non demographic explanatory variables that have been identified in the literature as being important determinants of saving and investment rates.[5] They are institutional quality (or *de jure* restrictions in capital, goods and services transactions), credit availability and real GDP per capita growth. A detailed description of all the individual variables used in the statistical analysis is provided in appendix 3.A.

This model specification assumes that country-specific unobservable characteristics are invariant over time. The Hausman test validates the hypothesis of fixed effect against random effect specification for each regression.

Time effects are also included in the estimation, in order to capture time specific shocks common to all countries. Time effects also allow to control for the feedback effect of demographic differences across countries on the world interest rate. The size of a given country feedback effect depends on the given country relative population size every thing else being equal. Controlling for this feedback effect is in line with the two previous chapters' theoretical foundations that rely on small open economy models. In a two country overlapping-generations model without capital market imperfections, the general equilibrium impact of an asymmetric fertility shock on the world interest rate reduces the scope for international capital flows.[6]

I use panel data estimation with annual variables.[7] The use of annual data favors the presence of serial correlation in the errors. Indeed, various serial correlation tests designed for fixed effects model (see Wooldridge [46] Chap 10 pp. 275) suggest the presence of such

[5] Loayza, Schmidt Hebel and Serven [27] provide a recent empirical study on the determinants of household saving. Servén and Salimano [43] provide a useful survey of the empirical literature on the determinants of investment.

[6] Further research will investigate the consequences of an asymmetric fertility shock in presence of capital market imperfections in a two country framework. I will then compare the latter models results with the small open economy ones.

[7] Estimations using three year averages deliver qualitatively similar results to those presented below.

serial correlations.[8] Under serial correlation, a robust variance matrix estimator (Arellano [4] following the general results from White [45], Chapter 4) is valid in the presence of any heteroskedasticity or serial correlation provided that the sample period length, T, is small relative to the total number of countries, N (see Wooldridge [46] Chap 10 pp. 276). Given the adequacy of our sample to the latter condition, I compute the robust standard errors as the square roots of the diagonal elements of robust variance matrix. To construct Wald statistics, I use this robust matrix as estimator of the true variance.

To capture the impact of a change in population age structure on the various dependent variables, I use a detailed population age structure consisting of 17 population age shares: 0-4, 5-9,..., 75-79 and 80+ (United Nations [44]). However including all available population age shares in the individual regressions will cause multicollinearity. To tackle this issue, the literature on the economic consequences of population age structure usually uses one or two broad population age shares. Despite providing parsimonious specification, the latter type of specification leads to a loss of accuracy in evaluating the economic impact of population age structure. In order to obtain a detailed picture of the economic effect of population age structure, I follow Fair and Dominguez [20] in using a low order polynomial representation of population age share coefficients.[9] As described in appendix 3.B, given specific assumptions, the information embodied in population age structure could be captured by three geometric combinations of age shares, denoted D_j. The estimation of δ_j associated with these complex geometric combinations allows me to obtain a detailed picture of the effect of age structure, while maintaining a parsimonious econometric specification.

I now turn to discuss the predicted signs of coefficients associated with those variables, first in the national saving regression, and then in domestic investment regression.

3.3.1.1 Saving Determinants

The coefficients associated with population age structure are expected to be distributed in an hump-shaped fashion in the saving regression, as predicted by the life-cycle hypothesis (see Modigliani and Brumberg [33] and [15]). However, the presence of liquidity constraints is likely to impede such life-cycle saving behavior, thus flattening the distribution of the coefficients associated with the effect of age structure on saving. Indeed, chapter 2 has shown

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[8] However, residuals serial correlation could be the result of persistence in omitted variables, that can be tackled through using lagged dependent variable specification. OLS estimations of such dynamic equations are biased of order $0(\frac{1}{T})$. Robustness checks using Arrellano and Bond [5] Generalized Method of Moments estimator (designed for the estimation of dynamic panel that provides unbiased and consistent estimators) deliver qualitatively similar results to those presented in the present chapter although less stable.

[9] F-test of joint significance of coefficients cannot reject the cubic polynomial representation of population age structure in the various individual regressions.

that the presence of liquidity constraints dampens the consequence of an asymmetric fertility shock on a small open economy's national saving. At the time the shock has occurred. more stringent liquidity constraints reduce the young-aged individuals increased borrowing. anticipating higher lifetime income. After the period in which the shock has occurred (corresponding to a middle-aged share increase in the empirical investigation), more stringent liquidity constraints dampen the increase in national wealth triggered by the shock through reducing middle-aged increased saving. These specific theoretical predictions will be subject to empirical investigation.

Institutional quality is proxied by an index of various rating factors such as rule of law and corruption (see appendix 3.A). Given the absence of theoretical underpinning on the effect of institutions and on saving, I expect the sign of the coefficient associated with the institutional quality index on saving to be ambiguous.[10]

Credit availability is proxied by domestic credit to the private sector over GDP (CREDIT). The associated coefficient is expected to have a negative sign in the saving regressions. As credit markets expand, borrowing constraints are eased and the aggregate saving rate is likely to decrease. Japelli and Pagano [24] provide theoretical and empirical evidence that liquidity constraints on households had a negative impact on the national saving rate in OECD countries during the 1980s.[11]

GDP growth rate (GROWTH) proxies a change in aggregate output. The coefficient associated with GROWTH is expected to have a positive sign in the saving regressions. Indeed in a life-cycle framework, income growth redistributes saving from elderly individuals to working individuals. Income growth therefore leads to an increase in the economy's aggregate saving, through the age compositional effect.[12] Most empirical studies show that GDP growth has a positive and significant impact on the saving rate.[13]

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[10]One noticeable exception is Edwards [19], who provides theoretical and empirical evidence that increased political stability enhances public saving.

[11]In my present study CREDIT is a relevant variable both for firms and individuals behavior and thus for corporate and household saving. Japelli and Pagano's [24] theoretical model focuses on individual behavior. Thus liquidity constraints proxies used in their empirical analysis are relevant only in explaining household saving, although they use national saving.

[12]Angus Deaton's chapter in Schmidt-Hebbel and Servén [41] provides a useful survey on the theoretical and empirical literature on the relationship between growth and saving. The author argues that causality between saving and growth can go in both directions. Thus my empirical estimations are potentially biased, due to reverse causation between saving and growth. I further address this issue through the use of instrumental variables techniques. Carroll, Overland and Weil [16] provide empirical evidence that the causality goes from growth to saving and not the other way round. They also show that introducing habit formation in a standard growth model can reconcile the fact that growth leads to higher saving and not the other way round.

[13]Deaton and Paxson [18] provide evidence of life cycle saving behavior at the individual level. The authors emphasize the fact that inference on individual saving behavior, based on multigenerational households behavior is misleading and usually leads to individual age saving profiles which is rather flat. The authors develop a method that can compute individual age saving from household saving surveys. Results indicate

I now turn to discuss the predicted signs of the coefficients associated with the variables included in the domestic investment regressions.

3.3.1.2 Investment Determinants

In presence of good institutions, I expect the distribution of the coefficients associated with population age structure in the investment regression to be hump shaped. An economy with a relatively younger population and therefore a more abundant labor force is likely to attract domestic and foreign investment taking advantage of lower wage levels. A relatively older population with a scarcer labor force will experience a lower investment rate, as wage levels will tend to be higher. In contrast, when institutions are poor, the distribution of the coefficients associated with population age structure in the investment regression is expected to be flat. Indeed, poor institutions prevent foreign investment. The economy is *de facto* closed so that differences in age structure across countries do not affect domestic investment. Indeed, chapter 1 has shown in a simple theoretical framework that, if the degree of external capital market imperfections is not too high, capital should flow from the fast aging to the slow aging country. As the aging difference vanishes, capital is repatriated in order to finance old-aged investor consumption. Those specific theoretical predictions will be subject to empirical investigation.

The coefficient associated with the institutional quality index is expected to have a positive sign in the investment regression. Indeed, the lack of property right enforcement is likely to deter foreign investment, as claimed for instance in Lucas [29].[14] Restrictions on capital, goods and services transactions (RESTRICTION), proxied by an average of various dummy variables are also used as an alternative indicator for external capital market imperfections.[15] The coefficient associated with RESTRICTION is thus expected to be positive in the investment regression. RESTRICTION captures both *de jure* (not necessarily binding) restrictions on inflows and outflows of capital or goods. In fact, most of the developing countries only present *de jure* restrictions on capital outflows. Thus one may argue that restrictions on capital outflows are unlikely to be relevant to explain investment. However, a country's willingness to undertake financial integration could be interpreted as a signal

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a hump shaped individual age saving profile, in line with the life cycle hypothesis of saving.

