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**Demographic Change, International
Trade and Capital Flows**

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Demographic change, international trade and capital flows

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Abstract

Trade in goods that are not perfect substitutes can considerably change the predictions of standard neoclassical models about the effects of asymmetric demographic developments. This paper considers a relative decrease in the population size of one country, when countries specialize in the production of different intermediate goods. The less those goods are substitutes, the stronger the long-run international spillover effects of the demographic shock will be. The degree of substitutability is crucial for the direction of capital flows between the countries and for the change in the interest rate. Depending on the saving rate of one country relative to the other, a shrinking labour force can lead to a higher interest rate, which is contrary to conventional findings.

JEL Classification: F21, F41, H55, J11

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1 Introduction

Demographic change, such as population ageing and migration, is a worldwide phenomenon, with some countries experiencing greater changes than others. This will strongly affect the relative size of the labour force, causing not only labour-market effects, but also effects on the capital market. In an open economy with perfect capital mobility, the typical argument goes that a relatively smaller labour force is followed by an outflow of capital so as to equalize the capital-labour ratio and interest rates (see Cutler et al. (1990), Börsch-Supan et al. (2006) or Arezki (2010) for example). Through these international capital flows, developments in one country cause spillover effects on another, especially if the countries' institutions are different. Adema et al. (2008), for instance, focus on differences in pension schemes and the spillover effects of demographic changes. In this paper, we show that a relatively smaller labour force does not necessarily imply a relatively smaller capital stock, if one allows for not one but different kinds of commodities and international trade. If the production of the final consumption good involves the input of intermediate goods that are produced in different countries, the degree of substitutability of those intermediates determines whether capital flows out of or into a country with a relatively shrinking labour force. Furthermore, it also affects the change in the real interest rate: a shrinking labour force due to e.g. population ageing not necessarily implies a lower real interest rate, contrary to the typical result of a one-sector model.

There are several papers, for example Adema et al. (2009) and de la Croix et al. (2010), that analyse the effects of ageing in a one-sector framework. In both papers, two types of demographic shocks are taken into account: an increase in longevity and a decrease in fertility. The general result is that population ageing evokes a larger export of capital to the rest of the world in case of an open economy, or leads to a higher capital-labour ratio and a lower interest rate in case of a closed economy. This decrease in the interest rate is especially painful for the old generation which is decumulating their savings, when the pension system has a large funded part. International spillovers of ageing caused by different pension systems were studied by Adema et al. (2008). They show that with a symmetric increase in longevity in two countries, the country with a funded pension scheme is in the long run more vulnerable to this shock if its neighbouring country has a PAYG-scheme. However, these models do not take international trade and changes in the real exchange rate into account. There is not much literature linking demographic changes with international trade. One exception is Sayan (2002, 2005), who investigates the link between changes in fertility and international trade. He shows that a country with higher fertility exports labour intensive goods, and that a shift from autarky to an open economy is not necessarily welfare improving. Similar conclusions are drawn by Naito and Zhao (2009).

The prediction of the classical Heckscher-Ohlin-Samuelson model (Samuelson 1948), which is confirmed by numerous later papers such as Sayan (2005), is that globalization and higher openness of markets lead countries to special-

ize in the goods for which they have a comparative advantage in production. As a result, goods produced in different countries are not necessarily perfect substitutes. Armington (1969) argues that even the same goods produced in different countries cannot be treated as perfect substitutes. This hypothesis was confirmed by many subsequent empirical papers, such as Shiells et al. (1986) and Blongen and Wilson (1999). We employ Armington’s approach for international trade to study the international aspects of asymmetric demographic developments. The use of this approach deviates our work from the other works studying the macroeconomic consequences of demographic shocks.

In this paper, we develop a simple model with two overlapping generations, two countries and one final good, which is produced out of two country-specific intermediate goods. To capture the different demographic developments in the world, we assume that one country’s labour force decreases temporarily compared to that of the other country. We show that the degree of capital outflow from the shrinking country depends on the elasticity of substitution between the intermediates. Smaller substitutability between the intermediates reduces the capital flow out of the shrinking country, and if the elasticity of substitution is less than unity, there will be an inflow of foreign capital. The long-run effect on the interest rate also depends on the degree of substitutability. If country-specific goods are substitutes, the world interest rate will decrease, as is usually found in the standard one-sector approach. But with trade in more than one commodity, the fall in the interest rate is smaller. However, if these goods are not very substitutable, a decrease in the population of one country can result in a higher interest rate, depending on whether this country saves more or less than the other. Finally, we show the welfare effects for different generations. It appears that in the short run, the international spillover effects of an asymmetric demographic shock are smaller compared with the standard one-good model, but the long-run spillover effects are larger.

