Projektbericht

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Aging, Pension Reform and the Current Account

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Abstract

Declining fertility and increasing life expectancy put pressure on the financing of social security in developed countries. Economists and policy makers have considered options to address this financing challenge, most of which contain reforms of the pension system. No pension reform appears unambiguously superior: reforms typically fare good in some dimensions, but not all. Because of trade-offs, evaluation criteria play a major role in the selection of the preferred policy reform. Typically, analysts consider financial sustainability of the system, evolution of output per capita and minimum income in old age. In this paper we add one criterion, current account imbalances. Using an overlapping-generations model calibrated for Austria with a multi-pillar pension system and an aging population, we compare pension reforms with pay-as-you-go financing and capital-funded financing. In contrast to a number of previous studies, the capital-funded pillar in our model contains both a tax component and insurance against the longevity risk, both realistic. Neglecting current accounts, we find that increases in retirement age with the current pay-as-you-go pension system achieve a good balance between output maintenance, pension finance sustainability and old-age anti-poverty, consistent with previous studies. Such arrangements however increase the dependence on net foreign assets, as the need to save for consumption after retirement is reduced. Adding a capital-funded pillar to the pension system helps achieve (and in some cases improve on) the same goals without increasing the dependence on net foreign assets, over the long run. Savings placed in the pension funds are indeed available for domestic investment. As in previous studies, there are however transitional costs.

Keywords: Aging, overlapping generations models, general equilibrium, pension reform, capital-funded pension pillar, national savings, current account

JEL-Classification: D58, D91, F34, H55, J26

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1 Introduction

Aging of the population is a well-known and researched challenge for developed economies, as the continuous decrease in the ratio of the working age population over retirees puts pressure on the financing of social security. Which is the most appropriate pension reform depends on the policy goals. Increasing the retirement age in a pay-as-you-go pension system achieves a good balance between the goals of maintaining output growth, financial sustainability and old-age anti-poverty[1]. If one also wants to avoid an increase in current account imbalances, such a policy may no longer be optimal, a lower private saving rate triggering a higher demand of foreign assets. Using an overlapping-generations model calibrated for Austria, we show that the concomitant introduction of a capital-funded pension pillar avoid this drawback, over the long run.

The three typical parametric reforms of current pay-as-you-go pension systems have different impacts. Increasing contribution rates secures the financial sustainability of the system with an aging population, but reduces incentives to provide labor supply and thus output growth. The same is true for a cut pension benefits. The latter reform also may threaten old-age anti-poverty protection. Increases of the retirement age on the other hand deliver a good balance between the three goals, financial sustainability, output growth and anti-poverty protection (see e.g. Jaag, Keuschnigg, and Keuschnigg, 2010).

The objective of this paper is to extent the analysis of pension arrangements when adding a fourth policy goal, avoiding the growth of current account imbalances. The effects on the current account and foreign assets are often overlooked and yet they have been at the heart of the policy debate on widening global imbalances for several years leading to the 2007 financial crisis (see e.g. OECD, 2011a). With this fourth goal, retirement age increases may not represent an optimal compromise anymore, since the need to save for consumption after retirement is reduced and thus the dependence on foreign assets increased. In contrast, a cut in pension benefits stimulates private savings, improving the net foreign asset position.

To reach our objective, we extend an existing overlapping-generations model calibrated for Austria to allow for more options in pension arrangements. The basis[2] has imperfect labor markets, three skill classes and labor supply decisions along intensive and extensive margins (participation, job search when unemployed and work hours). The pension system is financed in a pay-as-you-go fashion, has a flat part and an earnings-related component. During their working life, households face a changing and typically hump-shaped wage profile, as in Auerbach and Kotlikoff (1987). The instantaneous probability of dying increases with age, to replicate the age structure of the population. Since Austria is a small country, we assume that it is open and takes the interest rate as given.

We extend the basic model to include capital-funded pensions. While contributions in a pay-as-you-go system are immediately used to finance pension benefits of retirees, they are stored up in a fund for future consumption with capital-funded pensions. Pension systems with multi-pillar systems, including capital-funded pillars, will in theory be associated with higher domestic

[1]In the paper, we may speak of the *risk of old-age poverty* in reference to the literature analyzing the distributional consequences of aging and pensions. Our use of the terms is informal and loose but captures the policy concern.

[2]The basic model was initially developed in Berger et al. (2009). It is routinely used for policy evaluation (e.g. CPB and CAPP, 2013) and applied research (e.g. Keuschnigg et al., 2012).

savings, reducing dependence on foreign assets. The cross-country empirical analysis from Bloom, Canning, Mansfield, and Moore (2007) confirms this expectation. They find that an increase in life expectancy by one year in a fully-funded system increases the national savings rate by 0.4 %-points of GDP, while the effect is close to zero or slightly negative in a pay-as-you-go system.

We follow Keuschnigg, Keuschnigg, and Jaag (2011) for an explicit modeling of the capital-funded pillar. Contributions in a private saving fund are mandatory. The contribution rate is a policy parameter, and defines the size of the capital-funded pillar. Savings accumulated in the fund can be used by firms for investments and earn the standard capital market return. Because of administrative costs, net returns on savings are however smaller than the capital market rate. After retirement, the fund balance is converted in an annuity, received until death.

Although finding solutions becomes more complex, explicit modeling of capital-funded pensions has benefits. To avoid the complexity, many papers do not perform such an explicit modeling and interpret private savings as capital-funded pensions (including Kotlikoff, 1996; Boersch-Supan, Ludwig, and Winter, 2006, and Catalán and Magud, 2012). This simplified approach however ignores administrative costs of pension funds, a tax component which distorts household decisions. This simplification also ignores the risk insurance properties of capital-funded pensions against the longevity risk, when life duration is uncertain. None of these two drawbacks take place in our model.

A final benefit of our modeling approach is the detail in labor supply decisions. In our small open economy setting, the extent to which household savings can be invested domestically is key in defining the trade balance, and thus net foreign asset positions. In the long run, the domestic investment potential is determined by technology and labor supply, firms borrowing capital on the financial market to maximize expected profits, which depends on the capital-labor ratio. Labor supply itself is influenced by the design of the pension system through tax-benefit links and the tax component of pension contributions (see e.g. Feldstein and Samwick, 1992; and Disney, 2004). A model with a rich labor market representation is thus essential to quantify labor supply, domestic investment demand and thus current account reactions.

In summary, our contribution to the literature is as follows. With the exception of Catalán and Magud (2012), no other paper considers the impact of pension reforms on current account imbalances. That paper however uses a simplified model with no explicit modeling of capital-funded pensions and reduced labor supply margins (without any extensive margin), which ignores the tax and insurance properties of capital-funded pensions and provide a less precise estimate of domestic investment opportunities and thus current account impacts.

We start by comparing parametric reforms in a pay-as-you-go pension system. Consistent with the rest of the literature, we find that increases in retirement age are best at balancing goals of financial sustainability, output growth potential and old-age anti-poverty goals. However, they also increase dependence on foreign assets, for two reasons. First, the need to save to top-up pension income declines, reducing the availability of domestic capital. Second, later retirement date leads to an increase in labor supply. Profit-maximizing firms in a small open economy then increase their capital stock and demand, to keep the capital-labor ratio optimum. In our baseline simulations, Austria would no longer be a net creditor on the international capital market, but a net debtor. When we add a capital-funded pension pillar making up a fourth of the total pension system and keep average pension benefits as in the status quo, we find that all four policy goals can be achieved over the long run. Indeed, savings accumulated in private pension funds can be used for domestic investment, reducing the dependence on foreign assets. In our base simulations, such a policy even improves on output growth potential, given the labor supply incentive nature of capital-funded pensions, which are less distortive than pay-as-you-go pensions. As is standard in the fully-funded pension literature, we also find that the introduction of a capital-funded pillar comes with medium transition costs.

In the next section, we provide a discussion of the related literature. Section 3 describes the model and the following section presents its calibration. In section 5, we present long-run simulation results, while section 6 focuses on transition results. Robustness of the results are considered with sensitivity analysis in section 7. The last section concludes.

2 Literature review

This section provides a review of the literature which is relevant for the project[3]. For ease of reading, we informally split the review by topics or strand.

2.1 Pensions in Austria

With an aging population, long-term financing of the pension system is a challenge for all developed countries, in particular in Europe and Japan. The challenge is particularly large for Austria. Along with Belgium and Germany, the European Commission considers that Austria has relatively sound public finance management overall but states that "*reforms to address rising age-related costs will be indispensable*" (p.5, European Commission, 2009). Public debt pressure after the 2007 subprime crisis has already accelerated the implementation of pension reforms in most OECD countries, including Austria (OECD, 2012).

Yet, more remains to be done. According to the Ageing Working Group (2012), pension, healthcare and long-term care expenditures expenditures should increase 4.8 percentage points of GDP between 2010 and 2060. Since these projections only consider the expenditures side and ignore financing of old-age social security expenditures, they do not take into account potential feedback effects from revenue adjustments and underestimate the total public finance cost of aging. As noted for instance by Buiter (1997) and Miles (1999), computable general equilibrium (CGE) models provide more reliable evidence on the impact of demographic change on the economy.

Keuschnigg and Keuschnigg (2004) is an early CGE analysis of pension financing in Austria. More recent studies include Jaag et al. (2010), Keuschnigg et al. (2012) as well as Sánchez-Romero et al. (2013). The first three studies typically find that effective retirement age has to grow by at least 8 months for every extra year in life-expectancy to prevent increasing fiscal gaps and to preserve output per capita. The fourth study finds that 2000-2004 pension reforms go in the right direction, but are not sufficient to ensure the long-term financial sustainability of the welfare state.

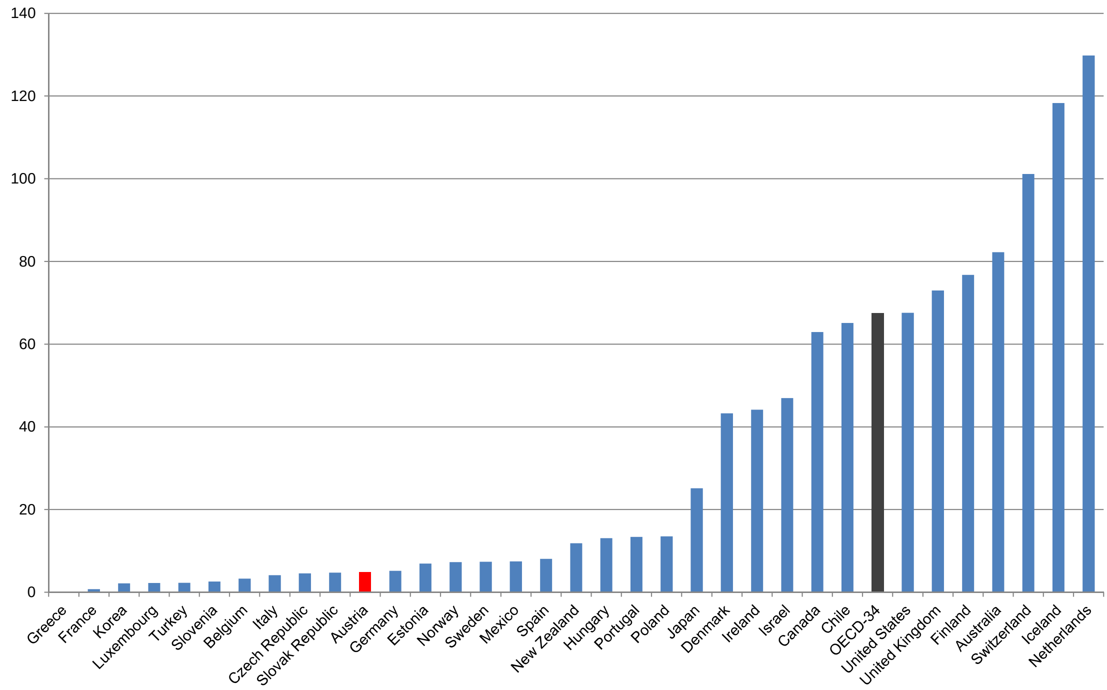
[3]The review expands and builds on the survey from the grant proposal documentation, dated 5 February 2013.

It is worth noting that none of those studies has addressed the effects on the net foreign asset position nor the consequences of the partial introduction of a funded pillar, which is considered in this project.

Apart from the classical pay-as-you-go pension system, there are two further notable old-age provision schemes in Austria which, in contrast, are pre-funded. The first is government subsidized private saving for old-age ('Zukunftsvorsorge'). The other is the severance pay system funded by contributions of the employers, although, in contrast to a prototype funded pension pillar, it gives employees the possibility to withdraw funds before retirement[4].