[14]Theoretically, economic and political uncertainty also play a role in investment decisions because they are irreversible (see Pindyck [34]). Moreover, Pindyck and Salimano [35] show empirically, using both cross-sectional and time-series data, that volatility of capital marginal profitability affects investment as the above theory would suggest.

[15]This index includes 4 indicators: 1) multiple exchange rate practices, 2) current account balance restrictions, 3) capital account balance restrictions, 4) surrenders of exports. See appendix 3.A for a detailed presentation of the data and their sources.

that this country is going to practice more friendly policies towards foreign investment in the future. Indeed, Bartolini and Drazen [9] suggest that removing restrictions on capital outflows can, through its signaling role, lead to an increase in capital inflows. Empirically, many countries have received significant capital inflows after removing restrictions on capital outflows (Mathieson and Rojas [31]).

The coefficient associated with CREDIT is expected to have a positive sign in the investment regression. Theoretical studies supported by a large body of empirical evidence suggest that financial development favors investment.[16] Indeed, a more developed financial system enhances the efficiency of the intermediation that allows to better mobilize saving (national and foreign) by reducing information, monitoring and transaction costs. Levine [30] provides a useful survey on theoretical and empirical evidence of the effect of financial development on growth.

The coefficient associated with GROWTH is expected to have a positive sign in the investment regression. In relatively recent theories of investment, a firm's investment decision is determined by the marginal Q ratio, which depends on the market value of additional investment and its replacement cost.[17] The efforts to validate the Q approach on historical data have had little success. When attempting to incorporate Q theory investment relevant determinants in my specification, data limitations on stock market valuation and cost of capital for developing countries raise severe empirical problems. I will rely here on a more *ad hoc* empirical literature specification that is strongly influenced by data availability. In fact, one of the most robust results of this empirical literature surveyed by Servén and Salimano [43] is the positive impact of a higher current growth on investment. Theoretically, the effect of change in current growth will capture the accelerator effect. In the *ad hoc* accelerator framework, an increase in aggregate output increases desired investment. Investment therefore increases in order to close the gap between desired investment and actual investment.

I now turn to the estimations' results.

3.3.2 Results

In this section, I present the results of various individual regressions on saving, investment and the current account position. I first test chapter 1's main theoretical prediction, claiming

[16]The use of credit availability as a proxy for financial development to explain investment raises the issue of reverse causality, that is addressed in the empirical analysis through the use of instrumental variables technique.

[17]In the baseline neoclassical model without adjustment costs and where firms face perfect elastic supply of capital, firms have no defined investment policy. Marginal product of capital equals its user cost which is a static condition determining the capital stock of the firm. Thus the firm has an infinite speed of investment and immediately adjusts its capital stock to the optimal level. It implies, for example, that discrete changes in economic environment produce infinite rates of investment or disinvestment. (see Romer [40])

that good institutions allow for an effect of age structure differences on international capital flows through the foreign investment channel. Then, I test chapter 2's prediction, claiming that looser credit constraints magnify the effect of age structure differences on international capital flows through the national saving channel.

3.3.2.1 On the Role of the Interaction between Age Structure and Institutions in Explaining International Capital Flows

According to the results displayed in figure 3.3, individually good institutions significantly foster investment and deteriorate the current account position, but do not prove to significantly affect saving. Indeed, poor institutional quality captures the presence of sovereign risk and poor governance, which are likely to deter investment. This result confirms Alfaro et al. [3] who provide empirical evidence using a cross country analysis that institutional quality matters in determining international capital flows.

Figure 3.3 presents individual population age share coefficients combined with their interactions with INSTITUTION for the corresponding saving, investment and current account regressions.[18] In order to retrieve these coefficients, I add to the estimated coefficients of the individual effects of change in population age shares the estimated coefficients of the interaction between population age shares and INSTITUTION evaluated at two different levels of institutional quality.[19] The solid line and dashed line displayed in Figure 3.3 correspond to those retrieved coefficients evaluated respectively at a high and low level of institutional quality. Those coefficients associated with population age structure are not behavioral coefficients. They are best interpreted as a resulting impact of a change in population age structure on national saving, domestic investment and the current account.

The results provide empirical evidence of a differentiated effect of age structure on international capital flows. Indeed, F-tests of joint significance both for investment and current account regressions, shown in Figure 3.3, point to a significant interactive effect between age structure and institutional quality.[20] The corresponding plot of coefficients associated with population age shares shows that in presence of high institutional quality, the distribution of the effect of change in population age structure on the current account position displays an

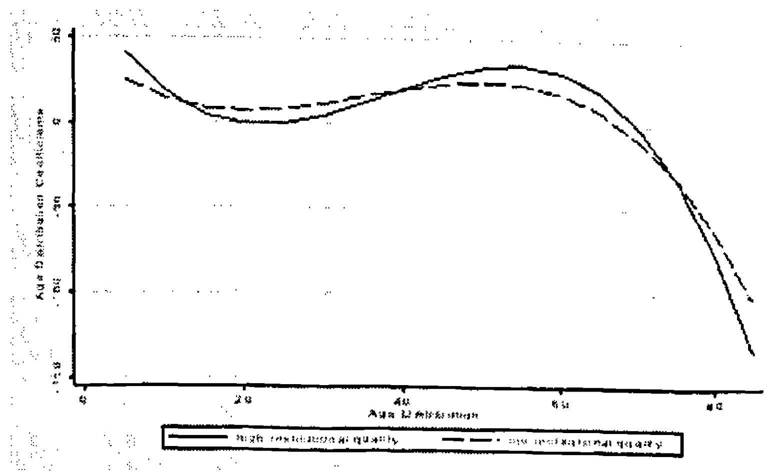
[18] In the present chapter, I do not intend to distinguish between the respective impact of fertility rate decline and life span lengthening on saving and investment. However, when including life expectancy and its square in saving regressions controlling for population age structure, I found hump-shaped impact of life span lengthening on saving, thus confirming Bloom, Canning and Bryan [12].

[19] The high level of institutional quality corresponds to the high income OECD countries' mean over the sample period. The low level of institutional quality corresponds to the low income countries' mean.

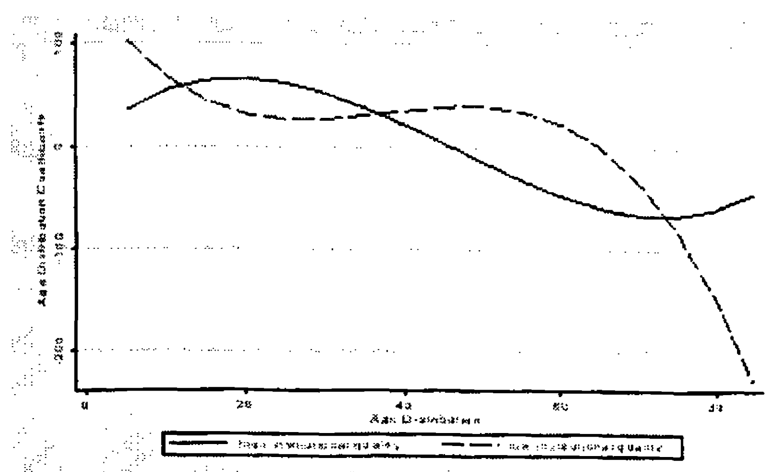
[20] F-tests associated with age structure and its interaction with institutional quality on the current account position indicate significance at the one per cent level for the individual effect of age structure and at the five per cent level for its interaction with institutional quality.

Age Structure and Institutional Quality

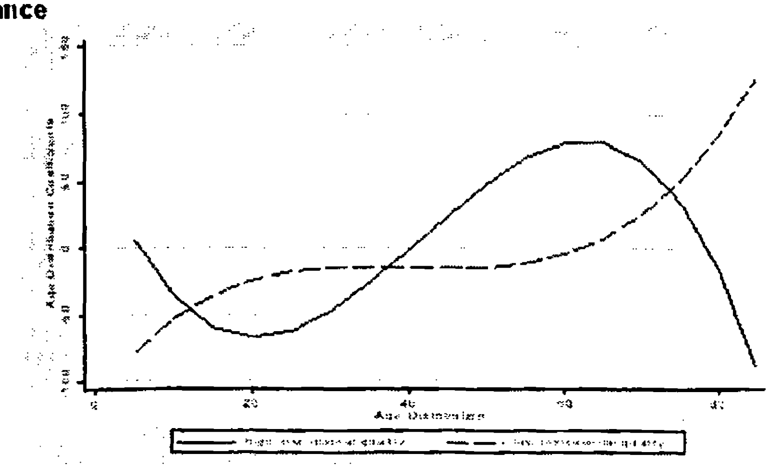
	National Saving
GROWTH	0.180***
	(4.16)
CREDIT	-0.047
	(1.03)
INSTITUTION	-0.005
	(0.03)
Demographic Effect	0.39
Interactive Effect	0.13
Joint Effects	0.49
Countries	103
Observations	1381
R-squared	0.73



	Investment
GROWTH	0.169***
	(4.50)
CREDIT	0.061
	(1.59)
INSTITUTION	0.482***
	(3.24)
Demographic Effect	12.43***
Interactive Effect	6.34***
Joint Effects	7.01***
Countries	103
Observations	1381
R-squared	0.67



	Current Account Balance
GROWTH	0.011
	(0.20)
CREDIT	-0.108*
	(1.84)
INSTITUTION	-0.457**
	(1.99)
Demographic Effect	3.70***
Interactive Effect	2.91**
Joint Effects	2.03*
Countries	103
Observations	1381
R-squared	0.59



The lines show the direct and combined effect associated with the labeled level of institutional quality.
Fixed effects and time effects are also included in the above specification but their estimations are not shown.
Robust absolute t-statistics in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%.