The rest of the paper is organised as follows: in the next chapter the basic concepts are introduced and the model is described. In Section 3, the main results are discussed. Section 4 concludes.

2 The model

Production and prices

Consider a model with two overlapping generations and two countries (“Home” and “Foreign”) with perfect capital mobility. In each country at time t , capital (K_t) and labour (L_t) are deployed to produce a particular (tradable) intermediate commodity x_t according to the following function:

$$x_t = F(K_t, L_t) = K_t^\alpha L_t^{1-\alpha}, \quad (1)$$

where $0 < \alpha < 1$, and the capital stock depreciates within one period. Intermediates from both countries are required to produce the final good X_t in Home

and \tilde{X}_t in Foreign:

$$X_t = [(x_t^H)^{1-1/\theta} + (\tilde{x}_t^H)^{1-1/\theta}]^{\frac{\theta}{\theta-1}}, \quad (2)$$

$$\tilde{X}_t = [(x_t^F)^{1-1/\theta} + (\tilde{x}_t^F)^{1-1/\theta}]^{\frac{\theta}{\theta-1}}, \quad (3)$$

x_t^i (\tilde{x}_t^i) is the amount of intermediate goods¹ produced in the Home (Foreign) country, used for production of final goods in country i ($i = H, F$). θ is the substitution elasticity. Final goods are used for consumption or investment purposes and are also internationally tradable.

Let p_t be the price of an intermediate good produced abroad relative to a domestic intermediate². Profit maximization by firms implies the following first-order conditions:

$$x_t^i = \tilde{x}_t^i p_t^\theta, \quad i = H, F \quad (4)$$

and the price of a final good (P_t), in terms of domestically produced intermediates:

$$P_t = (1 + p_t^{1-\theta})^{\frac{1}{\theta-1}}. \quad (5)$$

Both production factors are paid according to their marginal products, which, expressed in final goods, equal:

$$W_t = P_t(1 - \alpha)K_t^\alpha L_t^{-\alpha}, \quad (6)$$

$$1 + R_t = P_t\alpha K_t^{\alpha-1} L_t^{1-\alpha}. \quad (7)$$

Households

Individuals live for two periods, so that in each period, a young and an old generation are alive of size N_t and N_{t-1} , respectively. Initially, population grows in both countries at the same rate n , so that $N_{t+1} = (1 + n)N_t$. When young, the agent supplies one unit of labour; part of the wage income is taxed at the rate τ , the rest is consumed when young (C_t^y) and saved (S_t). In the second period of his life, the agent is retired and consumes C_{t+1}^o , which is financed with the return on savings and a publicly provided pension benefit B_{t+1} . Utility is derived from consumption according to:

$$U_t = \log(C_t^y) + \beta \log(C_t^o), \quad (8)$$

with

$$C_t^y = W_t(1 - \tau) - S_t, \quad (9)$$

$$C_{t+1}^o = (1 + R_{t+1})S_t + B_{t+1}. \quad (10)$$

¹Throughout the paper, variables denoted in capital (small) letters are in terms of final (intermediate) goods.

² p_t can also be considered as a real exchange rate. See Amdur (2010) for example.

Public pensions are based on a pay-as-you-go scheme with fixed contributions,³ implying that $B_{t+1} = \tau(1+n)W_{t+1}$.

Individual optimisation gives the following individual savings function:

$$S_t = \frac{\beta}{1+\beta}(1-\tau)W_t - \frac{\tau(1+n)W_{t+1}}{(1+\beta)(1+R_{t+1})}. \quad (11)$$

Similar derivations can be made for the Foreign country.