Despite those two policies, Austria still relies strongly on the pay-as-you-go paradigm, relative to other countries. Figure 2.1 illustrates this by plotting the assets in pension funds as of 2009 for the OECD countries. Comparable countries that rely on funded pension pillars have assets in pension funds that exceed 75 % (Finland) or even 100 % of GDP (Switzerland and the Netherlands), while this figure is about 5 % for Austria.

Figure 2.1: Assets in pension funds as % of GDP in the OECD, 2009



Source: OECD (2011b).

2.2 Capital-funded and pay-as-you-go pensions

The main difference between fully-funded (or capital-funded) pension systems and pay-as-you-go pension systems is the use of social security contributions. In the first case, contributions are saved and accumulated into a saving fund until the individual retires, at which point the savings are translated into an annuity payment. In the second case, contributions of current workers are used to pay pension payments to current retirees.

[4]For more details see Koman et al. (2005).

The respective merits of fully-funded and pay-as-you-go pension systems have been considered by a large literature. The goal in this section is not to review this literature. Instead, we summarize the main arguments (without being comprehensive) and provide references for details.

The main benefits of fully-funded pension systems are as follows. First, contributions earn an additional return, related to returns on capital markets. Second, under certain conditions which are sometimes debated[5], the system increases national savings, which can promote output growth and average income. Third, the pension system is financially balanced by design, as there is no need of reforms even under an aging population. Exposure to political risk (no reform) is thus lower.

The main drawbacks of fully-funded pension systems are the following. First, the pension system faces an additional risk, namely investment returns risk. Second and related to the first, the potential benefits of a fully-funded pension system, when compared to a pay-as-you-go system, depend in a sensitive manner on the assumption made on the returns on contributions. Part of the question is the extent of administration costs, which we discuss below. Although the third argument is not related to fully-funded systems themselves, it takes into account the pay-as-you-go nature of most existing pension systems. Moving from a pay-as-you-go to a fully-funded system comes with transition costs for current working generations, who need to pay contributions for the pensions of current retirees and their own future retirement.

Administrative costs of capital-funded pensions can mitigate their main advantage, the fact that they earn higher returns than a pay-as-you-go system, which yields an implicit return rate equal to the wage sum growth rate. As written above, the benefits of capital-funded pensions are sensitive to the net-of-costs returns. Feldstein (1997) uses for instance a real return rate to capital of 9 % for the United States. There are reasons why this rate could be lower[6]. However, even more conservative estimates concerning the return differential of about 1.5 - 3 %-points, as presented in Sinn (2000) for Germany, should be sufficient to cover the administrative costs of managing the public pension funds which can reduce the effective rate by up to 1 %-point.

Additional arguments are frequently used when discussing the merits of each system, but not directly related to systems themselves. First, pension systems can distort household decisions and reduce labor supply, and thus output, if the link between contributions and benefits is not perfect. By design, the link is perfect with a fully-funded pension system. The link can also be perfect in a pay-as-you-go pension system, with an appropriate design and implementation. To remain perfect, pension reforms are needed in this system as the population ages. Labor supply distortions are however not an inherent flaw in a pay-as-you-go system. Second, pension systems can have a cross-section insurance role, which can increase welfare if insurance effects are larger than moral hazard distortions. Pay-as-you-go systems are frequently implemented with a redistribution mechanism, either between households with a different income level or between households with different labor market history. This includes protection against old-age poverty. While fully-funded pensions do not have such an insurance mechanism, one can complement it with appropriate tax-and-transfers mechanisms or with an implementation of a mixed pay-as-you-go and fully-funded system[7].

[5] See for instance Barr and Diamond (2006) for a critical discussion of these conditions. Lindbeck and Persson (2003) present another, neutral, angle of analysis.

[6] Dimson et al. (2002), for example, report a long-run mean return to equity rate of 5.1 % averaged over several countries.

[7] The apparent advantage of a funded pillar becomes even smaller if households care about relative consumption in comparison to a reference group as shown by Knell (2010) who estimates the optimal share of a funded pillar to be at most 20 %.

Whether a fully-funded or a pay-as-you-go system is in the end more appropriate is still debated. One contribution of the present paper is to provide another argument in the debate. A good illustration of the debate, as well as arguments comparing the two systems, is provided by two successive presidential addresses at the American Economic Association meetings: Diamond (2004) defends the current US pay-as-you-go system while Feldstein (2005) advocates a shift towards a fully-funded system (or a mixture between pay-as-you-go and fully-funded). The overview by Lindbeck and Persson (2003) provide a more nuanced, impartial view[8].

2.3 Current account imbalances

The current account position of a country is one indicator of macroeconomic performance, among others. In a widely-quoted speech before the 2007 subprime crisis, the former Chairman of the US Federal Reserve Board mitigated the satisfaction one could derive from high US output growth, good labor market indicators and low inflation with the less satisfactory large US current account deficit (Bernanke, 2005).

Whether current account deficits are a bad thing or not is however still debated in academic and policy analysis circles.

Lane and Pels (2012) for instance believe that the European economic crisis following the 2007 US subprime crisis is "*partly attributable to the sharp increase in external imbalances across Europe during the pre-crisis period*" (p.0), while Wyplosz (2013) believes that "*the crisis was driven by excessive domestic demand, not by exogenous losses in competitiveness and current account deficits*" (p.19).

Blanchard and Milesi-Ferretti (2012) as well as Obstfeld (2012) review arguments for neglecting, or not, current account imbalances. Both believe that there are good and bad reasons for running a current account deficit. Among the good reasons are the optimal intertemporal allocation of resources. There are two kinds of bad reasons. One is the domestic perspective and the other is international. In the domestic case, a current account deficit is often a reflection of underlying distortions, such as imperfect labor markets or inappropriate policy. In this case, a current account deficit is not a problem in itself, but a symptom for other problems. Trying to reduce the deficit is in itself not a policy objective, as the focus should be on reducing the underlying distortions. Blanchard (2007) uses a simple analytical framework and arrives at similar conclusions. In the international case, there can be reasons for policy intervention aiming at reducing global account imbalances.

Obstfeld (2012) lists three arguments for reducing global current account imbalances. One is sudden stops and the sharp and painful adjustments in prices that they can trigger. Another argument is due to externalities when financial markets are incomplete. The final argument applies to countries within a common currency area (such as the Eurozone), in case of asymmetric shocks or adjustments. Bernanke (2005) focuses on the US current account deficit and mentions the risk of disorderly financial market adjustments and the risk of distortions in capital allocation or domestic policies when savings from the rest of the world are flowing in.

[8] There are other reviews of the literature. Barr (2002) as well as Barr and Diamond (2006) provide additional skeptical analysis of fully-funded pension systems, while Feldstein (1997) as well as Feldstein and Liebman (2002) defend an opposite, pro fully-funded view.

Rose and Spiegel (2011) take a different approach. Regardless of whether current account deficits in themselves are theoretically good or bad, they present empirical evidence that countries with current account surpluses appear to be better insulated from global crisis.

In this project, we do not provide new arguments to sort the debate. The analysis we perform however can be useful for each side of the debate, that is, whether current account deficits should be a policy target or not. In the first case, we show which pension system arrangements are most suitable to avoid an increase in current account deficits. In the second case, we show the contribution of population aging and pension arrangements in variations of the current account, which helps to provide a more accurate measurement of underlying domestic distortions.

2.4 Empirics on current account, aging and pensions

Several empirical studies investigate the relationship between aging, pension arrangements and national savings. Given that not all the changes in national saving can be absorbed domestically it should be clear that aging and aging related reforms also affect cross-country capital flows. Kohl and O'Brien (1998) provide a survey on empirical evidence concerning aging and national savings. Among the most relevant papers are Bailliu and Reisen (1998), Samwick (2000) and Bloom et al. (2007). By comparison, papers which look directly at the impact on current accounts are scarce.

The findings in Bloom et al. (2007) stem from an exhaustive cross-country panel and highlight that the characteristic of the pension system is an important indicator on how savings behavior is affected by aging. An increase in life expectancy by one year in a fully funded system is found to increase the national savings rate, i.e. national savings in % of GDP, by 0.4 %-points. The effect on national savings in a pay-as-you-go system is close to zero or even slightly negative. One can derive the conclusion that the effect on national savings is more negative the more generous the pension benefits are[9]. The interpretation is that in systems with higher replacement rates households save less in order to supplement their pension benefits. Some countries in the covered sample moved from a pay-as-you-go to a fully funded system. Bloom et al. (2007) uses this change to identify the corresponding effect on the long-run national savings rates which is estimated to be about 13 %-points. Their estimates confirm earlier results by Bailliu and Reisen (1998). Their findings are also consistent with Samwick (2000), who finds that countries with pay-as-you-go pension systems tend to have lower savings rate than countries with fully-funded pensions, even without population aging.

The empirical evidence of the effect of pension reforms on the current account (or foreign assets) are comparably scarce. Building on earlier work of Higgins (1998), Lührmann (2003) confirms using a panel data set consisting of 141 countries over the period 1960-1997 that international capital flows are indeed determined not only by current but also by predicted demographic variables, hence confirming forward-looking behavior of households. Lane and Milesi-Ferretti (2001) investigate the determinants of net foreign asset positions and find that countries with a larger share of older workers (and smaller share of younger workers) have a larger net foreign asset position, consistent with the expectation that countries with an older population need to

[9]The observation that a pay-as-you-go system crowds out national savings goes back to Feldstein (1976).

save more to finance consumption after retirement. Kerdrain et al. (2010) find in a recent cross-country panel study that an increase of statutory retirement age by one year reduces the current account balance by 0.5 % of GDP, confirming our motivation conjecture.

A related paper confirm the relevance of demographics and pension in national savings, going beyond mere theoretical interest. Schularick and Wachtel (2014) investigate variations in national savings in the US over the past 50 years. They find that national savings decreased from 1970 to 2010, in large part due to a fall in pension contributions. Pension savings have thus a significant contribution in national savings variations.

2.5 Theory on current account, aging and pensions

As aging and pension reforms are issues that will play a more prominent role in the future, the literature has used simulation models to assess the effects of aging and pension reforms on cross-border saving for the coming decades.

Ever since the seminal work by Buiter (1981), multi-country overlapping-generations (OLG) models have been used to help in explaining cross-country capital flows. An example is Brooks (2003). With a multi-region model, she finds that aging initially implies that savings by baby-boomers in Europe and North America exceed domestic investment opportunities, while it is reversed once the baby-boomers retire and start to dissave. In this case both regions will become net capital importers. In principle international capital flows are influenced by many factors, such as long-term growth trends, fiscal policy and business cycle fluctuations[10]. In a model ignoring these determinants, Domeij and Flodén (2006) estimate a structural OLG model with OECD data between 1960 and 2002 and find that a significant share of changes in low-frequency capital flows can be explained by changes in economies' population age structure. Ferrero (2010) pursue similar goals with a larger number of determinants and finds that differentials in productivity growth and population aging account for most of the current account variation between the US and (together) the rest of the G7.

An important contribution is Boersch-Supan et al. (2006). In contrast to the previous papers, they do not only focus on pure aging but also take pension reform into account. They base their analysis on a multi-country OLG model of the Auerbach and Kotlikoff (1987) style for France, Germany, Italy and other world regions. They confirm the capital exporter/importer time pattern predicted by Brooks (2003) and add two contributions. First, movements in aggregate national savings are amplified if the pension system is shifted from a pure pay-as-you-go to a fully funded system[11]. Second, they address the issue of imperfections of international capital mobility[12]. They emphasize that closed-economy set-ups would miss quantitatively important effects. In addition to assuming full asset market integration in the world, they check the robustness of their results if capital was only mobile within the OECD, only within the EU or only between France, Germany and Italy. The effect of those three countries moving to a fully funded pension system has a sizable impact on the interest rate only for the latter two scenarios.

[10] Ca' Zorzi et al. (2012) provide a summary of possible determinants.

[11] However, in contrast to our model they do not explicitly model a capital-funded system but simply cut pay-as-you-go pension benefits, which are then supplemented by private savings of perfectly forward looking agents and which they interpret as capital-funded pensions. Boersch-Supan et al. (2006) also do not consider changes in effective retirement age.

[12] See also Arezki (2010), who introduces capital market imperfections in a small open economy setting by modeling a symmetric wedge between the capital return of foreign and domestic investors.

There are a number of papers which look at aging and pension reform in individual countries using a small open economy assumption, as done in this study. Consider for example Huang et al. (1997) for the United States, Beetsma et al. (2003) for the Netherlands, Keuschnigg and Keuschnigg (2004) for Austria or Guest (2006) for Australia. Those papers however do not address the presence of an output/current account trade-off.