Figure 3.3: Interactive Effect of Age Structure and Institutions on Saving, Investment and CAB

inverted U shape. In contrast, when institutional quality is low, the distribution of the effect of population age structure is rather flat, implying a looser effect of change in population age structure on the current account position.

When institutional quality is high, the distribution of the effect of population age structure on saving and investment appears to be desynchronized along age, thus opening the scope for age structure to play a role in determining international borrowing and lending. In contrast, when institutional quality is low, the effect of population age structure on investment is fairly flat along age distribution leading to a looser effect of change in population age structure on the current account. Indeed, the corresponding plot of the effect of age structure on saving shows that the effect of age structure on saving is similar for low and high levels of institutional quality. However, for investment the "mass" of the distribution of the effect of change in population age structure appears to occur earlier in age in presence of high institutional quality than in the case of low institutional quality. Indeed, when institutional quality is high, the impact of a change in population age structure on investment is concentrated around 15 to 40 years old, whereas the effect is concentrated around 40 to 70 years old when institutional quality is low. Indeed, countries experiencing poor institutional quality rely heavily on national saving to finance their domestic investment, as the presence of sovereign risk prevents them access to external sources of financing, such as foreign investment which takes advantage of a cheaper labor force in these younger countries.

In presence of good institutions, a higher 40-65 share leads to an improvement in the current account position. In this context, an increase in the younger age population share (up to 40) leads to a current account deterioration. These empirical findings are in line with chapter 1 which underlines the existence of a differentiated effect of age structure on international capital flows.

These results also suggest that the bulk of the effect of age structure on saving occurs rather late in age, reaching a peak around 50. Furthermore, the elderly population age share tends to have a negative impact on national saving rather late in the age distribution starting, around 65. The distribution of the effect of age structure on saving appears to be skewed to the right, compared to what the life-cycle hypothesis would predict.[21]

[21]Studies based on household surveys provided empirical evidence pointing out that the elderly do save or at least do not dissave, contradicting the life-cycle hypothesis prediction. Evidence goes back to Mirer [32] and is being continuously updated as new data sets become available. However, it should be noted that household surveys rarely have adequate data on private pensions and other annuities: an elderly couple living on a pension from an ex employer is running down the value of an annuity, but if their consumption is less than their income (here the annual yield from annuity) they will be reported as saving. Such saving among the elderly has been observed among the elderly in the United States, Japan, the United Kingdom, Germany, Italy, and Taiwan (see for instance Attanasio [6]). This evidence is consistent with the presence of bequests motives.

3.3.2.2 On the Role of the Interaction between Age Structure and Domestic Liquidity Constraints in Explaining International Capital Flows

Individually, credit availability has a negative impact on the saving rate, as shown in Figure 3.4.[22] This result is in line with Japelli and Pagano [24], who provide empirical evidence that financial deregulation could help explain the decline in saving observed during the 1980s in OECD countries. Theoretically, credit availability favors the efficiency of the intermediation sector, which may trigger more investment. However, the coefficient associated with credit availability in the investment regression is positive but not significant. As a result, increased credit availability significantly favors a deterioration in the current account position. The latter result is driven by the effect of increased credit availability on saving.

The sign of the coefficient associated with RESTRICTION is negative, indicating that the presence of restrictions improves the current account position. Indeed, restrictions, through their signalling effect, can deter foreign investment. However, the coefficient is not significant.[23]

Figure 3.4 presents individual population age share coefficients combined with their interactions with CREDIT retrieved from the corresponding regression on saving, investment and current account. The solid line and dashed line displayed in figure 3.4 correspond to the joint effect of age structure and its interaction with CREDIT evaluated respectively at a high and low level of credit availability.[24] Results provide empirical evidence that lower domestic liquidity constraints magnify the effect of relative change in age structure in shaping national saving. Indeed, F-tests of joint significance for saving in figure 3.4 point to a significant interactive effect of credit availability and age structure in explaining national saving. The evidence that the interaction between age structure and credit availability impact the current account position is weaker. Indeed, F-tests of joint significance for current account position in figure 3.4 indicates that the interactive effect is not significant. However, F-tests indicate the joint effects of age structure and its interaction is significant. The hump-shaped distribution

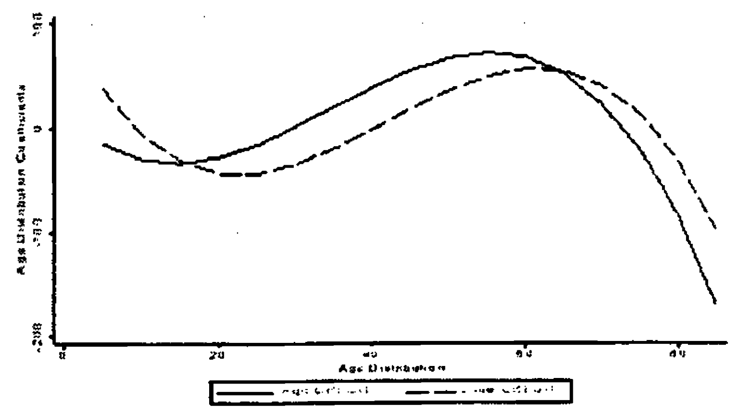
[22] RESTRICTION is used instead of institutional quality index in the present set of regressions in order to use the longest sample period (1970-2000). Indeed, institutional quality data is only available starting from the year 1985. The results shown in Figure 3.4 are qualitatively similar when institutional quality index is used as a proxy for external capital market imperfections.

[23] As seen previously, those restrictions are not always binding. For instance, if the quality of institution in a given country is so low that it will deter all possible investment. The presence of restrictions will have no direct influence on international borrowing and lending for that given country. One way to test for the presence of a differentiated effect in the relation between restrictions and international capital flows, would be to study the impact of the interaction between those *de jure* restrictions and institutional quality on international capital flows. However, those considerations take us away from the scope of the present dissertation.

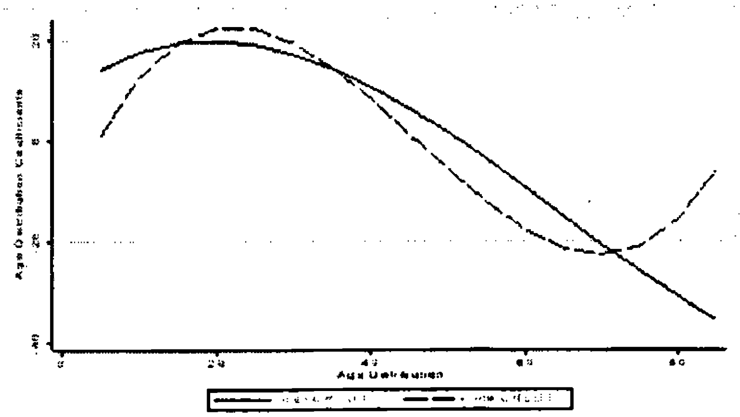
[24] The high level of credit availability corresponds to high income OECD countries' mean over the sample period. The low level of credit availability corresponds to the low income countries mean.