Equilibrium

General equilibrium is established when the following markets of the model are cleared:

- the labour market:

$$L_t = N_t, \quad (12)$$

$$\tilde{L}_t = \tilde{N}_t, \quad (13)$$

- the the markets for intermediates:

$$x_t^H + x_t^F = x_t = F(K_t, L_t), \quad (14)$$

$$\tilde{x}_t^H + \tilde{x}_t^F = \tilde{x}_t = F(\tilde{K}_t, \tilde{L}_t), \quad (15)$$

- the international market for final goods:

$$N_t(C_t^y + S_t) + \tilde{N}_t(\tilde{C}_t^y + \tilde{S}_t) + N_{t-1}C_t^o + \tilde{N}_{t-1}\tilde{C}_t^o = X_t + \tilde{X}_t, \quad (16)$$

- the international capital market:

$$K_{t+1} + \tilde{K}_{t+1} = N_t S_t + \tilde{N}_t \tilde{S}_t. \quad (17)$$

Equilibrium in the markets for domestic and foreign intermediate goods (equations (14) and (15), combined with the firms' first-order conditions (4), boils down to the following price of a foreign intermediate good:

$$p_t = \left(\frac{x_t}{\tilde{x}_t} \right)^{\frac{1}{\theta}}. \quad (18)$$

Furthermore, international arbitrage on the capital market implies:

$$\frac{\partial F(K_t, L_t)}{\partial K_t} = p_t \frac{\partial F(\tilde{K}_t, \tilde{L}_t)}{\partial \tilde{K}_t}, \quad (19)$$

³Allowing for a fixed replacement rate and variable contribution rates does not change the results of this paper.

and arbitrage on the market for final goods gives:

$$\tilde{P}_t = p_t P_t. \quad (20)$$

The last two equations then also imply that $R_t = \tilde{R}_t$, as defined by equation (7).

Combining equations (1), (7), (18), (19) and (20) gives the distribution of capital between the two economies:

$$\frac{\tilde{K}_t}{K_t} = \left(\frac{\tilde{L}_t}{L_t} \right)^{\frac{(1-\alpha)(\theta-1)}{\alpha+\theta(1-\alpha)}}. \quad (21)$$

With this, the price of a foreign intermediate good is:

$$p_t = \left(\frac{L_t}{\tilde{L}_t} \right)^{\frac{(1-\alpha)}{\alpha+\theta(1-\alpha)}} \quad (22)$$

units of Home-produced intermediate goods. Furthermore, the price of a final good produced in the Home country, as expressed in equation (5), can be derived:

$$P_t = \left[1 + \left(\frac{L_t}{\tilde{L}_t} \right)^{\frac{(1-\alpha)(1-\theta)}{\alpha+\theta(1-\alpha)}} \right]^{\frac{1}{\theta-1}}. \quad (23)$$

This equation shows that a change in the relative size of the countries' populations leads to an immediate jump to the new equilibrium value of the price of final goods.

3 Demographic change

3.1 International capital flows and investment returns

Initially, both countries have the same rate of population growth. At time $t = 1$, the Home country experiences an unexpected one-period drop in its fertility rate ($dn_1 < 0$), after which population growth returns to its original level.⁴ Consequently, the labour force in the Home country decreases relative to the other country, i.e., L_1/\tilde{L}_1 declines. Because the size of the labour force affects the return to capital, which is invested in both countries such that its return is equalized (in terms of domestic intermediate goods), changes in L_1/\tilde{L}_1 will cause a different allocation of capital between the countries. In the standard one-sector model, this leads to equal capital-labour ratios.⁵ In the current model,

⁴Naturally, the same results hold if the drop in fertility lasts for more than one (but a finite amount of) periods, if the Foreign country has a temporarily higher rate of population growth (or a drop in the fertility rate that is smaller than in Home), and if the population in the Home country decreases for other reasons.

⁵The current model boils down to the standard one-sector model for $\theta \rightarrow \infty$. Indeed, equation (21) can then be written as $K_t/L_t = \tilde{K}_t/\tilde{L}_t$.

however, this is not the case because of changes in the real exchange rate, as expressed by p . This leads to the following proposition.