A study related to Boersch-Supan et al. (2006) is Aglietta et al. (2007), who uses a world model where Europe is covered as a single region. In contrast to Boersch-Supan et al. (2006) they also look at an increase in the effective retirement age and actually confirm the output-current account trade-off, although they do not discuss this finding explicitly. They consider a scenario in which contributions are fixed and pension benefits are reduced accordingly over time on one hand, and a phased-in increase in retirement age by five years on the other hand. In the latter case, the yearly current account is lower by about 4 %-points of GNP in the medium run[13]. Backus et al. (2014) use a simplified multi-country OLG model with a larger number of countries and conclude that differences in demographics can account for trade balance variations between the US and Japan.

All of the studies discussed so far consider differentials in demographics between countries, with or without policy reforms, to account for cross-country capital flows. In comparison, there are very few papers which analyze current account deficits impacts due to pension policy alone, isolated from differential in demographics.

Schimmelpfennig (2000) uses a simple 2-periods OLG model to obtain analytical results, without providing a quantitative assessment of the magnitude of the effects. He considers a reform from a pay-as-you-go pension system towards a fully-funded system and finds that the impact on the current account is different if individuals are forward-looking or myopic. Catalán and Magud (2012) perform a quantitative analysis and find that different pay-as-you-go pension reforms have different impacts on the current account and output growth, but do not explicitly model fully-funded pensions.

3 Model

This section provides a description of the model used in simulations. We provide an overview for the existing model[14] but all details on the extension to capital-funded pensions. The extension follows Keuschnigg, Keuschnigg, and Jaag (2011), a similar but less detailed model for Switzerland. The numerical simulations are based on a full scale model which incorporates more institutional detail and additional margins, summarized in the end.

The overlapping-generations (OLG) model is embedded in a small open economy setting and built on the probabilistic aging approach introduced by Grafenhofer, Jaag, Keuschnigg, and Keuschnigg (2007), an extension of Gertler (1999) which nests different overlapping generations structures, from Blanchard (1985) to Auerbach and Kotlikoff (1987). Age groups differ in their productivities to mimic the life-cycle income profiles as well as in their mortality probabilities, delivering realistic demographic dynamics.

[13]In contrast to our study however, they do not focus on a single country and do not consider any reforms towards a funded pension pillar.

[14]See Berger et al. (2009) for a detailed description of the model before the extension.

The life-cycle is divided into periods of education, prime age work and retirement. Labor supply decisions take place along a number of margins[15]. First, households decide whether to participate in the labor market or not. Second, unemployed workers need to search for a job. Third, employed workers split hours between labor, on-the-job training and leisure. Fourth, households choose when to retire, taking into account the incentives set by the public pension system. For ease of understanding, we only present in the following labor supply decisions related to participation and hours. Labor demand is determined by a representative firm that decides how much to invest in physical capital, how many job openings to post and how many workers to lay off.

3.1 Demography and probabilistic aging

The demographic dynamics are modeled as follows. In period t the economy is inhabited by N_t persons who differ along several characteristics, including age group (a) and skill (i). The overlapping generations structure relies on the concept of 'Probabilistic Aging' (see Grafenhofer et al., 2007). There is a discrete number A of age groups[16]. Individuals[17] age stochastically, which means that they switch from age group $a \in \{1, ..., A\}$ to age group $a+1$ with a given probability $1-\omega^a$ per period. If a period is a year then the expected time a person stays in age group a is $1/(1-\omega^a)$ years. Once the last age group A is reached, the aging probability drops to zero, i.e. $\omega^A = 1$. Life does not necessarily end in age group A as individuals face an age-group dependent death probability $1-\gamma^a$ at the end of every period. As aging occurs stochastically two individuals in the same age group can differ by their life-cycle history $\alpha \in \mathcal{N}_t^a$, where $\mathcal{N}_t^a$ is the set of all possible biographies. A biography α is simply a vector that holds the information on the time an individual has aged from one age group to the other. The set of completely identical people who share the same life-cycle history is denoted $N_{\alpha,t}^{a,i}$. Aggregating over different biographies gives the number of persons in age group a with skill i at time t

$$N_t^{a,i} = \sum_{\alpha \in \mathcal{N}_t^a} N_{\alpha,t}^{a,i}. \tag{3.1}$$

The skill level is fixed before people enter age group $a = 1$ - either exogenously or endogenously as in the full scale model - which implies that there are no transitions between skill classes during a life-time. The laws of motion per age-skill group are then given as

$$N_{t+1}^{1,i} = \gamma^1 \omega^1 N_t^{1,i} + New_{t+1}^i, \tag{3.2}$$

$$N_{t+1}^{a,i} = \gamma^a \omega^a N_t^{a,i} + \gamma^{a-1}(1-\omega^{a-1}) N_t^{a-1,i}, \tag{3.3}$$

where New_{t+1}^i are exogenously given 'newborns', i.e. people who attain an age that allows them to participate in the labor market[18]. Because of our assumption that individuals cannot switch between different skill classes during their lifetime, the household sector can be easily partitioned according to the skill levels. The household problems of different skill groups do therefore not differ except for the different parametrization. Spill-overs occur only through prices and general equilibrium effects. We will therefore drop the skill index i when describing the household problems to save notation, as the extension to several skill groups is straightforward. Aggregation

[15] For this project, we consider exogenous and constant education decisions. There exists a version of the model with endogenous education decisions.
[16] In the full model specification we work with $A = 8$ age groups.
[17] We use an individualistic approach, hence the terms 'individual' and 'household' are used interchangeably.
[18] In the full model specification we interpret entering $a = 1$ as having an age of 15 years.

over different characteristics can easily be done by summing up

$$N_{t+1}^{i} = \sum_{a=1}^{A} N_{t+1}^{a,i} \text{ and } N_{t+1} = \sum_{i} N_{t+1}^{i}. \tag{3.4}$$

3.2 Life cycle optimization

The life cycle is partitioned into three stages defined by setting a retirement decision age group a_r. In case of $0 < a < a_r$ individuals are in the working stage. If $a = a_r$ individuals find themselves in the retirement decision stage, while they are in the retirement stage if $a_r < a \leq A$. Individuals in groups $a \leq a_r$ face the same decision problems concerning participation, consumption and labor supply. Retired persons only decide how much to consume. The particularity of the retirement decision stage is that non-participation is interpreted as retirement. Households in the working stage optimize life-time utility subject to the laws of motion for the following three stock variables: regular assets A, mandatory pension savings assets A^F and obtained pension rights in the pay-as-you-go part of the pension system P^E. In the retirement stage $a = a_r$ the pension fund savings A^F are converted into an annuity plan, i.e. a fixed yearly gross payment, which depends on the expected remaining life expectancy, and an exogenous yearly valorization factor. The entitlements to a payout from the capital funded pillar are recorded in the stock variable P^F which is only applicable at $a \geq a_r$. Accumulated pension rights P^E in the pay-as-you-go system are also converted into payments, but without the use of an annuity formula. The dynamics of the pension related stock variables are discussed in detail in section 3.4. Using an actuarially fair reverse-life insurance (see Blanchard, 1985) the evolution of regular assets, i.e. the inter-temporal budget constraint, is given by

$$G\gamma^a A_{\alpha,t+1}^{a} = R_{t+1} Sav_{\alpha,t}^{a}, \qquad \text{with } Sav_{\alpha,t}^{a} \equiv \left[A_{\alpha,t}^{a} + y_{\alpha,t}^{a} - C_{\alpha,t}^{a}\right], \tag{3.5}$$

where G is an exogenous productivity growth factor by which the model is detrended. Income flow $y_{\alpha,t}^{a}$ is explained in the consecutive sections, $C_{\alpha,t}^{a}$ denotes household consumption, while $R > 1$ is the interest factor. Individuals have preferences according to the following Epstein-Zin specification[19]

$$V_{\alpha,t}^{a} = \max \left[\left(Q_{\alpha,t}^{a}\right)^{\rho} + \gamma^a \beta \left(G\omega^a V_{\alpha,t+1}^{a} + G(1-\omega^a) V_{\alpha',t+1}^{a+1} \right)^{\rho} \right]^{1/\rho}. \tag{3.6}$$

Individuals in age groups $a \leq a_r$ maximize utility with respect to participation $\delta_{\alpha,t}^{a}$, hours worked $l_{\alpha,t}^{a}$ and consumption $C_{\alpha,t}^{a}$. The effort-adjusted consumption is given as $Q_{\alpha,t}^{a} = C_{\alpha,t}^{a} - \varphi_l^a\left(l_{\alpha,t}^{a}\right) - \varphi_\delta^a\left(\delta_{\alpha,t}^{a}\right)$, where the effort costs functions $\varphi_l^a(\cdot)$ and $\varphi_\delta^a(\cdot)$ are convexly increasing. Households in the retirement stage $a = a_r$ in principle face the same decision problems, with the only differences that non-participation is interpreted as retirement and that households are entitled to pension payments based on past earnings instead of exogenous non-participation benefits[20]. Retired workers just decide about optimal consumption, hence $Q_{\alpha,t}^{a} = C_{\alpha,t}^{a}$, $\forall a > a_r$. The resulting optimal consumption-savings decision is governed by a typical Euler-equation

$$\left(Q_{\alpha,t}^{a}\right)^{\rho-1} = \beta R_{t+1} \bar{\eta}_{\alpha,t+1}^{a} G^{\rho-1}, \tag{3.7}$$

[19]The elasticity of intertemporal substitution is $1/(1-\rho)$ while individuals are risk-neutral. See Farmer (1990) and Weil (1990) for details.

[20]In line with evidence and theories of retirement bunching (Hurd, 1990; French, 2005), we also assume that households within the same skill-class make a collective retirement decision (that is, choose the same retirement date).

where $\bar{\eta}^a_{t+1} \equiv \omega^a \frac{\partial V^a_{\alpha,t+1}}{\partial A^a_{\alpha,t+1}} + (1-\omega^a)\frac{\partial V^{a+1}_{\alpha,t+1}}{\partial A^{a+1}_{\alpha,t+1}}$ is the shadow price of a marginal increase in assets, taking aging into account.

3.3 Labor market

The per-period income flow $y^a_{\alpha,t}$ depends on age in the following form:

$$y^a_{\alpha,t} = \begin{cases} \delta^a_{\alpha,t} \cdot (1-\tau^a_t) \cdot y^a_{\alpha,t,par} + \left(1-\delta^a_{\alpha,t}\right) \cdot y^a_{t,npar} & \text{if } a < a_r, \\ \delta^a_{\alpha,t} \cdot (1-\tau^a_t) \cdot y^a_{\alpha,t,par} + \left(1-\delta^a_{\alpha,t}\right) \cdot y^a_{\alpha,t,pens} & \text{if } a = a_r, \\ y^a_{\alpha,t,pens} & \text{if } a > a_r. \end{cases} \tag{3.8}$$

where $y^a_{t,npar}$ is the net value of non-participating, such as home production and simple welfare benefits. The value of participating $y^a_{\alpha,t,par} = l^a_{\alpha,t} \cdot \theta^a \cdot w_t$ depends on labor supply $l^a_{\alpha,t}$, an age dependent productivity parameter θ^a and the wage rate w_t. The second line emphasizes how $\delta^a_{\alpha,t}$ captures the retirement decision when $a = a^r$. The after-tax pension payout is given as follows and consists of three parts (or three *pillars*):

$$y^a_{\alpha,t,pens} = (1-\tau^a_t)\left[P_0 + \nu^a P^{E,a}_{\alpha,t} + P^{F,a}_{\alpha,t}\right].$$

The first part P_0 is an exogenous flat part. The second part $\nu^a P^{E,a}$ is the entitlement to a pay-as-you-go pension payment, where the conversion factor ν^a translates earned pension rights $P^{E,a}_{\alpha,t}$ into actual payments. The third part is the annuity payment that stems from the mandatory savings in the capital-funded pension pillar. The accumulation of the last two pillars is described in more detail in the next section.

3.4 Pension pillars

During their working life, individuals build up their pay-as-you-go pension rights $P^{E,a}_{\alpha,t}$ with labor market income[21], according to:

$$\begin{aligned} GP^{E,a}_{\alpha,t+1} &= R^{P,a}\left[\delta^a_{\alpha,t} m^a_t y^a_{\alpha,t,par} + \sigma^P \cdot P^{E,a}_{\alpha,t}\right] && \text{if } a < a_r, \\ GP^{E,a}_{\alpha,t+1} &= R^{P,a}\left[\sigma^P(\delta^a_{\alpha,t}) m^a_t y^a_{\alpha,t,par} + \sigma^P(\delta^a_{\alpha,t}) \cdot P^{E,a}_{\alpha,t}\right] && \text{if } a = a_r, \\ GP^{E,a}_{\alpha,t+1} &= R^{P,a} P^{E,a}_{\alpha,t} && \text{if } a > a_r. \end{aligned}$$

An accumulation factor m^a converts the individual income into an increase in the pension rights, and therefore an increase in the actual payment after retirement. The factor σ^P allows to give earlier incomes a lower weight for the computation of the pension. The index factor $R^{P,a}$ can either be set to imply price indexation of pension ($R^{P,a} = 1$), wage indexation ($R^{P,a} = G$) or a mixture. If aging from one to the next age-group occurs, pension rights are simply brought along, i.e. $P^{a+1,E}_{\alpha',t+1} = P^{a,E}_{\alpha,t+1}$. In the retirement stage, the individuals are subject to 'corridor' pension incentives, measured by the function $\sigma^P(\delta^a_{\alpha,t}) = \sigma^P + \sigma^P_1(\delta^a_{\alpha,t} - \delta^P_t)$. Postponed retirement beyond the statutory retirement age δ^P_t leads to a larger increase in the pension payment, and

[21] The full model is flexible enough to allow contributions from employed income, unemployed income and/or time of participation alone, independent of earnings.

vice-versa. Whenever individuals retire earlier than the statutory retirement age, they encounter a financial penalty. The strength is parametrized by σ_1^P.