Age Structure and Domestic Liquidity Constraints

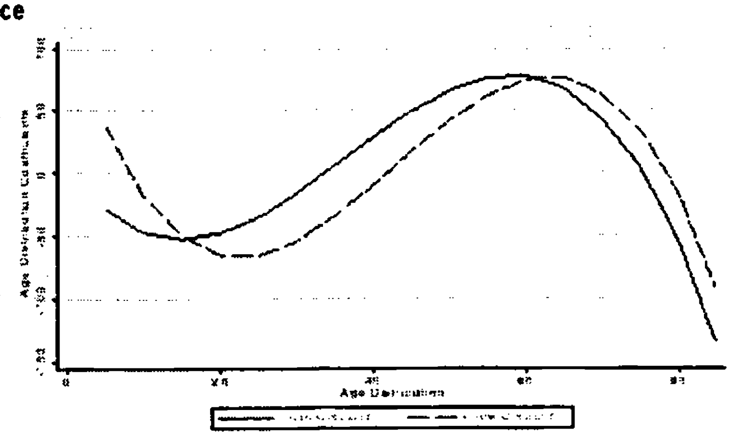
	National Saving
GROWTH	0.199***
	(5.54)
CREDIT	-0.136***
	(3.80)
RESTRICTION	-3.107
	(0.83)
Demographic Effect	4.01***
Interactive Effect	8.73***
Joint Effects	13.67***
Countries	115
Observations	2198
R-squared	0.71



	Investment
GROWTH	0.198***
	(5.72)
CREDIT	-0.006
	(0.19)
RESTRICTION	0.554
	(0.17)
Demographic Effect	2.45*
Interactive Effect	0.86
Joint Effects	2.81*
Countries	115
Observations	2198
R-squared	0.64



	Current Account Balance
GROWTH	0.001
	(0.02)
CREDIT	-0.131***
	(3.08)
RESTRICTION	-3.661
	(0.86)
Demographic Effect	7.59***
Interactive Effect	5.90***
Joint Effects	13.45***
Countries	115
Observations	2198
R-squared	0.51



The lines show the direct and combined effect associated with the labeled level of credit availability.
Fixed effects and time effects are also included in the above specification but their estimations are not shown.
Robust absolute t-statistics in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%.

Figure 3.4: Interactive Effect between Age Structure and Domestic Liquidity Constraints on Saving, Investment and CAB

of the population age share coefficients in the saving regression implies that, in the presence of a high level of credit availability, the life cycle hypothesis appears to be more at play than in the case of lower credit availability. Indeed, for a high level of credit availability, younger and middle aged population age shares have stronger impacts (in absolute value) on aggregate saving than is the case with lower credit availability. Moreover, the interaction between age structure and credit availability is of limited relevance in the investment regression when compared to the saving regression. Thus, the effect of change in population age structure on the current account position is magnified by a high level of credit availability. These empirical findings are in line with chapter 2 which underlines that looser liquidity constraints magnify the impact of an asymmetric fertility shock on national saving and current account position of the small open economy over time.

3.3.3 Robustness

In order to determine whether or not the empirical results presented above are robust, I proceeded along two lines. First, I analyzed the robustness of the results with respect to the presence of outliers. To do so I used a two-step procedure. I first identified influential observations (Davidson and MacKinnon [17] pp. 32-39) through computing the change in the coefficient of interest indexed by i, resulting from the deletion of observation j, namely $DFBETA_{i,j}$ (Belsley, Kuh and Welsch [11]). Then, I re-ran the above regressions excluding influential observations (observation with a $DFBETA_{i,j}$ absolute value above a given cutoff) from the sample one by one and all simultaneously.[25] For instance, in the first set of regressions shown in Figure 3.3, I deleted up to 82 observations out of 1381 observations. In the second set of regressions shown in Figure 3.4, I deleted up to 114 observations out of 2198 observations. My main results are not driven by outliers. Indeed, the combined effect between age structure and its interaction with both institutional quality and credit availability on saving, investment and the current account position remain significant. Moreover, results obtained after deletion of influential observations lead to a differentiated effect of age structure on the current account position qualitatively similar to the results presented above.

Secondly, I analyzed the robustness of the above results to various specifications. The results presented in Figure 3.3 are robust over various specifications and the use of various indicia for institutions. Appendix 3.C presents tables of results for the robustness checks. For instance, when using the indicia capturing a country's degree of corruption as a proxy for external capital imperfection (EXTIMP), my main results indicating a differentiated impact of age structure on investment and current account position are still significant at the one

[25]I used a DEFBETAS cutoff of $2/\sqrt{n}$ as suggested by Belsley, Kuh and Welsch [11].

per cent level as shown in the specification (4) of Figure 3.8. Figure 3.8 also presents the results of estimations using RESTRICTION and one of indicia capturing the presence of current account restrictions (RESTRICT2) as proxy for external capital market imperfections. The main results are robust to those modifications. However, it appears more difficult to find alternative proxies for internal capital imperfections (INTIMP) that have a time dimension. I resort to the use of stock market development indicators such as stock market capitalization (CAPITALIZATION). Figure 3.9 presents those results for a variety of stock market indicators (see appendix 3.A for data sources). The results confirm the presence of a significant interacted effect of age structure and internal capital market imperfections in explaining national saving and current account position.

I also investigated whether omitted variables such as income level could have biased, and led to inconsistency, of the above results. It could well be that the above results have captured the impact of the level of income that determines both age structure and dependent variables, such as saving and investment. Indeed, models of subsistence consumption have shed light on how income level may affect saving. Growth models have provided a framework in which initial conditions affect investment during the transition. Income level influences age structure through its impact on fertility rates and life expectancy. For instance, Becker and Barro [10] constructed a growth model in which economic development influences family choices about the number of children, and hence affects fertility rates. Empirical studies have found a strong linkage between economic variables, such as per capita income, and demographic variables, such as fertility and mortality rates, as sketched in Figure 3.1. To take this potential omitted variable bias into account, I included the lagged level of the logarithm of GDP as a control variable in the main specification presented above.[26] The resulting estimates of the combined effect of age structure and its interaction with both external and internal capital market imperfections remain significant as shown in Figure 3.10 in Appendix 3.11. The distribution of age structure coefficients is similar to the above regression results. The existence of a differentiated effect of age structure and international capital flows is a robust result. However, this inclusion may lead the regressions being plagued with simultaneity bias. I thus used instrumental variable estimation.[27]

[26] I also used dynamic specifications that includes lagged dependent variables in the left hand side of the regressions. This lagged dependent variable specification accounts for the persistence in omitted variables, thus providing a more general robustness check to omitted variables problem than including GDP per capita as a control. Ordinary Least Squares (OLS) estimator of such dynamic equations are biased of order $0(\frac{1}{T})$. I thus used Arrellano and Bond [5] Generalized Method of Moments designed for the estimation of dynamic panel and which provides unbiased and consistent estimates.Results are qualitatively similar to the above results although less stable.

[27] The instruments for current GDP per capita are lagged values of current GDP per capita. Further discussion on endogeneity bias is provided in the following subsection.

3.3.4 Endogeneity Issues

So far there has been no discussion of problems of endogeneity. One concern about the above regressions is that they are plagued with simultaneity bias. Indeed, the direction of causality between income growth/availability of credit/institutional quality and the various dependent variables, namely saving and investment rates, is not necessarily clear-cut. For instance, endogenous growth models (see Romer [38] [39] and Lucas [28]) provide a theoretical framework in which higher saving (higher investment in a closed economy) leads to higher output growth. Moreover, higher saving, through its impact on the supply side of credit, may influence credit availability. Higher investment, through its impact on the demand side of credit, is likely to impact credit availability. To take this potential bias into account I performed instrumental variable estimations. The instruments used for GDP growth are first order lagged values of GDP growth. As for credit availability and institutional quality, the literature has provided instruments that are now commonly used. For instance, Japelli and Pagano [24] use down payments as a proxy for the presence of liquidity constraints to avoid endogeneity problem. Following Laporta et al. [25], [26], legal origin has been widely used to instrument for current institutions. Alternatively, Acemoglu et al. [1] [2] suggest that conditions in the colonies as instrument for current institutions. Unfortunately, both data unavailability of those variables for most of the countries included in our sample and their lack of time series dimension, prevent their use as instruments in the present study.[28] I thus used first order lagged values as instruments for credit availability/institutional quality. Interacted terms are also instrumented using first order lagged values of credit availability and institutional quality times demographic variables. Using lagged values as instruments could be problematic if credit availability/institutional quality shocks are persistent and instruments are insufficiently lagged. However, when including higher order lagged values as instruments, overidentification tests indicate that those models are not correctly specified. The estimated coefficients associated with age structure and with its interactive terms in all the various regressions using 2SLS are virtually not affected, as shown in Figure 3.11, compared to those obtained in the above subsection.