Proposition 1. *If the size of the labour force in the Home country decreases relative to that in the Foreign country, the share of capital in the Home country will*

- *decrease iff domestic and foreign intermediate goods are substitutes,*
- *increase iff domestic and foreign intermediate goods are complements,*
- *not change iff the substitution elasticity is unity.*

Proof. Totally differentiating (21) gives

$$\frac{dK}{K} - \frac{d\tilde{K}}{\tilde{K}} = \frac{(1-\alpha)(\theta-1)}{\alpha+\theta(1-\alpha)} \left(\frac{dL}{L} - \frac{d\tilde{L}}{\tilde{L}} \right). \quad (24)$$

From this, it immediately follows that $\frac{dK}{K} < (>) \frac{d\tilde{K}}{\tilde{K}}$ iff $\frac{dL}{L} < \frac{d\tilde{L}}{\tilde{L}}$ and $\theta > (<) 1$, and $\frac{dK}{K} = \frac{d\tilde{K}}{\tilde{K}}$ iff $\theta = 1$. \square

If Home's labour force experiences a decline compared to that of Foreign, capital will be attracted to Foreign because it becomes more productive there. On the other hand, a higher production of foreign intermediate goods makes domestic goods scarcer, driving p down, which can be interpreted as a real appreciation of Home. This attracts capital to Home. The latter effect dominates if foreign and domestic intermediate goods are complements. Consequently, capital does not always "follow labour" (as it would in the standard model): the production factors can move in opposite direction. Note that these results do not depend on the (relative) size of the PAYG-pension scheme, which is an important determinant of savings.

The more a country relies on a funded scheme for financing its pension expenditures, the more sensitive it will be to interest rate changes, which can be caused by demographic developments. In the standard one-sector model of two countries with an integrated capital market, the long-run effect of an asymmetric fertility shock on the interest rate depends only on the size of the PAYG-scheme compared to that of the other country.⁶ With more than one commodity, however, what matters is the real rate of return, which in our model is the investment return measured in units of consumption (i.e. final) goods. As these are produced with both domestic and foreign intermediates, the rate at which domestic intermediates can be exchanged for foreign intermediates is an important factor determining the relevant investment return. This, in turn, depends on the elasticity of substitution, which is therefore another important factor that should be taken into account, as stated in the following proposition.

⁶Then, if the country with a temporarily lower fertility rate runs a relatively small PAYG-scheme, the long-run capital-labour ratio will decrease in both countries, leading to a higher interest rate. In the opposite case, the interest rate will decrease.

Proposition 2. *If the size of the labour force in the Home country decreases relative to that in the Foreign country, the steady-state interest rate will*

- *decrease iff the Home country runs a larger (smaller) PAYG-scheme than the Foreign country, and domestic and foreign intermediate goods are substitutes (complements),*
- *increase iff the Home country runs a larger (smaller) PAYG-scheme than the Foreign country, and domestic and foreign intermediate goods are complements (substitutes),*
- *not change iff both countries run an equally large PAYG-scheme or if the substitution elasticity is unity.*

Proof. Define $\lambda \equiv \frac{L}{\bar{L}}$ and $z \equiv \lambda^{\frac{1}{\theta(1-\alpha)+\alpha}} > 0$. Furthermore, $n = \tilde{n}$ in steady state. Combining equations (6), (7), (11), (17) and (20) gives the steady-state capital-labour ratio for the Home country:

$$\frac{K}{L} = k^* = \left(\frac{\alpha\beta(1-\alpha) \left[(1-\tau)\lambda P + (1-\tilde{\tau})z^\alpha \tilde{P} \right]}{(1+n) [\alpha(1+\beta)(\lambda+z) + (1-\alpha)(\tau\lambda + \tilde{\tau}z)]} \right)^{\frac{1}{1-\alpha}}, \quad (25)$$

Combining this with equations (20), (22) and (23) into (7) gives:

$$1 + R = \frac{(1+n) [\alpha(\lambda+z)(1+\beta) + (1-\alpha)(\tau\lambda + \tilde{\tau}z)]}{\beta(1-\alpha) [(1-\tau)\lambda + (1-\tilde{\tau})z]}. \quad (26)$$

Differentiating (26) with respect to λ results in:

$$\frac{\partial(1+R)}{\partial\lambda} = (\theta-1)(\tau-\tilde{\tau})\Psi, \quad (27)$$

with $\Psi = \frac{(1+n)(1+\alpha\beta)z}{\beta[(1-\tau)\lambda+(1-\tilde{\tau})z]^2[\theta(1-\alpha)+\alpha]} > 0$. This clearly shows that $\frac{\partial(1+R)}{\partial\lambda} > 0$ if $\theta > 1 \wedge \tau > \tilde{\tau}$ or $\theta < 1 \wedge \tau < \tilde{\tau}$, and $\frac{\partial(1+R)}{\partial\lambda} < 0$ if $\theta > 1 \wedge \tau < \tilde{\tau}$ or $\theta < 1 \wedge \tau > \tilde{\tau}$. If $\theta = 1$ or $\tau = \tilde{\tau}$, then $\frac{\partial(1+R)}{\partial\lambda} = 0$. \square