Note that the pay-as-you-go payout is not directly related to the social security contribution rate nor to life-expectancy. The parameters of this pension pillar and the contribution rates can obviously be set such that this part of the pension system breaks even. There is however no automatism and underlying changes in the demographic structure towards an older society, while keeping the parameters of the system constant, are bound to lead to a deficit in the pay-as-you-go system. The capital-funded pillar works quite differently. The asset stock is directly related to the contributions that have been made over the life-time. When an individual retires the asset stock is converted into an annuity plan based on life expectancy.

$$
\begin{array}{lll}
G\gamma^a A^F_{\alpha,t+1} & = R^F \left[\left(t_t^{F,a} + t_t^{F,F,a} \right) \delta^a_{\alpha,t} y^a_{\alpha,t,par} + A^{F,a}_{\alpha,t} \right] & \text{if } a < a_r, \\
P^{F,a}_{\alpha',t} & = \frac{1}{\mu_t^{F,a}} \cdot A^{F,a}_{\alpha',t} & \text{if switch to } a_r \text{is at } t, \\
GP^{F,a}_{\alpha,t+1} & = R^{F,a} \left[\sigma^F \left(\delta^a_{\alpha,t} \right) / \gamma^a \cdot \left(\left(t_t^{F,a} + t_t^{F,F,a} \right) y^a_{\alpha,t,par} + P^{F,a}_{\alpha,t} \right) \right] & \text{if } a = a_r, \\
 & \quad + R^{PF,a} P^{F,a}_{\alpha,t} & \\
GP^{F,a}_{\alpha,t+1} & = R^{PF,a} P^{F,a}_{\alpha,t} & \text{if } a > a_r.
\end{array}
$$

During their working life, the worker $(t_t^{F,a})$ and the firm $(t_t^{F,F,a})$ contribute to the capital-funded pillar. Note that the workers' contribution rate is part of their total tax wedge τ^a. The return to mandatory pension savings is the market rate minus administration costs, i.e. $R^F = R - \rho^F$. The factor $R^{PF,a}$ is simply an exogenous indexation factor by which the capital-funded pension payout grows every year. After the working phase, saved assets are transformed into the annuity using the annuitization factor $\mu^{F,a}$. The following result is useful for finding the numerical solution:

Lemma 1. *The annuitization factor is given as*

$$
\begin{array}{rl}
a < a^R : & \mu_t^{F,a} = 1 \\
a = a^R : & \mu_t^{F,a} = 1 - \delta^a_{\alpha,t} + \left(\gamma^a R^{PF,a} + \sigma^F(\delta^a_\alpha) R^{F,a}_{t+1} \right) \dfrac{\bar{\mu}^{F,a}_{t+1}}{\Omega^a_{t+1} R^{F,a}_{t+1}} \\
a > a^R : & \mu_t^{F,a} = 1 + \left(\gamma^a R^{PF,a} \right) \dfrac{\bar{\mu}^{F,a}_{t+1}}{\Omega^a_{t+1} R^{F,a}_{t+1}} \\
\forall a : & \bar{\mu}^{F,a}_{t+1} = \omega^a \mu^{F,a}_{t+1} + (1 - \omega^a) \left(\Lambda^a_{\alpha,t+1} \right)^{1-\rho} \mu^{F,a+1}_{t+1} \\
a = a^R : & \sigma^F(\delta^a_\alpha) = \delta^a_{\alpha,t} \dfrac{\Omega^a_{t+1}}{\bar{\mu}^{F,a}_{t+1}}.
\end{array}
$$

Proof. The proof is provided in Keuschnigg et al. (2011). □

Ω and Λ are terms related to the marginal propensity of substitution between groups, explained in details in Berger et al. (2009). The annuitization factor μ^F is forward looking and depends positively on all future survival rates γ^a as well as all future indexation factors $R^{PF,a}$, as the recursive representation shows. The higher these variables, the lower the stream of pension payouts out of the mandatory savings stock. This is consistent with intuition, as one expects that a larger life expectancy reduces the annuity, ceteris paribus. Keuschnigg, Keuschnigg, and

Jaag (2011) present details on the working incentives effects of all three pension pillars. The contribution rate to fund flat pay-as-you-go pensions is naturally perceived as a tax, while the effective tax component in a system with a strong earnings-benefits link, or a corridor pension, can be greatly reduced. A funded system can in principle be neutral with respect to the labor market decisions of the workers if the return is that of the market, $R^F = R$. As we assume that the capital-funded pillar comes with administration costs, i.e. $R^F > R$, the funded system is distortive as well. In principle, a pay-as-you-go system can also be designed in a way to have little distortions on households' labor market decisions, similar to a capital-funded system. As the names suggest, the fundamental difference is that the latter involves the accumulation of actual assets usable in production, with its consequences on asset returns in goods terms, while the former only has notional (accounting) accumulation, without any returns in goods terms.

3.5 Production

Production is carried out by a competitive representative firm taking input prices, i.e. wage rates, the interest rate and the price of the output good, which serves as numeraire, as given. Production is subject to capital adjustment costs, a standard feature of computable OLG models. In this presentation wage rates are determined in skill-dependent perfect labor markets. The full model features unemployment and wage setting through bargaining. The production function is linear homogenous:

$$Y_t = F^Y \left(K_t, L_t^{D,i=1}, L_t^{D,i=2}, L_t^{D,i=3} \right). \tag{3.9}$$

The labor inputs $L_t^{D,i}$ from different skill classes are not perfect substitutes. We assume that high skill labor and capital are more complementary than low skill labor and capital and use a nested CES-specification from Jaag (2009). The firm maximizes its end of period value V^F, which equals the stream of discounted dividend payments χ:

$$\begin{aligned} V(K_t) \quad &= \quad \max_{I_t, L_t^{D,i}} \left[\chi_t + \frac{GV(K_{t+1})}{R_{t+1}} \right], \\ s.t. \quad & \quad \chi_t = Y_t - I_t - J(I_t, K_t) - \sum_i (1 + t^{F,F,a}) w_t^i L_t^{D,i}, \\ & \quad GK_{t+1} = \left(1 - \delta^K\right) K_t + I_t, \end{aligned} \tag{3.10}$$

where $J(\cdot)$ denotes the adjustment costs, which are homogenous of degree one as in Hayashi (1982). Labor demands are pinned down by the marginal products and the labor costs consisting of wage and contribution rates, i.e. $Y_{L^{D,i}} = (1 + t^{F,F,a}) w^i$. The firm value V, based on optimal firm decisions, is a part of asset demand.

3.6 Aggregation

So far decision problems have been set up for the smallest set of identical households, i.e. households of the same age and skill, at the same time sharing the same history concerning the stochastic aging process. As shown in Grafenhofer et al. (2007) aggregation can be performed under certain assumptions such that the model can be analyzed at the age and skill class level, without distinguishing between different biographies α. The assumptions are separability of consumption and leisure in the utility function, a collective retirement decision within an age-skill class and income pooling within an age-skill class. With income pooling, the probability of participation is equivalent to the share of a representative household which participates in the labor market. Labor market decisions of the households are thus independent of their current asset position and are simply determined by current observables, including wages, tax rates as well as forward looking shadow prices. As all of those determinants are independent of biographies, households in the same age and skill class make the same labor market decisions, i.e. $\delta_t^a = \delta_{\alpha,t}^a$ and $l_t^a = l_{\alpha,t}^a$.

The aggregation of a variable X simply sums up over all biographies and weights with the relative population shares

$$X_t^{a,i} = \sum_{\alpha \in \mathcal{N}_t^a} X_{\alpha,t}^{a,i} \cdot N_{\alpha,t}^{a,i}. \tag{3.11}$$

For example, total private consumption per age-skill group is given by $C_t^{a,i} = \sum_\alpha C_{\alpha,t}^{a,i} \cdot N_{\alpha,t}^{a,i}$. Effective labor supply L^S takes both labor supply margins and productivity into account, $L_t^{S,a,i} = \sum_\alpha \delta_{\alpha,t}^{a,i} \cdot l_{\alpha,t}^{a,i} \cdot \theta^a \cdot N_{\alpha,t}^{a,i}$. While aggregation of static relationships, like the first order conditions for labor supply and participation, is simple it becomes more involved for the difference equations for private and mandatory assets or pension points, given the dependence of stocks on biographies. One obtains the following result:

Lemma 2. *Asset aggregation for private and mandatory assets.*

$$GA_{t+1}^{a,i} = R_{t+1}\left[\omega^a Sav_t^{a,i} + \left(1-\omega^{a-1}\right) Sav_t^{a-1,i}\right], \quad Sav_t^{a,i} \equiv \left[A_t^{a,i} + y_t^{a,i} N_t^{a,i} - C_t^{a,i}\right].$$

$$\begin{aligned}
\forall a: \quad & A_{t+1}^{F,a} = \omega^a R_{t+1}^{F,a}\left[A_t^{F,a} + x_t^a T_t^{F,a} - (1-x_t^a) P_t^{X,a}\right] + \\
& \qquad \left(1-\omega^{a-1}\right) R_{t+1}^{F,a-1}\left[A_t^{F,a-1} + x_t^{a-1} T_t^{F,a-1} - (1-x_t^{a-1}) P_t^{X,a-1}\right] \\
a > a^R: \quad & x_t^a = 0 \\
& T_t^{F,a} = 0 \\
& P_{\alpha,t}^{X,a} = P_{\alpha,t}^{F,a} \qquad\qquad P_t^{X,a} = \sum_\alpha N_{\alpha,t}^a P_{\alpha,t}^{X,a} \\
a = a^R: \quad & x_t^a = \delta_t^a \\
& T_{\alpha,t}^{F,a} = \left(t_t^{F,a} + t_t^{F,F,a}\right) y_{\alpha,t,par}^a \qquad T_t^{F,a} = \sum_\alpha N_{\alpha,t}^a T_{\alpha,t}^{F,a} \\
& P_{\alpha,t}^{X,a} = P_{\alpha,t}^{F,a} \qquad\qquad P_t^{X,a} = \sum_\alpha N_{\alpha,t}^a P_{\alpha,t}^{X,a} \\
a < a^R: \quad & x_t^a = \delta_t^a \\
& T_{\alpha,t}^{F,a} = \left(t_t^{F,a} + t_t^{F,F,a}\right) y_{\alpha,t,par}^a \qquad T_t^{F,a} = \sum_\alpha N_{\alpha,t}^a T_{\alpha,t}^{F,a} \\
& P_{\alpha,t}^{X,a} = 0 \qquad\qquad P_t^{X,a} = \sum_\alpha N_{\alpha,t}^a P_{\alpha,t}^{X,a} = 0
\end{aligned}$$

Proof. extension of Grafenhofer et al. (2007). □

Berger et al. (2009) contains similar aggregation results for other stocks, human capital, pay-as-you-go pension rights and household savings. Aggregation over age groups or skill classes is done by simply summing up, i.e. $X_t = \sum_{a,i} X_t^{a,i}$. For example, effective labor supply by skill class is given by $L_t^{S,i} = \sum_a L_t^{S,a,i}$.

3.7 Market clearing and government budget

The asset market is central to the understanding of the results of this paper. First, we assume that all assets are perfect substitutes. Total private household assets (A) and pension funds (A^F) are invested in the domestic representative firm (V), government debt (D^G) and foreign assets (D^F). Hence, the asset market clearing condition can be written as

$$A_t + A_t^F = V_t + D_t^G + D_t^F \tag{3.12}$$

Given the small open economy assumption with a fixed real interest rate, foreign assets D^F, and thus the current account, simply adjust to clear the asset market. In our simulations, government debt is kept constant by balancing the government budget in every period. In this case, a pension reform can influence foreign assets in three ways: (a) by changing the private savings behavior of the households, through A, (b) by changing mandatory savings rules, through A^F or (c) by changing the domestic investment opportunities, through V. As in Berger et al. (2009) and following Hayashi (1982), one can show that the value of the representative firm is directly related to the capital stock, $V = tob \cdot K$, where tob is Tobin's q. Given the constant user costs of capital, the capital stock K and thus the domestic investment opportunities V are in the long run determined by effective labor supply. This illustrates the importance of modeling precisely labor market decisions to quantify the impact of pension reforms on the current account.