3.4 Past and Projected Consequences of Global Demographic Changes

I evaluate the past, present and projected impact of the global aging phenomenon on international capital flows. To do so, I exploit countries' past and projected population age structure information together with previously estimated coefficients of the effect of

[28] Instruments include fixed effects and time effects.

population age structure, and its interaction with capital market imperfections on saving, investment and the current account position.[29] As capital is becoming increasingly mobile, countries' borders are less relevant in influencing international capital flows.[30] In addition, I expect demographic differences to play an important role in shaping future world economic developments, future international capital flows being one important aspect of those developments. I thus choose to consider homogenous demographic regions when investigating the consequences of aging on international borrowing and lending.[31]

As seen previously, there is evidence of a differentiated effect of age structure on international capital flows. I choose to use a medium scenario of internal capital market imperfections, to quantify the overall effect of age structure on saving, investment and international capital flows.[32]

Tables 3.5, 3.6, 3.7 present the impact of age structure on saving, investment and the current account position, for the four demographic clusters under a medium capital market imperfections scenario. The levels of the effect of age structure change on saving, investment and current account are of limited interest, as they are arithmetic averages of age structure effects on country cluster members. Changes in the levels of age structure effect are the relevant features to be analyzed. I therefore present the age structure impact in terms of change relative to the period 1970 to 1975. It should also be noted that our out of sample projection exercise is *ceteris paribus* by nature. Indeed, given the present focus of the paper, I do not make any attempt to forecast the individual evolution of non-demographic variables such as INSTITUTION, CREDIT, GROWTH and RESTRICTION, that are however relevant in determining the future changes in saving, investment and the current account position.[33]

Up to 2025, relative changes in age structure have limited effect on the aggregate saving rate in more advanced aging countries corresponding to cluster 4 in figure 3.5. Indeed, age structure change is estimated to have contributed to an increase in saving of two and half per cent over the period 1970 to 2020 in more advanced aging countries. After this date, the

[29] I used United Nations [44] median scenario projection covering population age distribution from 2000 to 2050.

[30] In contrast, countries' borders are of greater importance when considering international labor movements. In this respect, national policies, influenced by economic and political cycles, regulate immigration inflows and sometimes outflows.

[31] I distinguished four countries groups on the strict basis of population age structure differences, attempting to match the four stages of the demographic transition model described in Figure 3.1. I proceeded to a cluster analysis to design those groups using population age distribution in the year 2000 as a criteria. Figure 3.12 in Appendix 3.E presents the country composition of the different clusters.

[32] In this medium internal capital market imperfections scenario, each cluster degree of credit availibility corresponds to an unweighted country average degree of credit availability during the period 1970 to 2000.

[33] However, it should be noted that given the differentiated effect of age structure on saving, investment and the current account, I resort to a "medium scenario" hypothesis on degree of internal capital imperfection to compute the interacted effect of age structure with such imperfection.

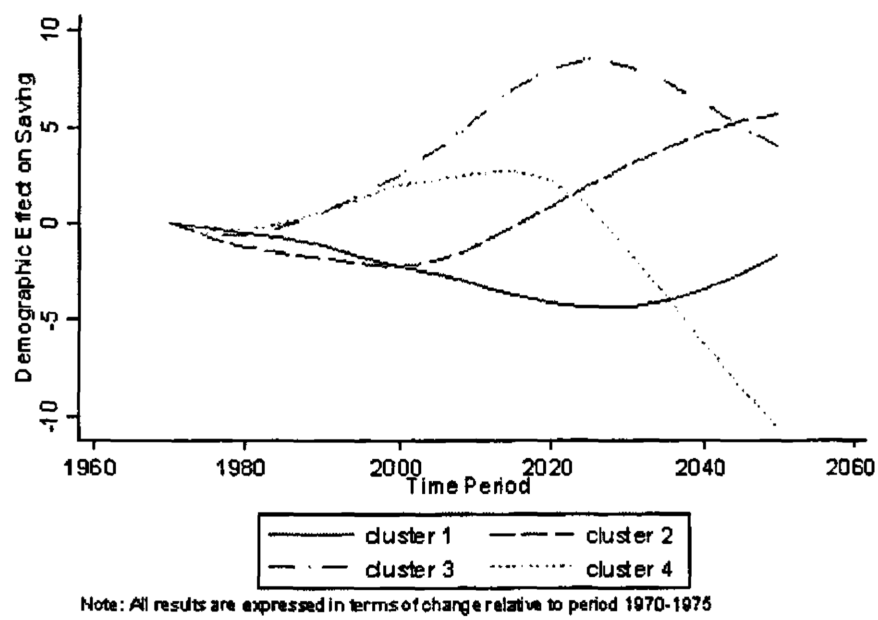


Figure 3.5: Past, Present and Projected Impact of Age Structure on Saving

increase in the very old individuals population share is projected to lead to a sharp decline in the aggregate saving rate. In "fast aging" countries corresponding to cluster 3, age structure change will contribute to a rapid rise in their saving rate, reaching a peak around 2025. After this date, age structure change is projected to provoke a sharp decline in saving. "Moderate aging" countries corresponding to cluster 3 are also experiencing a hump-shaped effect on aggregate saving rate over time, similar to "faster aging" countries. However this decline is delayed in time compared to the latter countries' experience. Poorer credit availability in less advanced aging countries also reduces the hump shaped effect of aging on saving. In "fertility trapped" countries represented by cluster 1, age structure change has first provoked a decrease in the saving rate as the fertility rate is relatively high and then an increase in saving, as the population of cluster 1 will age rapidly.

Changes in age structure have contributed to a sharp decline in investment in more advanced aging countries as shown, in figure 3.6. As a result, age structure change is projected to improve the current account position in advanced aging countries up to the year 2020, as shown in figure 3.7. Over the past three decades, I estimate that age structure changes have contributed to improve the current account position by five percent of GDP in more advanced aging countries. After 2020, age structure changes are projected to cause the current

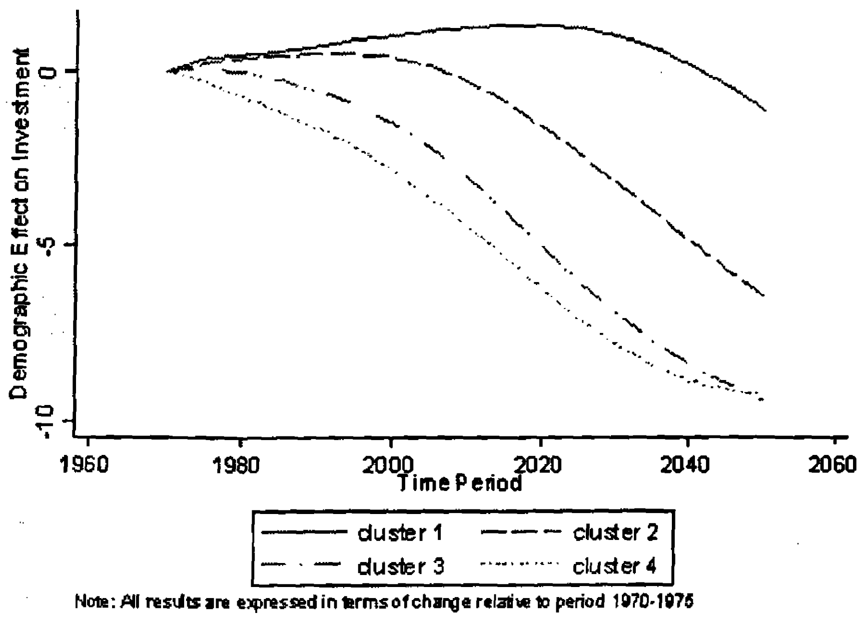


Figure 3.6: Past, Present and Projected Impact of Age Structure on Investment

account position to deteriorate for advanced aging countries, as these changes will start to put downward pressure on saving. Age structure changes are also projected to put downward pressure on investment for less advanced countries in the demographic transition, but in a delayed fashion with respect to the more advanced countries, the delay is shorter, the more advanced the country is in the demographic transition process. As a result, age structure changes are projected to also improve less advanced countries' current account position in the future (see figure 3.7) as those countries are also aging rapidly.

This prediction of a global improvement in current account balance is impossible as changes in current account position should theoretically cancel out. Indeed, our statistical exercise suffers from the caveat that it does not allow for adjustments through prices. For instance, the general equilibrium effect of aging on world interest rate will limit the amount of international capital flows triggered by age structure differences.[34] In this respect, these results are certainly overestimating the impact of age structure changes on international capital flows. However, these results are delivering important insights both on the direction and the importance of the international capital flow induced by age structure differences. Indeed, these results point to the substantial role of age structure in shaping international

[34]In order to remedy to this caveat, I introduced time effects in the empirical specifications.