The effect on the interest rate is caused by changes in the capital-labour ratio and changes in the price of final goods. We illustrate this and the subsequent welfare effects for the cases that the country that is hit by the shock has a larger and a smaller PAYG-scheme

3.2 Case 1 - Ageing in Europe: North vs. South

Countries in Europe are experiencing different demographic developments. Broadly speaking, countries in southern Europe such as Italy, Spain and Greece have a population that is ageing stronger than in northern European countries such

as Germany, the United Kingdom, the Scandinavian countries and The Netherlands. In terms of the model, we can therefore denote South Europe as the Home country experiencing a negative demographic shock compared to North Europe. Furthermore, national savings are typically larger in North Europe relative to the southern part, which is not only due to a more sizeable funded part of pensions in the North, but also because of smaller public debt ratios. Hence the assumption that $\tau > \tilde{\tau}$. As can be seen from figure 1,⁷ the capital-labour ratio increases in the short run due to the temporarily lower fertility rate in the South. Obviously, the direct effect of a smaller labour force on this ratio is positive. But the shock also implies that capital is reallocated from the South to the North country, be it to a smaller extent than in the one-sector model where capital-labour ratios would be equal. This is caused by the fact that a smaller labour force also implies a lower quantity of intermediate goods being produced in southern Europe, which makes intermediate goods from the North cheaper compared to intermediates from the South. Hence, there is an immediate drop in the price of northern produced intermediates (p), and less capital will be reallocated to the North so as to equate the marginal product of capital measured in southern intermediate goods. The capital-labour ratio increases therefore in the South, while it decreases in the North. This difference will be more pronounced if the substitutability of intermediate goods is lower. Note that in the standard one-sector model, such a difference does not exist, and the capital-labour ratio would therefore rise in both countries. Furthermore, with the decrease of p , the price of final goods in terms of southern intermediates is higher, which has a positive effect on the real interest rate.⁸ Put differently, the ageing south experiences a favourable real exchange rate change. As can be seen from figure 2, the reaction of P on a change in the relative labour force is stronger if intermediates are less substitutable, the more so if the capital share in the production of intermediates is smaller. This has important consequences for the welfare effects in the short and long run.

Welfare effects

Figure 3 shows the effects of a one-time drop in the fertility rate in the South, occurring in period 1, on the welfare of different generations in both regions.⁹

Two observations can be made. First, the figure shows that in the short run, for the generation born at time $t = 0$ (one period before the unexpected shock), the welfare effects of the demographic shock are less unequal between the two regions compared to the standard model. As noted above, the capital-labour ratio rises more in the South, leading to a much lower real interest rate, although this is somewhat mitigated by a higher price of final goods. Because the southern countries have a relatively large PAYG-scheme, and therefore low

⁷The underlying parameter values are: $\alpha = 0.3$, $\beta = 1$, $\theta = 2$, $n = \tilde{n} = 0$, $\tau = 0.2$, $\tilde{\tau} = 0.1$. Initially, the countries are equally large; in period 1, n drops to -0.2, after which it returns to its original level.

⁸Indeed, from equation (5) follows $dP/dp = -P/(p + p^\theta) < 0$.

⁹The figure shows the amount with which the individual's new lifetime income (i.e., after the shock) should be reduced to achieve the same level of utility as before the shock (expressed as percentage of the lifetime income in the initial steady state).