The clearing of the labor market has been described in previous sections. By Walras' Law, the goods market clears when the two other markets, for asset and labor, clear. It is instructional however to state the goods market clearing condition:

$$Y_t = C_t + I_t + G_t + TB_t,$$

where G_t is government expenditure and TB_t is the trade balance, which affects the evolution of foreign assets in the following way:

$$D_{t+1}^F = R_{t+1}\left(D_t^F + TB_t\right).$$

3.8 Full scale model

Numerical simulations are performed with a full scale computational model with features unrelated to capital-funded pensions and not described in the simple presentation above, for simplicity. Those features are not important for understanding qualitative mechanisms but improve the quantitative predictions of the model.

We now briefly list the additional features. A detailed description of the full model without capital-funded pensions is provided in Berger et al. (2009). First, there is an additional labor market margin, namely unemployment. The probability of finding a job depends on the search effort of workers and the amount of vacancies created by the firm, in a static search-and-matching framework derived from Boone and Bovenberg (2002). Second, to match the observed distribution of consumption over the life-cycle, the model incorporates a warm-glow motive. Inter-vivo transfers take place from the older to the younger age groups within a skill class. Third, as the pathway to retirement via the disability pension system is quantitatively important in Austria, the full scale model incorporate disability shocks and insurance. Since entitlement to a disability pension follows an exogenous shock, the pension reforms that we consider exclude adjustments or changes of the disability pension system. Fourth, the full model has a complete institutional setting on taxation and transfers to individuals and firms. In particular, we make a difference between a general budget and a social security budget, the latter paying for pensions, unemployment benefits, disability benefits and health insurance and being financed by social security contributions of employers and employees. Health insurance costs are exogenously defined, with a constant age-dependent spending per capita. The general budget is financed by income, consumption and corporate taxes and is used to cover own government expenditures, the deficit of the social security system, firm and household subsidies and interests on government debt.

For a better understanding of the effect of aging and pension arrangements on savings behavior and foreign assets, we do not use all capacity of the full scale model. We consider exogenous human capital, on-the-job training and retirement decisions. The first two decisions remain constant, while the latter is changed via policy reforms.

4 Calibration

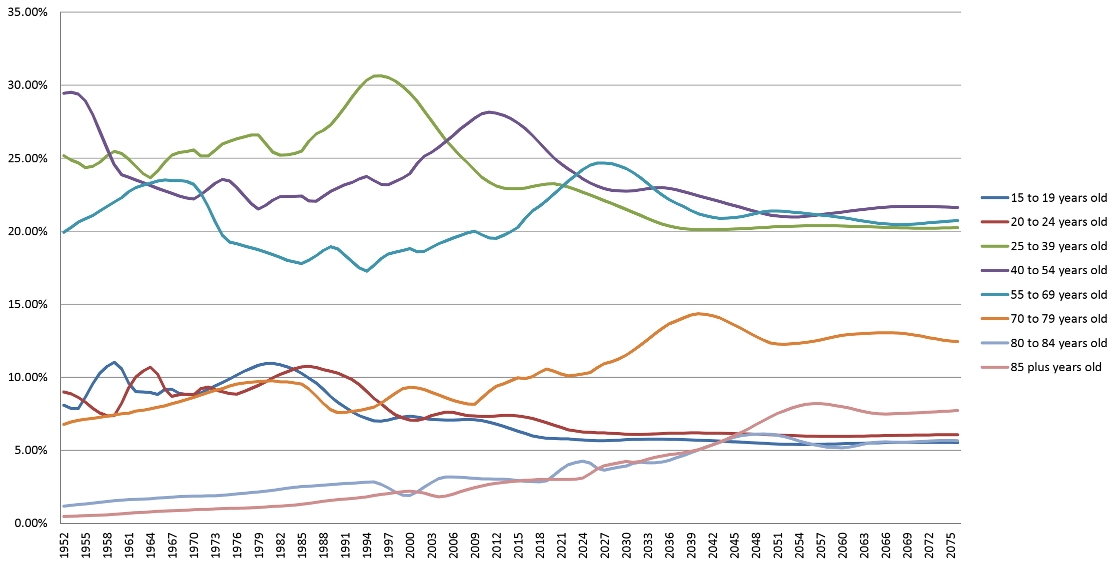
This section describes the calibration of the model for Austria, using 2013 as the basis year. In the parametrization we choose the number of age-groups to be $A = 8$ and the three different skill-groups (low, medium, high) resulting in a total of 24 representative households. Low skill is any level below upper secondary (ISCED 0-2), that is individuals without '*Matura*' in Austria. Medium skilled individuals have an upper secondary education degree (ISCED 3-4) and high skilled have an academic degree (ISCED 5-6). Calibration of the household sector of the model, including productivity and labor disutility parameters, is made by fitting model predictions with the conditional first moments for representative households in recent pooled microdata, in particular the Labour Force Survey (LFS) and the Community Statistics on Income and Living Conditions (EU-SILC). The calibration of the macro aggregates is based on national accounts information, while the behavioral elasticities are chosen in accordance with standards from the literature.

Berger et al. (2009) provide a detailed description of the calibration procedure, which we follow with some exceptions. We describe exceptions in the continuation. First, the basis year is 2013 instead of 2009. Second, as long run real interest rate we set $r = 0.025$ which is crucial for the savings behavior and therefore for one of the main variables of interest, namely foreign assets. We will address these concerns by running sensitivity test of the results with respect to different choices of the subjective discount factor β in section 7.

The third and fourth differences relate to the capital-funded pillar and deserve a detailed discussion. In the third difference, there are some extra parameters which have to be set simply because of the introduction of the capital-funded pillar. The administrative costs of running the pillar are set to 10% of the real return, i.e. $r^F = 0.025 \times 0.9 = 0.0225$. The indexation of capital-funded pension payouts is assumed to be the same as for the earnings-related PAYG pension payouts. As a fourth difference, we chose an alternative calibration strategy for the time discount factor than Berger et al. (2009). A fundamental problem when calibrating an equilibrium model is that the economy currently observed is not in a steady state. This is a particular problem for the foreign assets and the current account. In equilibrium both are related by the steady-state relationship $TB = -r/(1+r)D^F$, where D^F are foreign assets and TB is the trade balance. Hence, a trade surplus in the long run is only consistent with negative foreign assets. Equivalently a country can permanently run a trade deficit only if it accumulated positive foreign assets before. The observed trade balance is therefore very likely a temporary phenomenon as Austria generated current account[22] surpluses in the recent past will having a positive net foreign asset position[23]. Calibrations that replicate the current trade balance as an equilibrium outcome therefore have to assume a considerably different underlying savings behavior than actually observed. Hence, modelers face a clear trade-off: either replicate the current trade balance but fail to replicate the actual savings behavior (as parametrized by the discount factor β) or replicate the savings behavior but fail to replicate the current trade balance. We argue that for the question to be answered, capturing the savings behavior as well as possible is of primary importance. Our calibration therefore falls short of generating a realistic initial trade balance as well as foreign assets stock, which is why we only interpret the changes in these variables in our simulations. In section 7 we elaborate on this choice further by comparing the simulation results for different calibration values for the discount factor. In our benchmark calibration we use $\beta = 0.99$.

The final point worth mentioning is a related problem, namely the calibration of the model to an initial demographic distribution when the observed current demographic structure is not stationary. This is illustrated in figure 4.1. Again one faces a trade off. On one hand one can use the currently observed age-dependent mortality rates which in steady state would lead to an older population than currently observed. On the other hand one could match the current demographic structure by lowering the mortality rates, which however implies a lower life expectancy than actually faced by the current population. We address this by compromising between both targets. The fit of the model with the demographic data in 2013 and 2060 (based on the medium scenario projection of the Austrian Statistical Office, Statistik Austria) is illustrated in figure 4.2.

Figure 4.1: Projection, Austria, relative sizes of age groups as share of total +15 population

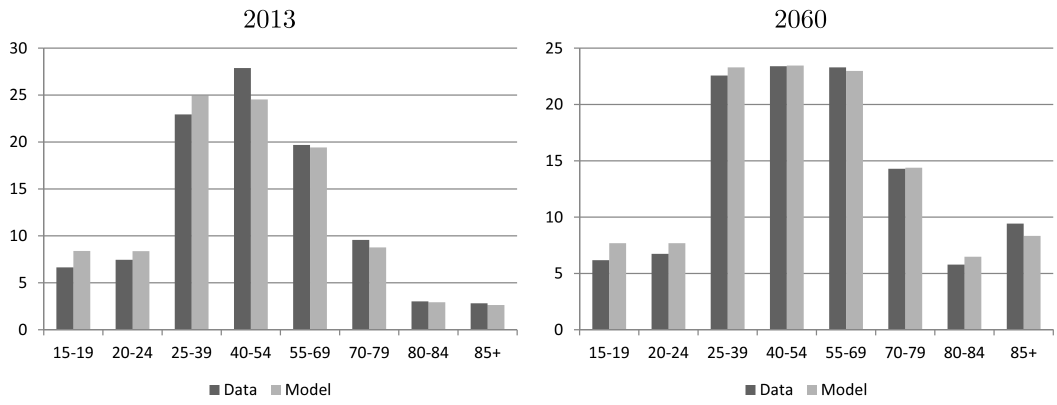


Source: Statistik Austria, medium population projection.

[22]As we have only one good in our model and therefore no services trade the meaning of current account and trade balance coincide.

[23]In the data compiled in the World Development Indicators from the World Bank, Austria had a net foreign assets position equal to 71% of GDP in 2013, and an external balance on goods and services equal to 3.6% of GDP.

Figure 4.2: Absolute population size per age groups in Austria for 2013 and 2060



Note: Populations of the 15+ year old is normalized to 100 in 2013.
Source: Statistik Austria and simulation results.

5 Long run simulations

In this section we consider long run simulation results by reporting the results of different shocks and reforms on the final steady states. This gives a good understanding of the underlying mechanisms. As we will show in the next section, it is also quantitatively close to results for 2070 onward. In total we present nine simulations, whose results are shown in table 2. First, we present the benchmark aging scenario. We then have a look on the effects of four standard parametric pay-as-you-go pension reforms. We then introduce a capital-funded pillar and compare it to a pay-as-you-go benchmark. We finish with two combinations of capital-funded pillar and parametric pension reforms.

We will compare outcomes along four policy criteria: fiscal sustainability, output per capita, pension payout generosity and foreign asset position. The overall aim is to find a policy reform mix with the best balance along these four dimensions. Table 1 provides a schematic summary of the effects of pension reforms (lines) along the four evaluation dimensions (columns). For instance, an increase in retirement age in a pure pay-as-you-go system improves the output growth potential (compared to the status quo with population aging) but decreases the net foreign asset position. The following informal statement provides a preview of the main results:

Summary finding 1: *Over the long run, parametric pension reforms in a pure pay-as-you-go system improve financial sustainability but either penalize output growth (pension cuts, contribution increase), increase risk of old-age poverty (pension cuts) or increase the dependence on foreign assets (retirement age increase); with the introduction of a capital-funded pension pillar combined with a small pension cut and an increase in retirement age, all four policy goals can be achieved: financial sustainability, output growth maintenance, low old-age poverty risk and no dependence on foreign assets.*

We provide details on results and a discussion in the remainder of the section.

Table 1: Summary findings long-run simulations

	Financial sustainability	Output growth potential	Protection old-age poverty risk	Net foreign assets
Pension cuts in pure PAYG	+	-	-	+
Contribution increase in pure PAYG	+	-	=	+
Later retirement in pure PAYG	+	+	=	-
Capital-funded pillar introduction	-	+	+	+
Pension cut + Later retirement + Capital-funded pillar introduction	+	+	=	+

Note: effects are compared to the no-reform status quo under population aging.

5.1 Population aging benchmark

Column (1) of table 2 gives the long run impact of the population aging shock, without any policy reforms. These results provide a benchmark to identify the impact of reforms considered in the other simulations.

Mortality rates and the number of newborns are adjusted in order to match the projected demographic change and kept constant after 2075. In the final steady state the population older than 15 years is 112% of what it was in 2013. As the retirement age is kept constant, population aging leads to a relative drop in labor supply: yearly hours per capita drop from 897 in 2013 to 769 in the long run. The capital stock adjusts by shrinking accordingly, which leads to a 13% drop in GDP per capita (compared to the productivity growth trend). Pension expenditures increase from 14 to 22% of GDP, although pension expenditure per recipient shrinks 4% due to population aging, declining participation over the life-cycle and the link of earnings during working time and the pension payouts[24]. The public finance challenge is illustrated by a rise of the social security deficit from 3.6 to 15.7% of GDP.