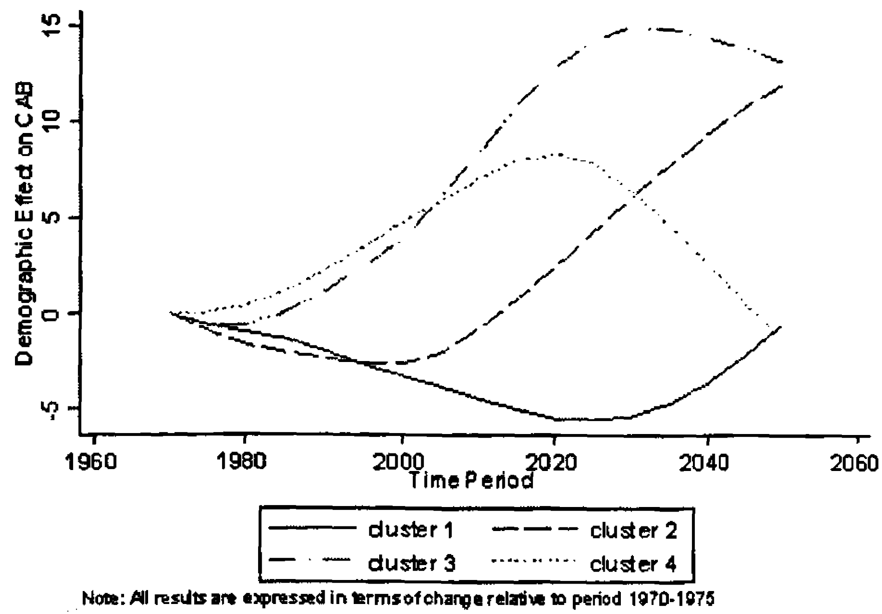


Figure 3.7: Past, Present and Project Impact of Age Structure on the CAB

capital flows from currently more advanced to less advanced countries in the demographic transition, both in the past and in the coming decades. Everything else being equal, these results open the scope for a future reversal in the direction of international capital flows around the year 2020, from currently less advanced/poor to more advanced/rich countries. Different scenarios of both internal and external capital market imperfections reveal that the scope for international capital flows is reduced, when imperfections are high, though through different channels.[35]

3.5 Conclusion

Our objective in this paper has been to empirically investigate the consequences of changes in age structure and their interaction with both internal and external capital market imperfections in explaining international capital movements. I undertook a systematic empirical analysis of the role of age structure and its interaction with capital market imperfections, using a sample of up to 115 countries for the period 1970 to 2000.

Our results point to the existence of a differentiated effect of age structure on inter-

[35]Projections using these different scenarios are available from the author upon request.

national capital flows, thus validating chapter 1 and 2 main theoretical predictions. Good institutions allow for a differentiated impact of age structure differences on saving and investment, opening the scope for an impact of demographic differences in driving international capital flows. In contrast, bad institutions result in no effect of age structure on international capital flows. Despite increased credit availability contributing to reduced aggregate saving, this will nevertheless magnify the role of the population age structure in driving international capital flows.

Over the past three decades, I estimate that age structure changes have contributed to improving the current account position by five percent of GDP in more advanced aging countries. Around the year 2020, age structure changes are projected to deteriorate the current account position in the latter countries. In other regions, the faster the aging process, the sharper the expected improvement in the current account position. This improvement is expected to reverse itself, at a later stage in time in regions with a slower aging process. Different scenarios of both internal and external capital market imperfections reveal that the scope for international capital flows is reduced when imperfections are high though through different channels.

This work suffers from several caveats. Demography should be accounted for in labor efficiency units that will considerably scale down the age structure differences and explain the potential lack of flow in certain regions, as discussed in Lucas [29]. In addition the adjustment could also take place through migration, which could lead to overestimation of the future capital flows induced by projected age structure relative differences.

Appendices

3.A Data Sources

The basic data set draws from World Bank, World Development Indicators [47] (WDI2K4), from International Monetary Fund, Annual Report on Exchange Rate Arrangements and Exchange Restrictions [23], from The Political Risk Services Group, International Country Risk Guide [36], from United Nations, World Population Prospects: The 2002 Revision [44] (U.N.). It covers at most the period 1970 to 2003 for up to 173 countries. CREDIT is proxied by domestic credit to private sector available from World Bank, World Development Indicators [47]. Further robustness checks will use other proxies for CREDIT such as liquid liabilities (M2 or M3 over GDP), stock market capitalization, domestic listed companies, stocks turnover, stocks traded that are also available from World Bank, World Development Indicators [47]. INSTITUTION is the sum of all the ten ratings components from The Political Risk Services Group, International Country Risk Guide. These individual components range from 0-6 where a higher score means a lower risk.[36] RESTRICTION is the mean of all the 4 dummies variables from International Monetary Fund, Annual Report on Exchange Rate Arrangements and Exchange Restrictions [23]. Those individual dummies variables take the value 1 in the presence of the corresponding restrictions or 0 otherwise.

3.B Age Structure Coefficients Polynomial Representation

This section illustrates the polynomial representation used in the estimations to identify population age structure coefficients. For simplicity, I assume that the dependent variable y_t follows the following data generating process.

$$y_t = \delta_1 p_{1,t} + ... + \delta_J p_{J,t} + \alpha + u_t \tag{3.1}$$

$p_{1,t}, ..., p_{J,t}$ represent J population age shares; α is a constant term and u_t is an iid

[36]This index includes: 1) government stability, 2) socioeconomic conditions, 3) internal conflict, 4) external conflict, 5) corruption, 6) military in politics, 7) religion in politics, 8) law and order, 9) democratic accountability 10) bureaucracy quality.

perturbation.

In order to avoid the regression being plagued by multicollinearity, I use a polynomial representation of population age share coefficients following Fair and Dominguez [20]. I make the following two assumptions. First, I assume that the sum of all individual coefficients associated with the J population age shares is equal to zero, in order to avoid multicollinearity with the constant as expressed formally in equation (3.2a). Second, I assume that each of the individual coefficients has a cubic polynomial representation as formally expressed in equation (3.2b).

$$\sum_j^J \delta_j = 0 \tag{3.2a}$$

$$\delta_j = \gamma_0 + \gamma_1 j + \gamma_2 j^2 + \gamma_3 j^3 \qquad \forall j = 1, ..., J \tag{3.2b}$$

Combining equations (3.2a) and (3.2b) with equation (3.1) leads to expression (3.3).

$$y_t = \gamma_1(\sum_j^J p_{j,t} - \frac{1}{J}\sum_j^J j) + \gamma_2(\sum_j^J j^2 p_{j,t} - \frac{1}{J}\sum_j^J j^2) + \gamma_3(\sum_j^J j^3 p_{j,t} - \frac{1}{J}\sum_j^J j^3) + \alpha + u_t \tag{3.3}$$

This expression can be rewritten as expression (3.4) using the corresponding D_j which are geometric combination of $p_{j,t}$.

$$y_t = \gamma_1 D_{1,t} + \gamma_2 D_{2,t} + \gamma_3 D_{3,t} + \alpha + u_t \tag{3.4}$$

γ_1, γ_2, γ_3 are directly obtained from the estimation of equation (3.4).

γ_0 can be easily retrieved using expression (3.5) obtained from the combination of expressions (3.2a) and (3.2b).

$$\gamma_0 = -\frac{1}{J}(\gamma_1 \sum_j^J j + \gamma_2 \sum_j^J j^2 + \gamma_3 \sum_j^J j^3) \tag{3.5}$$

Given the sequence of γ_j, I can easily retrieve the value of the coefficients associated with the $p_{j,t}$, namely the δ_j.