Figure 1: Change in capital-labour ratios after a temporary fertility decline in South Europe, when $\tau^{South} > \tilde{\tau}^{North}$

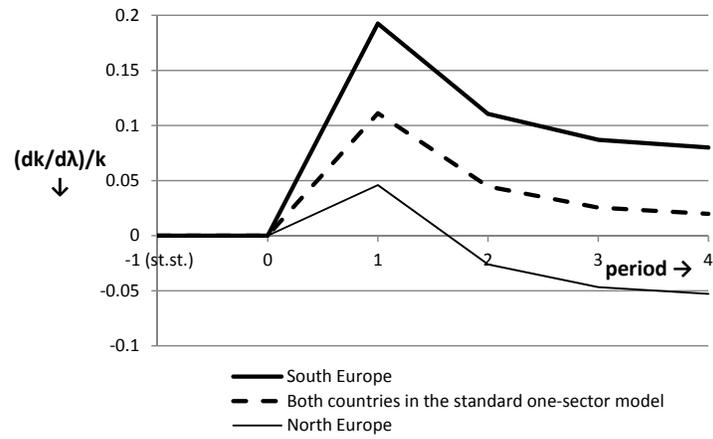


Figure 2: Relative change in domestic price of final goods as a function of the elasticity of substitution (for different capital intensities)

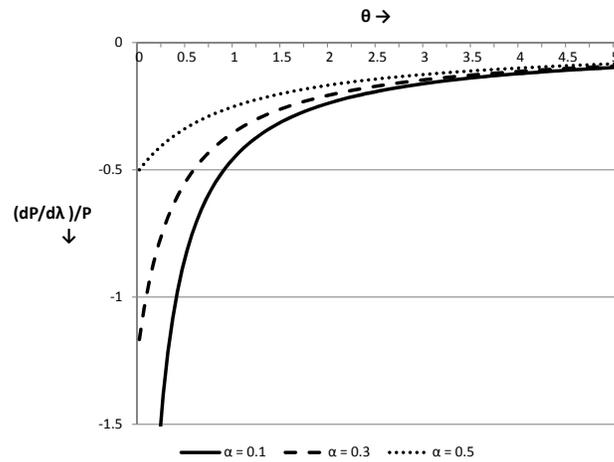
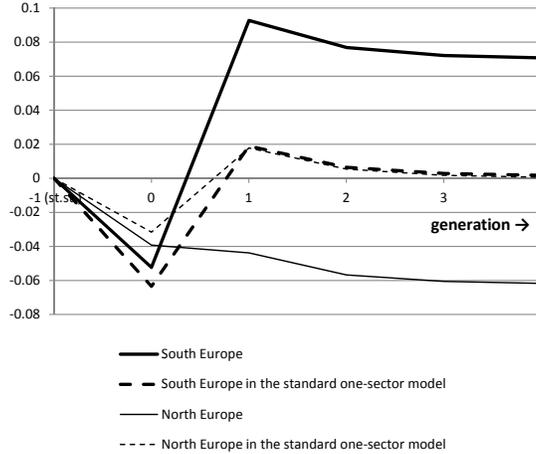


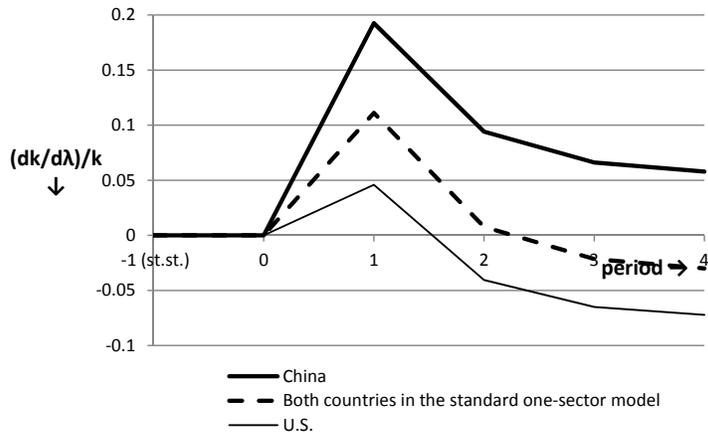
Figure 3: Welfare effects (compensating variation as % of initial lifetime income) after a temporary fertility decline in South Europe, when $\tau^{South} > \tilde{\tau}^{North}$



savings, this lower interest rate has a rather moderate effect on the consumption possibilities of those who are retired at the time of the shock. Even though the smaller labour force at time $t = 1$ has a direct negative effect on the PAYG-pension benefit, this is alleviated by the strong wage increase in that period, to which public pension benefits are linked. Altogether, the consumption and utility of the retired living in the South at the time of the shock decrease to a smaller extent compared to the one-sector model. The opposite holds for the northern countries. The short-run spillover effects are therefore smaller for the retired, the more so if domestic and foreign intermediates are complements. For those who are born at the time of the shock, however, the spillover effects are larger, which also holds for all subsequent generations.