[24]The labor market participation rate declines over the life-cycle. Because the population ages and the retirement age is constant, the average age of workers increases. The average participation thus declines. Lifelong labor income thus also decline. Because of the 2nd pillar of the pension system, earnings-related, average pension payments decline.

Table 2: Long-run results

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Aging		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Increase in retirement			+2 years	+6 years					+6 years	+6 years
Pension cut					Yes					Yes
Contribution increase						Yes	Yes			
Capital-funded pillar (3rd pillar)								Yes	Yes	Yes
	2013	FSS	FSS	FSS	FSS	FSS	FSS	FSS	FSS	FSS
Population (normalized)	100	112	112	112	112	112	112	112	112	112
Hours/capita	897	769	809	887	762	747	734	784	906	897
Labor costs (Δ%)		0.09	0.92	2.43	0.44	2.46	3.81	-1.87	0.26	0.55
Pension expend./retiree (all pillars) (Δ%)		-3.86	-4.29	-5.65	-15.77	-3.59	-3.38	6.62	18.82	-3.24
GDP/capita (Δ%)		-13.03	-8.11	1.73	-13.88	-15.38	-16.65	-11.97	3.21	2.17
Private Consumption/capita (Δ%)		-2.45	-1.08	1.70	-5.73	-7.10	-9.21	-1.14	5.07	0.50
Government Consumption/capita (Δ%)		-114.83	-84.60	-23.57	-98.12	-101.65	-96.34	-107.68	-25.72	-0.14
Pens. Exp (% of GDP)	14.20	22.23	19.56	14.95	19.67	22.91	23.31	24.36	18.56	15.27
Share 3rd pillar (% of total pensions)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26.31	35.23	42.98
SS deficit (% of GDP)	3.58	15.68	13.25	8.34	13.27	13.20	12.11	15.69	9.82	6.22
PAYG deficit (% of GDP)	2.25	9.93	7.82	3.55	7.40	8.23	7.46	8.60	3.46	-0.29
TB (Δ absolute)		-0.11	0.41	1.36	-0.95	-1.20	-1.82	-0.77	0.94	-0.32
D^F (Δ absolute)		8.61	-32.20	-107.81	75.11	95.55	144.40	61.25	-74.93	25.16
A (Δ absolute)		5.35	7.73	16.98	54.58	-7.36	-13.21	-79.50	-114.86	-31.97
$(A + A^F)$ (Δ absolute)		5.35	7.73	16.98	54.58	-7.36	-13.21	142.48	158.05	238.87
V^F (Δ absolute)		-3.26	39.93	124.80	-20.53	-102.91	-157.61	81.24	232.98	213.71

Notes: Absolute deviations (Δ absolute) are expressed in terms of gross value added, normalized to 100 in 2013. Gross domestic product in 2013 is 112. Pension expenditures per retiree, GDP per capita, Private and Government Consumption figures are all deviations from the productivity growth trend.

In reality, the magnitude of the public finance challenge is however even larger than indicated by these figures, for two reasons. First, the deficit in the social security system is financed by the general budget, which creates a gap. The gap is even increased, as revenue from income and consumption tax per capita decrease. To close the government budget gap, we assume that government reduces its own expenditures (in other words, government consumption is the budget closing instrument). Note that government consumption in our specification excludes education and health costs, which we keep constant in per age and per capita terms. The overall fiscal consequence of pure aging is that government consumption has to drop by 115%, which would clearly not be feasible in reality. Closing with government consumption is also related to the second reason why the fiscal consequences of aging are underestimated. Government consumption is non-productive in the model and therefore non-distortive (similar to lump-sum taxes). If we used realistic financing instruments and closed the budget with a distortive tax, e.g. income taxes, relative labor supply would drop even further and the tax base would shrink, increasing the challenge of financing old-age social security.

In terms of foreign debt the effect of aging is not very pronounced. In the long run the foreign asset stock would increase by less than 8% in terms of initial GDP. The increase in net foreign assets is due to the declining domestic investment opportunities, as the firms' capital stock drops.

5.2 Parametric pay-as-you-go pension reforms

We now look at the effect of three typical parametric pension reforms: an increase in retirement age by either 2 years (column 2) or six years (column 3), a cut in pensions by reducing the payout factor ν^a by 20% (column 4) and an increase in the workers social security contribution rate by 6.5 pp (column 5). Reforms in columns (2), (4) and (5) were set such that all of them reduce the social security deficit from 15.7% of GDP in the benchmark aging scenario to about 13.2% of GDP. The reform in column (3) is later used as comparison point in future simulations. Since its impacts are the same as in column (2) but larger, we do not discuss it.

Out of the three reform options the increase in retirement age (column 2) performs best in terms of GDP per capita, as the drop can be reduced to -8% instead of -13% in the benchmark aging scenario. The same conclusion holds for the effect on private and public consumption. Although the social security deficit is comparable in all three reform options, the lower drop in government consumption under retirement age increase indicates higher improvements in financial sustainability. Not surprisingly, the pension cut reform (column 4) increases most the risk of old-age poverty, the average pension expenditure per retiree dropping almost 16%. These outcomes are consistent with the existing literature.

The last and novel evaluation criteria is the current account impact, or, equivalently, the net foreign asset position. The effects on foreign assets differ considerably between the three measures. The foreign asset stock increases most in case of a rise in the contribution rates (column 5). Because the provision of labor supply is discouraged, the capital stock shrinks more, which has an effect on the domestic investment opportunities (as confirmed by the drop in the firm value V^F). This is the main explanation for the increase in foreign assets, as domestic households simply ship their investment abroad due to the lack of domestic opportunities. In case of a pension cut (column 4), foreign assets increase for two reasons. First, because of the pension-earnings link a cut in pension benefits has a discouraging effect on labor supply with similar consequences on the firm value as in the case of a contribution increase, though quantitatively less pronounced. In addition households change their savings behavior. In order to compensate for the loss in public pensions and finance consumption after retirement, they increase their private savings over their life time which leads to higher asset supply (as confirmed by the larger increase in asset positions A). Given the reduced domestic investment opportunities this extra saving is invested abroad. In the case of an increase of the retirement age by 2 years (column 2), the effect on foreign assets is reversed, as the position decreases. The explanation is that labor supply, production and firm value rise compared to the pure aging scenario such that asset holdings abroad are shifted to the local firm. The drop in foreign assets amounts to less than 30% of initial GDP. However, if the increase in retirement age is 6 instead of 2 years, as in column (3), which implies an effective retirement age of about 65 years (i.e. the current statutory retirement age), the drop in foreign assets is larger than one time the initial GDP. Since the net asset position in 2013 was positive at 71% of GDP, an increase of the effective retirement age to its statutory level would transform Austria from a net creditor into a net asset debtor on the international capital market. The impact is thus large and justifies policy attention.

5.3 Capital-funded pillar

In this section we consider two reforms. The first is the introduction of a capital-funded pillar into the existing pay-as-you-go system (column 7). The second is a reform of the current pay-as-you-go system so that it mimics some properties of capital-funded pensions, for comparison purposes (column 6).

We consider the introduction of a capital-funded pillar so that pension expenditures (payouts) in this pillar amount to approximately one fourth of total pension expenditures (column 7). In order to do so, we shift 3.8 pp of the current contribution rates of workers and firms from the pay-as-you-go pillars to the capital-funded pillar, keeping the total burden on labor identical. We also reduce in equivalent proportion the accumulation factor for pension rights in the earnings-related pay-as-you-go pillar.

For comparison purposes, we perform a reform of the pure pay-as-you-go pension system in order to mimic some of the properties of a system with a capital-funded pillar (column 6). One core difference between a pay-as-you-go pension system and a capital-funded system are the returns on contributions (more specifically, on accumulated contributions in mandatory savings) in the second system. Another core difference is that contributions and benefit payouts are balanced (for the average life expectation) under capital-funded pensions, while they are not necessarily balanced with pay-as-you-go pensions. In the latter case, even if contributions and payouts are balanced at some point in time, they become unbalanced if the population ages and there are no reforms[25]. To disentangle the effects from these two differences due to the introduction of a capital-funded pillar, the simulation (6) changes the contribution rates of the pay-as-you-go system (in a skill-dependent fashion) such that the balance between contributions and payouts in the pay-as-you-go pillars are equivalent in reforms (6) and (7)[26]. This allows to assess the effect of the returns on contributions *alone*, comparing outcomes of reforms (6) and (7).

[25]These two core differences also lead to differences in labor supply incentives.

[26]Specifically, we use (payouts - lifetime contributions)/payouts as a measure of the balance of the pay-as-you-go pension pillars, where both payouts and contributions refer to the pay-as-you-go pillars only. With aging and no reform, the measure is 0.50 for the average household (benchmark scenario 1). In reform (7), the pay-as-you-go pillars are only 26% of the total pension expenditures (over all 3 pillars), so we increase contribution rates in reform (6) such that the balance measure equals (0.74 x payouts - lifetime contributions)/0.74 x payouts, or 0.32.

We discuss the introduction of a capital funded pillar first (column 7). Even if workers officially face the same total contribution rates, the reform has an effect on labor supply, as contributions to a capital-funded pillar have a lower tax component (see discussion above): yearly hours per capita rise from 769 in the benchmark aging scenario to 784. Because of the earnings link in the pay-as-you-go pension pillars, the payout from these pillars also increases, explaining why average pension payouts are higher. The risk of old-age poverty thus declines[27]. Because of the labor supply incentives, output per capita is larger than in the benchmark aging case, declining only 12% instead of 13%. Net foreign assets also increase more than in the benchmark case. The reason is that total savings, the sum of private and mandatory savings, is stimulated by the introduction of the capital-funded pillar: contributions to this pillar are not longer consumed but saved. Together they increase by about 1.3 times of initial GDP, which is larger than the increase in domestic investment opportunities created by the increase in labor supply, as indicated in the firms value V^F increase. Hence, part of the total savings increase is invested abroad. While the reform fare well on the output growth, protection against old-age poverty and foreign assets criteria, it is not as successful as other reforms along the financial sustainability criterion. Unlike other reforms, it is not successful in reducing the social security deficit, unchanged at 15.7% of GDP. Although the relative size of the pay-as-you-go pension pillars decline (from 100% to 74%), their absolute size increase (24 instead of 22% of GDP), following the rise in average payouts. The financing unbalance of these pillars is not corrected.

We next compare outcomes with the reform of the pure pay-as-you-go pension system (column 6) so that it mimics the balance properties of the capital-funded pillar system (column 7). Labor supply incentives in the mimicking case (6) are significantly worse than in the capital-funded case (7), yearly hours per capita dropping to 734 instead of 784. Reasons are similar as for reform (5). The bigger drop of output growth per capita is a natural consequence, as well as the drop in domestic investment opportunities and the larger increase in net foreign assets. The only favorable outcome of the mimicking case concerns financial sustainability, along several dimensions. For instance, the deficit of the pay-as-you-go pension system is 8.2% of GDP, instead of 8.6%. This outcome is due to the fact that reform (7) only moves partially to a fully-funded system, to the earnings-related component of the pay-as-you-go pillar and to the labor supply incentive of the reform (see above). The general message from this comparison is that (some) outcomes can be improved when one introduces a partial capital-funded pillar if one considers at the same time some parametric reforms of the pay-as-you-go system. This strategy will be used in the next section.

5.4 Capital-funded pillar and retirement age increase

In the last pair of simulations we combine the introduction of the capital-funded system with the increase of the retirement by 6 years (columns 8 and 9). On top of this, we cut pay-as-you-go pensions[28] such that generosity is comparable to the benchmark aging scenario, in the last simulation (column 9). Because effects are cumulative and the last simulation delivers the best outcomes, we only discuss this scenario (column 9).

We change the contribution rate for each skill-group separately to reach similar targets, when computed for the average households within each skill class. Contributions have to be increased 9.2 pp for the low-skilled, 9.7 pp for the medium-skilled and 9.5 pp for the high-skilled.

[27] The average pension payouts (over all pillars) increase for the total population and for each skill class. Indeed, they increase 3% for low-skilled, 7% for medium-skilled and 12% for high-skilled households (not reported in table).

[28] The flat part as well as the earnings-related part.