3.C Robustness

	(1) Saving	Investment	CAB	(2) Saving	Investment	CAB	(3) Saving	Investment	CAB	(4) Saving	Investment
GROWTH	0.180	0.169	0.011	0.199	0.198	0.001	0.200	0.201	-0.001	0.185	0.179
	(4.16)***	(4.50)***	(0.20)	(5.54)***	(5.72)***	(0.02)	(5.55)***	(5.70)***	(0.02)	(4.25)***	(4.57)***
D1	14.647	-217.224	231.872	-85.067	23.839	-108.906	-72.721	11.261	-83.982	11.248	-140.280
	(0.16)	(4.09)***	(2.54)***	(2.56)***	(0.85)	(3.09)***	(3.01)***	(0.55)	(3.39)***	(0.22)	(3.63)***
D2	-1.545	32.687	-34.232	11.967	-3.546	15.533	10.938	-1.092	12.030	-1.299	20.464
	(0.11)	(3.96)***	(2.44)***	(2.38)**	(0.83)	(2.87)***	(2.96)***	(0.35)	(3.15)***	(0.16)	(3.46)***
D3	0.033	-1.366	1.400	-0.452	0.132	-0.584	-0.437	0.014	-0.451	0.039	-0.832
	(0.06)	(3.90)***	(2.39)**	(2.19)**	(0.74)	(2.60)***	(2.84)***	(0.11)	(2.83)***	(0.12)	(3.43)***
CREDIT	-0.017	0.061	-0.108	-0.136	-0.006	-0.131	-0.114	0.007	-0.121	-0.082	0.060
	(1.03)	(1.59)	(1.84)*	(3.80)***	(0.19)	(3.08)***	(3.44)***	(0.27)	(3.16)***	(1.97)**	(1.49)
D1*CREDIT	0.106	0.118	-0.012	0.629	-0.234	0.862	0.610	-0.122	0.732	0.053	0.138
	(0.24)	(0.31)	(0.02)	(1.77)*	(0.68)	(2.10)**	(1.91)*	(0.40)	(1.98)**	(0.13)	(0.23)
D2*CREDIT	-0.007	-0.017	0.010	-0.052	0.034	-0.086	-0.051	0.016	-0.065	0.005	-0.063
	(0.11)	(0.30)	(0.14)	(0.97)	(0.69)	(1.41)	(1.09)	(0.36)	(1.25)	(0.08)	(1.17)
D3*CREDIT	0.000	0.001	-0.001	0.001	-0.001	0.002	0.001	-0.001	0.002	-0.001	0.002
	(0.01)	(0.32)	(0.24)	(0.41)	(0.70)	(0.93)	(0.51)	(0.36)	(0.73)	(0.25)	(1.13)
EXTIMPER											
INSTITUTION	-0.005	0.451	-0.457								
	(0.03)	(3.19)***	(1.99)**								
RESTRICTION				-3.107	0.654	-3.661					
				(0.83)	(0.17)	(0.86)					
RESTRICT2							3.011	-2.671	5.652		
							(0.96)	(1.06)	(1.85)*		
CORRUP										-1.908	-0.383
										(1.58)	(0.39)
D1*EXTIMPER	-0.728	3.393	-4.120	44.902	-33.113	78.014	39.386	-43.932	63.319	-7.306	35.214
	(0.47)	(3.91)***	(2.52)***	(1.54)	(1.39)	(2.66)***	(2.25)**	(1.76)*	(3.90)***	(0.57)	(3.95)***
D2*EXTIMPER	0.106	-0.518	0.624	-6.018	5.659	-10.578	-8.723	3.944	-9.667	1.024	-6.029
	(0.45)	(3.86)***	(2.44)***	(1.14)	(1.90)	(2.30)**	(2.06)**	(1.84)*	(3.72)***	(0.53)	(3.69)***
D3*EXTIMPER	-0.004	0.021	-0.025	0.152	-0.335	0.387	0.227	-0.168	0.396	-0.041	0.193
	(0.42)	(3.79)***	(2.37)**	(0.84)	(1.51)	(2.05)**	(1.91)*	(1.85)*	(3.54)***	(0.52)	(3.44)***
				(0.84)	(1.51)	(2.05)**					
Countries	103	103	103	115	115	115	115	115	115	103	103
Observations	1381	1381	1381	2198	2198	2198	2223	2223	2223	1381	1381
R-squared	0.73	0.67	0.59	0.71	0.64	0.52	0.71	0.71	0.71	0.73	0.66

Fixed effect and time dummies are included in the specification but respective estimated coefficients are not shown
Robust t statistics in parentheses (absolute values)
* significant at 10%; ** significant at 5%; *** significant at 1%

Figure 3.8: Robustness of the Impact of the Interaction between Age Structure and External Capital Market Imperfections on International Capital Flows

	(1)			(2)			(3)			(4)	
	Saving	Investment	CAB	Saving	Investment	CAB	Saving	Investment	CAB	Saving	Investment
GROWTH	0.199	0.198	0.001	0.116	0.351	-0.206	0.180	0.360	-0.051	0.159	0.278
	(5.54)***	(5.72)***	(0.02)	(2.39)**	(6.70)***	(2.52)***	(3.50)***	(5.17)***	(1.11)	(3.30)***	(5.50)***
D1	-85.067	23.839	-103.906	30.896	-36.963	67.859	-1.163	2.789	-4.252	48.741	9.320
	(2.56)**	(0.85)	(3.09)***	(0.68)	(0.96)	(1.37)	(0.05)	(0.12)	(0.14)	(1.54)	(0.40)
D2	11.987	-3.546	15.533	-6.052	4.887	-9.940	-0.594	0.653	-1.247	-7.989	-1.584
	(2.38)**	(0.83)	(2.87)***	(0.26)	(0.84)	(1.38)	(0.12)	(0.19)	(0.29)	(1.63)	(0.43)
D3	-0.452	0.132	-0.584	0.162	-0.214	0.377	0.008	-0.082	0.090	0.301	0.041
	(2.19)**	(0.71)	(2.50)***	(0.61)	(0.89)	(1.30)	(0.04)	(0.58)	(0.49)	(1.49)	(0.27)
RESTRICTION	-3.107	0.554	-3.661	9.477	6.946	2.531	1.873	7.738	-6.565	-1.303	4.956
	(0.83)	(0.17)	(0.56)	(1.20)	(0.85)	(0.26)	(0.36)	(1.56)	(0.99)	(0.27)	(1.03)
D1*RESTRICTION	44.902	-33.113	78.014	2.503	79.742	-77.239	-12.081	-2.351	-9.520	-36.129	-2.938
	(1.54)	(1.39)	(2.66)***	(0.05)	(1.51)	(1.25)	(0.27)	(0.06)	(0.21)	(0.81)	(0.08)
D2*RESTRICTION	-6.018	5.559	-10.578	-2.117	-14.069	11.952	1.669	-1.846	3.515	5.307	-1.065
	(1.14)	(1.50)	(2.31)**	(0.27)	(1.75)*	(1.35)	(0.27)	(0.33)	(0.53)	(0.85)	(0.20)
D3*RESTRICTION	0.152	-0.235	0.387	0.138	0.622	-0.484	-0.063	0.137	-0.200	-0.217	0.086
	(0.84)	(1.51)	(2.05)**	(0.44)	(1.86)*	(1.36)	(0.26)	(0.61)	(0.75)	(0.88)	(0.39)
INTIMPER											
CREDIT	-0.136	-0.008	-0.131								
	(3.80)***	(0.19)	(3.08)***								
STOCKTURN				-0.002	0.028	-0.029					
				(0.10)	(1.41)	(1.26)					
STOCKTRAD							-0.006	0.051	-0.057		
							(0.33)	(2.33)**	(2.38)**		
CAPITALIZATION										-0.015	0.001
										(0.64)	(0.07)
D1*INTIMPER	0.629	-0.234	0.862	-0.133	0.598	-0.731	-0.749	0.036	-0.785	-1.180	-0.117
	(1.77)*	(0.68)	(2.11)**	(0.61)	(2.73)***	(2.89)***	(2.99)***	(0.16)	(3.12)***	(4.66)***	(0.59)
D2*INTIMPER	-0.052	0.034	-0.086	0.021	-0.092	0.112	0.106	-0.021	0.127	0.163	0.010
	(0.97)	(0.59)	(1.41)	(0.62)	(2.81)***	(2.95)***	(2.95)***	(0.70)	(3.57)***	(4.48)***	(0.36)
D3*INTIMPER	0.001	-0.001	0.002	-0.001	0.004	-0.005	-0.004	0.001	-0.005	-0.006	-0.000
	(0.41)	(0.70)	(0.93)	(0.82)	(2.85)***	(2.97)***	(2.89)***	(1.04)	(3.96)***	(4.29)***	(0.26)
Countries	115	115	115	84	84	84	80	80	80	87	87
Observations	2198	2198	2198	574	574	574	798	798	798	827	827
Rsquared	0.71	0.64	0.52	0.89	0.80	0.70	0.86	0.76	0.65	0.87	0.27

Fixed effects and time dummies are included in the specification but respective estimated coefficients are not shown
Robust t statistics in parentheses (absolute values)
* significant at 10%; ** significant at 5%; *** significant at 1%

Figure 3.9: Robustness of the Impact of the Interaction between Age Structure and Internal Capital Market Imperfections on International Capital Flows