In the long run, the southern region with the larger PAYG-scheme has become smaller in size, which implies a higher capital-labour ratio. This positively affects the wage and negatively affects the interest rate. But with trade in intermediates, two additional effects occur. First, the more intermediates are complements, the less capital will be reallocated to the North (the share of capital allocated in South may even increase). Hence, also in the long run, the development of the capital-labour ratio is different in both regions: it increases in the South more than in the standard model, while in the North it increases less, or –in this case– even decreases. Second, the more intermediates are complements, the stronger the price effect will be. These two effects imply a stronger wage increase in the long run in the southern countries, which boosts savings and thus the accumulation of capital. Because this effect already occurs in the period

Figure 4: Change in capital-labour ratios after a temporary fertility decline in China, when $\tau^{China} < \tilde{\tau}^{US}$



that the shock occurs, it will have an amplifying effect on the capital-labour ratio in subsequent periods. We can therefore conclude that complementarity in tradable intermediate goods increases the long-run spillover effects of asymmetric demographic developments (as long as countries have different pension schemes).

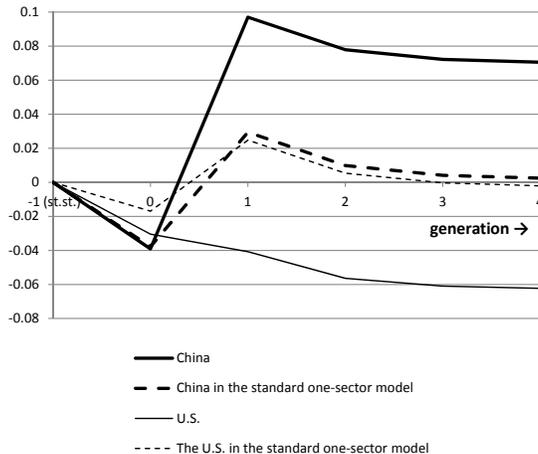
3.3 Case 2 - China vs. the U.S.

In this case, the Home country is China, experiencing a demographic shock compared to the U.S., which is the Foreign country.¹⁰ It is reasonable to assume $\tau < \tilde{\tau}$ as the U.S. is running large current account deficits and China has surpluses.¹¹ As can be seen from Figure 5, there is almost no difference with the previous case. In the one-sector model, people in the U.S. are worse off in the long run, but far more so in the two-sector model. So the price effect is much more important than the difference in PAYG-schemes (as a matter of fact, even if $\tau = \tilde{\tau} = 0$ there will be spillover effects). And in the one-sector model, the global capital-labour ratio decreases in the long run, while it increases for China in the two-sector model.

¹⁰Although the opposite occurred so far: the Chinese population grew faster than the U.S. population. In the coming decades, however, China will experience a relatively faster ageing population than the U.S.

¹¹In the simulations, $\tau = 0$ and $\tilde{\tau} = 0.2$ is used.

Figure 5: Welfare effects (compensating variation as % of initial lifetime income) after a temporary fertility decline in China, when $\tau^{China} < \tilde{\tau}^{US}$



4 Conclusions

In this paper we have shown that inclusion of international trade with country specific intermediate goods significantly changes the standard predictions of the one-good model. The direction and size of capital flows, the effects on interest rates and welfare which are caused by an asymmetric demographic shock, depend to a large extent on the elasticity of substitution between the country specific goods, and may be even opposite to the common results discussed in the literature. Blongen and Wilson (1999) estimated the elasticity of substitution for 146 sectors in the U.S. The arithmetic average of these estimates is equal to 0.81 with a standard deviation of 0.63, which shows that the case with $\theta < 1$ is quite realistic. But even with larger values of θ the effects described in our model differ a lot from the standard predictions. International spillover effects, caused by an asymmetric population shock and different pension schemes, will be larger if products produced in different countries are less than perfect substitutes. In particular, the welfare effects of ageing in another country or another part of the world are much stronger than predicted by the standard one-sector model.

Alternatively, the model could be rewritten with country-specific final goods appearing directly in the individual utility function as final consumption goods instead of intermediates in the production function. However, this would not change the results as long as those different goods are considered to be less than perfect substitutes by consumers.

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