The labor supply incentives are strongest. In spite of population aging, the labor supply remains as high as in 2013, at 897 yearly hours per capita. As a consequence, output per capita, private consumption per capita and public consumption per capita also remain essentially unchanged, when not improving. The increase in labor supply is due to the same reason it increases for reforms in columns (2) and in columns (7), but cumulates them. Thanks to the increase in labor supply, social security contributions payments increase. Combined with the pension cuts, the deficit of the pay-as-you-go pension system disappears, a strong improvement of the financial sustainability of old-age social security, counteracting the effect of population aging. By design, the risk of old-age poverty is the same as in the benchmark scenario, average pension payouts being the same[29]. The impact of the reform on the net foreign asset position is slightly positive, as it increases by about 20% of GDP. On the one hand, the increase in labor supply creates domestic investment opportunities, firms building up their capital stock in the same proportion as labor supply increases. On the other hand, the introduction of a capital-funded pillar increases (mandatory) savings. Overall, the increase in domestic firm values V^F and total savings $A + A^F$ are comparable, the latter being slightly higher than the former, so that some investment opportunities are sought abroad.

Overall, the new policy mix with a capital-funded pillar, an increase of the effective retirement age to its statutory level and a moderate pay-as-you-go pension cuts deliver the best compromise, when evaluated over the four targeted criteria: financial sustainability, output growth maintenance, protection against old-age poverty risk and current account balance.

6 Transition simulations

In this section we present the full transition path towards final steady states. We focus on the preferred reform, the introduction of a capital-funded pillar, an increase of the effective retirement age to its statutory level and a moderate pay-as-you-go pension cut (column 9 in table 2; see section 5.4). We also consider the two reforms which constitute the main basis for the preferred reform, namely the introduction of the same capital-funded pillar (column 7) and an identical increase in retirement age (column 3). The main conclusions from this section can be summarized informally by:

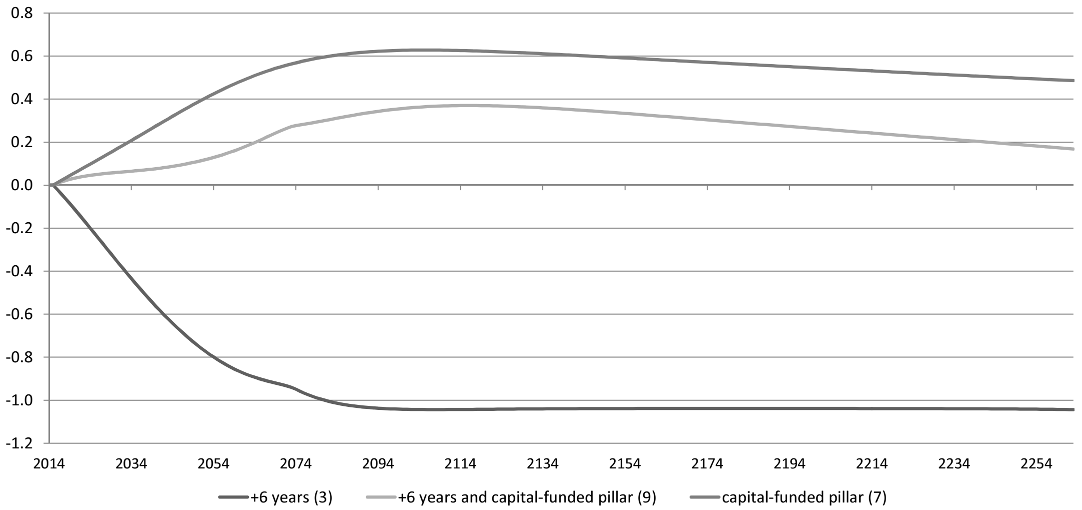
Summary finding 2: *Most of the transition to the new equilibrium, in the final steady state, takes place over the first 70 years; there are transition costs related to the introduction of the capital-funded pillar, both in income terms for the old generations and in public finance terms.*

Along the transition, we assume a different timing for each (part of the) reform. Increases in retirement age are linearly phased-in over the first 60 years. In contrast, the introduction of the capital-funded pillar is effective immediately. The third pillar is still gradually built up over time, as contributions in the fund accumulate little by little. We will compare an immediate implementation of the pension cut with a gradual implementation, where the cut is phased-in linearly over the first 60 years.

[29]Pension payouts are maintained in average but also across skill classes. Compared to 2013, they increase 0.1% for low-skilled, 1.1% for medium-skilled and 0.4% for high-skilled households (not reported in table).

Figure 6.1 confirms our finding on the long run value of net foreign assets. The figure displays changes of foreign assets in terms of initial GDP, compared to the benchmark case of aging. We see that a mixture of introducing a capital-funded pillar and increasing the retirement age works best in order to keep changes of the foreign asset position to a minimum. Using either one of those two reforms in isolation would lead to a considerable positive or negative change in the foreign asset holdings, not only on the long run but along the entire transition path.

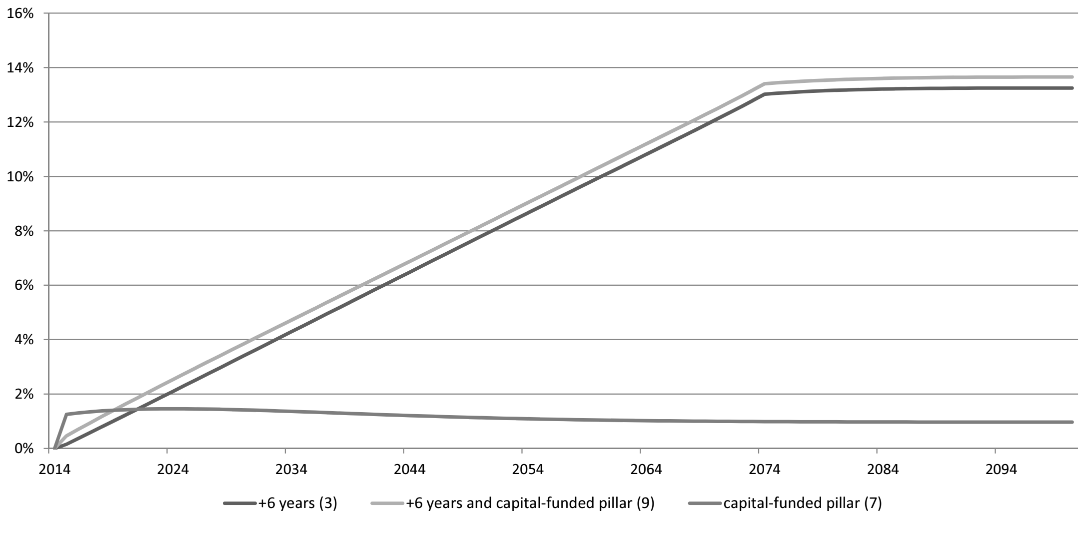
Figure 6.1: Change of foreign assets in terms of initial GDP



Note: Changes are measured versus the benchmark scenario of pure aging.

Figure 6.2 shows the relative change of GDP per capita, compared to the aging benchmark scenario. A clear conclusion is that maintaining output per capita growth in a significant fashion can only be performed with an increase in the retirement age, as the sole implementation of a capital-funded pillar hardly outperforms the result of the benchmark aging scenario. The effect takes place slowly over time, because the retirement age is only increased gradually.

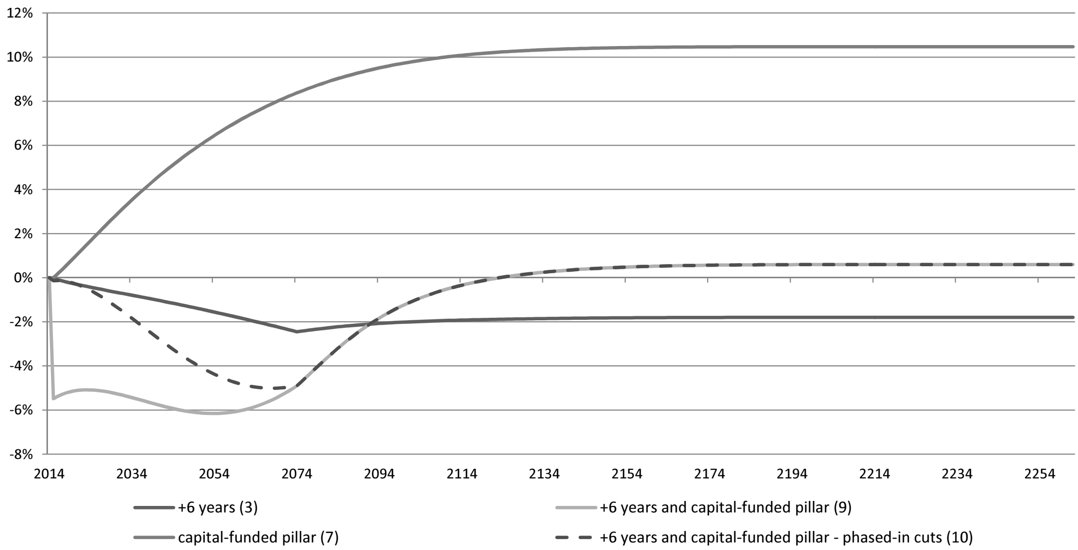
Figure 6.2: Change of GDP per capita in pp



Note: Changes are measured versus the benchmark scenario of pure aging.

Figure 6.3 displays the change in average pension benefits, compared to the aging benchmark scenario. The figure displays the same scenarios as before and an additional one, equivalent to the preferred scenario (9) but with a phased-in introduction of the pay-as-you-go pension cuts (10). Recall that pension cuts where applied from the start in scenario (9), with the aim to have the same effect on average pension benefits over the long run as the benchmark aging scenario. The first main observation is that average pension benefits drop in the first three decades in the main scenario (9), because current retirees and older workers suffer from the pay-as-you-go cuts and do not have the time to accumulate (much) savings in their capital-funded pensions, as share[30] of the 3rd pillar in figure 6.4 confirms. It is a first illustration of the transition costs of the reform. The sole introduction of the capital-funded pensions (7) also lead to a drop in average pension benefits, again as the older generations do not have the time to build up (much) their capital-funded pensions. The drop is however lower, as there is no pension cuts. Over the long-run, the average pension benefits in this scenario remain lower, since there is no increase in the retirement age (nor average pensions, through the earnings-related part). The second main observation in this figure is that the transition costs can be reduced if one uses a different schedule for the implementation of the reforms. When the pension cuts are only gradually implemented, as in scenario (10), the transition costs are lower than when they are immediately enforced, as in scenario (9). It is possible to further minimize these transition costs, if the cuts are delayed in time.

Figure 6.3: Change average pension benefits in pp



Note: Changes are measured versus the benchmark scenario of pure aging.

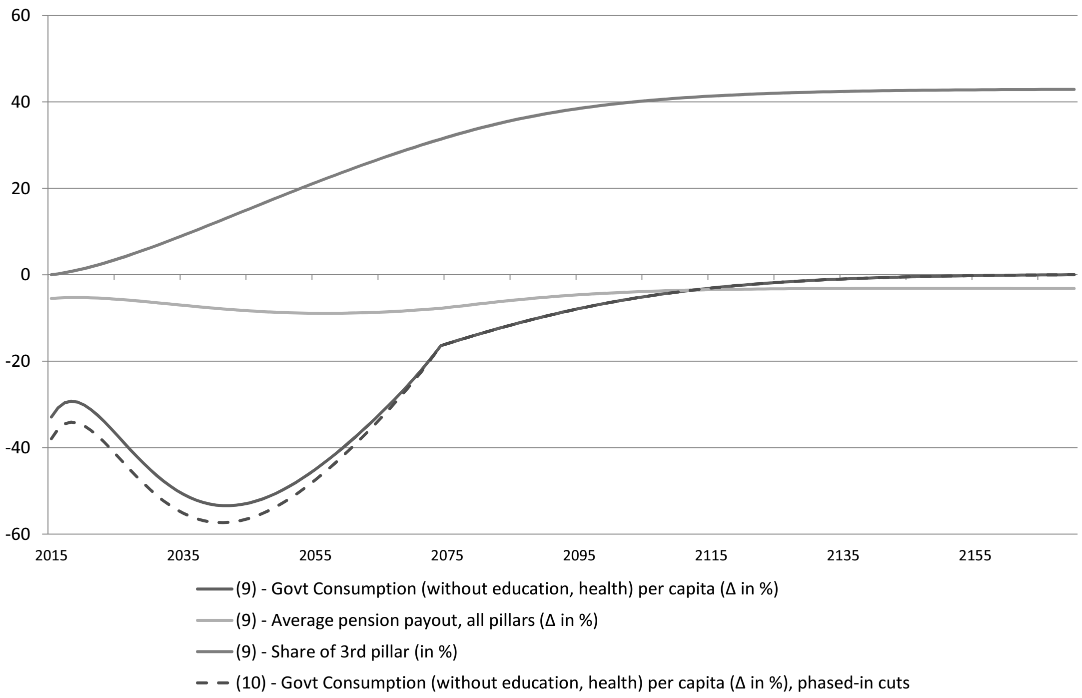
Figure 6.4 plots different variables for the preferred scenario (9) and the related scenario (10) and illustrates another dimension of transition costs, namely public finance. In this figure, all curves refer to scenario (9) with one exception. The relative constant development of average pension payouts and the gradual increase in the share of the third pillar are visible for reform (9). The third curve plotted is the budget closing instrument for the same reform (9), government consumption per capita[31]. We see that, while reform (9) is budget neutral in the long run, there are high public finance transitional costs: government consumption per capita temporarily has to

[30]The share is measured as the part of total pension payouts to the households that stems from mandatorily accumulated pension savings.