	(1)			(2)		
	Saving	Investment	CAB	Saving	Investment	CAB
GROWTH	0.283	0.251	0.031	0.312	0.261	0.051
	(7.13)**	(6.89)***	(0.59)	(9.83)***	(7.87)***	(1.08)
D1	39.142	-197.597	236.738	-31.900	53.441	-85.341
	(0.43)	(3.87)***	(2.59)***	(1.04)	(2.01)*	(2.45)*
D2	-2.929	31.579	-34.507	3.823	-8.091	11.915
	(0.21)	(3.97)***	(2.45)*	(0.81)	(1.98)*	(2.22)*
D3	-0.012	-1.402	1.391	-0.155	0.297	-0.452
	(0.02)	(4.15)***	(2.35)*	(0.79)	(1.75)	(2.02)*
CREDIT	0.007	0.104	-0.097	-0.096	0.017	-0.113
	(0.15)	(2.89)***	(1.66)	(2.57)*	(0.61)	(2.59)***
D1*CREDIT	0.139	0.146	-0.005	0.297	-0.418	0.715
	(0.33)	(0.43)	(0.01)	(0.92)	(1.29)	(1.76)
D2*CREDIT	-0.027	-0.033	0.006	-0.021	0.051	-0.072
	(0.43)	(0.65)	(0.08)	(0.42)	(1.08)	(1.19)
D3*CREDIT	0.001	0.002	-0.000	0.000	-0.002	0.002
	(0.49)	(0.82)	(0.15)	(0.12)	(0.93)	(0.81)
EXTIMPER						
INSTITUTION	0.144	0.572	-0.427			
	(0.70)	(3.97)***	(1.82)			
RESTRICTION				3.561	4.267	-0.705
				(0.95)	(1.27)	(0.16)
D1*EXTIMPER	-0.779	3.351	-4.131	40.382	-35.629	76.011
	(0.49)	(4.12)***	(2.50)*	(1.44)	(1.55)	(2.59)***
D2*EXTIMPER	0.075	-0.543	0.618	-5.319	5.392	-10.711
	(0.30)	(4.28)***	(2.38)*	(1.23)	(1.49)	(2.36)*
D3*EXTIMPER	-0.002	0.023	-0.025	0.196	-0.210	0.406
	(0.17)	(4.34)***	(2.28)*	(1.09)	(1.38)	(2.13)*
Log(GDP)	16.609	12.507	3.101	18.157	10.110	8.048
	(7.78)**	(8.24)***	(1.31)	(15.94)***	(9.55)***	(5.34)***
Countries	103	103	103	115	115	115
Observations	1381	1381	1381	2198	2198	2198
R-squared	0.75	0.69	0.59	0.76	0.67	0.53

Fixed effects and time dummies are included in the specification but respective estimated coefficients are not shown
Robust t statistics in parentheses (absolute values)
* significant at 10 %; ** significant at 5 %; *** significant at 1 %

Figure 3.10: Robutness of the Main Specifications including Lagged Logarithm of GDP

3.D Endogeneity Treatment

First Stage

	GROWTH	CREDIT	INSTITUTION	GROWTH	CREDIT	RESTRICTION
LAGGED GROWTH	0.068	0.053	0.100	0.125	0.090	0.000
	(2.56)***	(1.05)	(5.00)***	(6.27)***	(3.00)***	(0.57)
LAGGED CREDIT	-0.021	0.839	-0.015	0.000	0.872	0.001
	(0.45)	(9.46)***	(0.43)	(0.00)	(17.30)***	(0.66)
LAGGED INSTITUTION	0.256	0.618	0.950	1.982	-4.187	1.079
	(1.56)	(2.00)**	(7.72)***	(0.54)	(0.76)	(10.84)***
D1	144.173	95.478	15.889	-33.990	-7.539	-1.372
	(2.65)***	(0.93)	(0.39)	(1.39)	(0.20)	(2.05)**
D2	-16.994	-13.728	0.331	4.764	2.070	0.208
	(2.01)**	(0.86)	(0.05)	(1.24)	(0.36)	(1.98)**
D3	0.542	0.488	-0.094	-0.169	-0.119	-0.009
	(1.52)	(0.73)	(0.35)	(1.04)	(0.45)	(1.99)**
Countries	1276	1276	1276	113	113	113
Observations	101	101	101	2150	2150	2150
R-squared	0.28	0.97	0.96	0.24	0.97	0.89

Second Stage

	(1)			(2)		
	Saving	Investment	CAB	Saving	Investment	CAB
GROWTH	0.642	2.667	-2.025	1.000	1.650	-0.650
	(1.61)	(2.98)***	(2.46)***	(4.50)***	(6.04)***	(2.97)***
D1	-102.658	-717.345	614.679	-40.740	101.072	-141.812
	(0.89)	(3.12)***	(2.93)***	(0.96)	(1.94)**	(3.40)***
D2	13.478	93.360	-79.880	4.873	-14.543	19.416
	(0.84)	(2.95)***	(2.77)***	(0.73)	(1.78)*	(2.97)***
D3	-0.497	-3.371	2.874	-0.164	0.540	-0.704
	(0.80)	(2.76)***	(2.96)***	(0.59)	(1.58)	(2.85)***
CREDIT	-0.118	0.128	-0.246	-0.184	-0.015	-0.169
	(1.62)*	(0.89)	(1.87)*	(3.38)***	(0.22)	(3.16)**
D1*CREDIT	-0.464	-1.588	1.124	0.318	-0.788	1.106
	(0.72)	(1.24)	(0.97)	(0.72)	(1.45)	(2.53)***
D2*CREDIT	0.097	0.263	-0.166	0.014	0.127	-0.113
	(0.98)	(1.33)	(0.92)	(0.21)	(1.90)	(1.66)*
D3*CREDIT	-0.005	-0.011	0.006	-0.002	-0.005	0.003
	(1.14)	(1.34)	(0.84)	(0.77)	(1.51)	(1.10)
EXTMPER						
INSTITUTION	-0.079	-0.412	0.332			
	(0.22)	(0.58)	(0.51)			
RESTRICTION				-8.796	-3.241	-5.554
				(1.37)	(0.41)	(0.88)
D1*EXTMPER	2.102	13.655	-11.563	-6.390	-151.780	145.390
	(0.94)	(3.08)***	(2.86)***	(0.16)	(3.08)***	(3.08)***
D2*EXTMPER	-0.298	-1.853	1.555	3.010	22.633	-19.622
	(0.95)	(2.98)***	(2.74)***	(0.48)	(2.92)***	(3.16)***
D3*EXTMPER	0.011	0.068	-0.057	-0.185	-0.306	0.720
	(0.94)	(2.84)***	(2.60)***	(0.69)	(2.76)***	(2.74)***
Countries	1276	1276	1276	2150	2150	2150
Observations	101	101	101	113	113	113

Fixed effects and time dummies are included in the first and second stages specifications but respective estimated coefficients are not shown.
Interaction terms are also instrumented using lagged values of either CREDIT or EXTMPER times demographic variables.
Robust t statistics in parentheses (absolute values)
* significant at 10%; ** significant at 5%; *** significant at 1%

Figure 3.11: Instrumental Variables Regressions

3.E Cluster Membership

Cluster 1: "Fertility Trapped" Countries

Afghanistan, I.S. of	Rwanda	Chad	Congo, Republic of
Burkina Faso	Senegal	Burundi	Mauritania
Eritrea	Nigeria	Liberia	Ethiopia
Benin	Ghana	Togo	Kenya
Uganda	Guatemala	Tanzania	Malawi
Zambia	Zimbabwe	Oman	Guinea
Niger	Madagascar	Angola	Sierra Leone
Mali	Congo, Dem. Rep. of	Somalia	Mozambique

Cluster 2: "Slow Aging" Countries

Algeria	Uzbekistan	Haiti	Pakistan
Ecuador	Morocco	Saudi Arabia	Colombia
Dominican Republic	Sudan	Papua New Guinea	Kyrgyz Republic
Iraq	Egypt	Mongolia	Iran, I.R. of
Myanmar	Côte d'Ivoire	Malaysia	Tajikistan
Vietnam	Lao People's Dem. Rep	India	Philippines
Peru	Syrian Arab Republic	Bangladesh	Venezuela, Rep. Bol.
El Salvador	Nepal	Paraguay	Honduras
Central African Rep.	Nicaragua	Libya	Cameroon
Turkmenistan	Mexico	Bolivia	South Africa
			Jordan

Cluster 3: "Fast Aging" Countries

Albania	Indonesia	Singapore	
Argentina	Lebanon	Armenia	
Kuwait	Brazil	Moldova	
Tunisia	Israel	Uruguay	
Chile	Panama	Macedonia, FYR	
Azerbaijan	Kazakhstan	New Zealand	
Costa Rica	Jamaica	Ireland	
Sri Lanka	Turkey	Korea	
China, P.R.: Mainland	Thailand		

Cluster 4: "Advanced Aging" Countries

Georgia	Ukraine	Norway	Switzerland
China, P.R.: Hong Kong	Latvia	United Kingdom	Italy
Hungary	Belarus	Croatia	Czech Republic
Belgium	Greece	Bulgaria	Sweden
Poland	Japan	Spain	Slovak Republic
United States	Germany	Canada	Romania
Netherlands	Australia	Denmark	Portugal
Austria	Finland	Lithuania	France
			Russia

Figure 3.12: Cluster Membership

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