[31]Recall that it is defined exclusive of health and education costs.

drop by more than 50%. The reason for such transitional costs is the introduction of the capital-funded pillar, as contributions into this new pillar come with a decrease in the contributions in the pay-as-you-go pension pillars (see section 5.3). Because there are less contributions into these pillars but payments to current retirees are still due, the deficit of the pay-as-you-go pension system increases at the reform introduction. The drop in government consumption (the budget closing instrument) finances the deficit. Overtime, as the number of retirees with high pay-as-you-go earnings-related pension rights drop, the pay-as-you-go pension deficit decreases. The accumulated fiscal costs from 2014 up to the end of the simulation horizon, 60 years later, are about 2.6 times the GDP of 2014. Note this evaluation of the public finance cost is a conservative estimate, as a cut in government consumption is non-distortive and, at such an extent, unrealistic. Using distortive instruments instead would have negative consequences for the labor supply, the tax base and tax revenue and would therefore further increase the public finance challenge for the government. The last curve in the figure plots government consumption per capita for scenario (10). Recall that it is the same scenario (9) except that the pension cuts are gradually phased-in. As seen above, the gradual implementation of the pension cut from scenario (10) leads to lower transition costs for current generations. It comes however with a higher public finance cost, unsurprisingly, but those are limited. The consumption per capita has to drop more than in reform (9), but the drop is always less than 60%. The accumulated fiscal costs up from 2014 to the end of the simulation horizon are about 2.7 times the GDP of 2014, compared to 2.6 times in scenario (9).

Figure 6.4: Costs of transition to a partially capital-funded system, reforms (9) and (10)



7 Sensitivity analysis

We perform sensitivity analysis along two axes. The focus is the benchmark aging scenario as well as the preferred reform and its two main basis (see table 2 and section 5.4), respectively scenario (1), reforms (9), (3) and (7). The main conclusions from the sensitivity analysis can be summarized as follows:

Summary finding 3: *The impact of the reforms considered is similar qualitatively and close quantitatively when the discount factor is smaller or when the hours and participation labor supply elasticities are smaller; because of a dramatic change in saving behavior and in outcomes for discount factors larger than one, the use of such discount factors is best avoided, consistent with the literature and our calibration strategy.*

7.1 Discount factor

The main contribution of this paper is the analysis of pension reform using an additional evaluation criteria, current account imbalances. In a country which faces a constant interest rate, saving behavior plays a critical role in defining cross-border investment flows, and thus the current account. We thus perform sensitivity analysis with different values for the time discounting factor β.

In the baseline scenario, the yearly interest rate is $r = 0.025$ and the discount factor is $\beta = 0.99$, implying relative patience by households: the discount rate $\rho = (1-\beta)/\beta \approx 0.01$ is smaller than the interest rate. We consider two sensitivity cases. First, we use $\beta = 0.97$ which implies $\rho \approx 0.03 > r$, such that households are slightly impatient. Second and returning to the discussion on the calibration of the trade balance (see section 4), we set β in order to replicate the actual observed trade balance. This implies that $\beta = 1.05$ and a negative discount rate $\rho = (1-\beta)/\beta \approx -0.05$. Note that in an OLG model $\beta > 1$ is an unorthodox choice. However and in contrast to a Ramsey type model, this value can in principle still be consistent with the existence of a steady state as agents die before accumulating assets *ad infinitum*[32].

Table 3 presents the simulation results for the aging benchmark scenario and the selected reforms, all of which result in different outcomes for the baseline value of the discount factor and the two sensitivity cases. Appendix A provides details for all reforms.

The main difference between $\beta = 0.99$ and $\beta = 0.97$ already appears in the benchmark aging scenario: different β lead to different asset holdings of the households, namely +4% versus -74% of initial GDP. However, conclusions on the effect of reforms remain qualitatively identical and quantitatively close. Figure 7.1 display the net foreign asset positions for $\beta = 0.97$ and the three reforms considered, to be compared to the baseline case $\beta = 0.99$ in figure 6.1. An increase in retirement age in reform (3) reduces foreign asset holdings by around 80% ($\beta = 0.97$) instead of around 100% ($\beta = 0.99$) of initial GDP. As the effect of introducing a capital-funded pillar in reform (7) are almost identical in both cases, foreign assets are increasing about 20 pp of initial GDP more with $\beta = 0.97$ in the combined reform (9). For a lower discount factor, the policy reform approach is the same, except a smaller capital-funded pillar is required to neutralize the effect of aging and retirement age increases on foreign assets.

[32]What matters for the savings behavior is the difference between the discount rate (defined by the discount factor) and the interest rate. Sensitivity analysis on the discount factor is thus equivalent to sensitivity analysis on the capital market return rate.

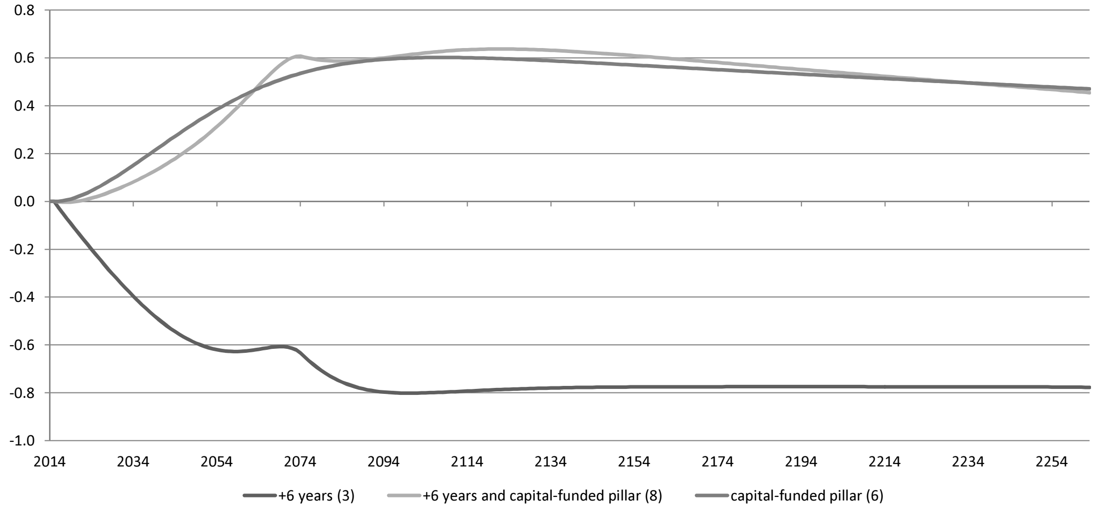
For the second sensitivity check $\beta = 1.05$ we find extreme and implausible results, net foreign assets shown in figure 7.2 deviating markedly from the baseline case $\beta = 0.99$ in figure 6.1. This finding provides an additional motivation for our calibration strategy, which ignored the trade balance currently observed and chose instead a discount factor in line with the literature ($\beta = 0.99$). The increase in retirement age in reform (3) and consequently also the combined reform (9) first lead to a decrease in foreign assets of almost 15 times the initial GDP, before increasing twice this magnitude. The pattern as well as the magnitude are implausible. Our conclusion is that for the research question at hand, a negative discount rate should simply be avoided.

Table 3: Sensitivity analysis w.r.t. discount rate - long-run results comparison

	(1)	(1)	(1)	(3)	(3)	(3)	(7)	(7)	(7)	(9)	(9)	(9)
β	0.99	0.97	1.05	0.99	0.97	1.05	0.99	0.97	1.05	0.99	0.97	1.05
Aging	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Increase in retirement				+6 years	+6 years	+6 years				+6 years	+6 years	+6 years
Pension cut										Yes	Yes	Yes
Contribution increase												
Capital-funded pillar (3rd pillar)							Yes	Yes	Yes	Yes	Yes	Yes
	FSS	FSS	FSS	FSS	FSS	FSS	FSS	FSS	FSS	FSS	FSS	FSS
Hours/capita	769	769	761	887	887	890	784	784	785	897	897	913
Labor costs (Δ%)	0.09	0.08	0.54	2.43	2.45	0.47	-1.87	-1.87	-1.86	0.55	0.58	-1.62
Pension expend./retiree (all pillars) (Δ%)	-3.86	-3.86	-0.60	-5.65	-5.65	-4.59	6.62	6.65	21.84	-3.24	-3.19	11.88
GDP/capita (Δ%)	-13.03	-13.20	-12.84	1.73	1.65	5.96	-11.97	-12.15	-10.84	2.17	2.10	7.67
Private Consumption/capita (Δ%)	-2.45	-3.92	5.18	1.70	1.12	36.36	-1.14	-2.56	9.16	0.50	-0.07	38.07
Government Consumption/capita (Δ%)	-114.83	-116.77	-160.12	-23.57	-24.20	17.51	-107.68	-109.55	-173.97	-0.14	-0.63	31.71
Pens. Exp (% of GDP)	22.23	22.28	22.94	14.95	14.96	14.52	24.36	24.41	27.49	15.27	15.29	16.76
Share 3rd pillar (% of total pensions)	0.00	0.00	0.00	0.00	0.00	0.00	26.31	26.33	23.81	42.98	43.00	38.24
SS deficit (% of GDP)	15.68	15.68	19.29	8.34	8.34	11.99	15.69	15.69	21.63	6.22	6.22	11.93
PAYG deficit (% of GDP)	9.93	9.93	12.44	3.55	3.55	5.96	8.60	8.60	13.53	-0.29	-0.29	4.32
TB (Δ absolute)	-0.11	1.02	-7.72	1.36	2.11	-27.53	-0.77	0.36	-7.94	-0.32	0.39	-28.43
D^F (Δ absolute)	8.61	-80.73	613.64	-107.81	-167.52	2187.07	61.25	-28.79	630.79	25.16	-30.78	2259.31
A (Δ absolute)	5.35	-83.72	591.77	16.98	-44.46	2438.41	-79.50	-170.51	486.62	-31.97	-90.53	2338.69
$(A + A^F)$ (Δ absolute)	5.35	-83.72	591.77	16.98	-44.46	2438.41	142.48	52.36	714.59	238.87	181.10	2617.01
V^F (Δ absolute)	-3.26	-3.00	-21.87	124.80	123.06	251.34	81.24	81.15	83.79	213.71	211.88	357.69

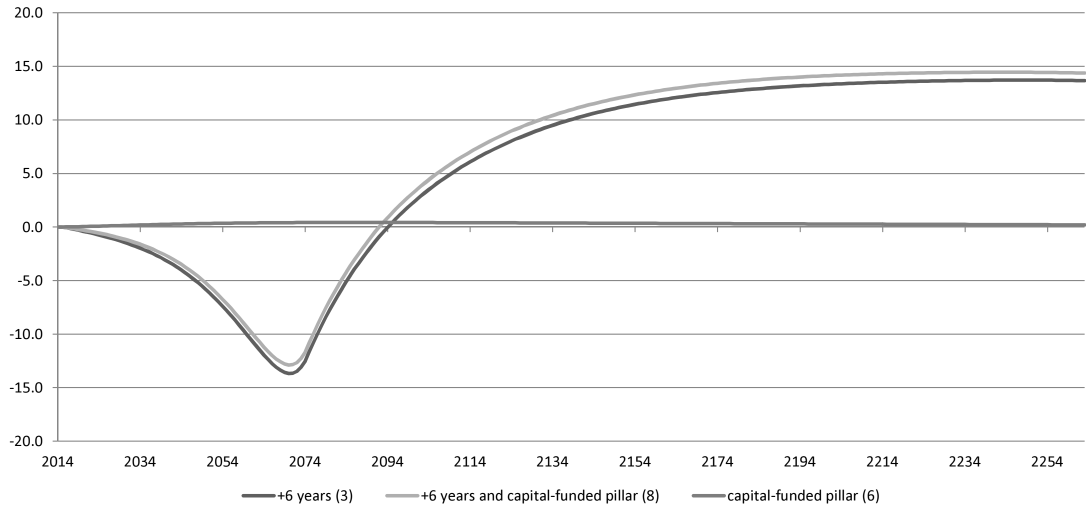
Notes: $\beta = 0.99$ corresponds to the baseline case; see also notes in table 2.

Figure 7.1: Change of foreign assets in terms of initial GDP - $\beta = 0.97$



Note: Changes are measured versus the benchmark scenario of pure aging.

Figure 7.2: Change of foreign assets in terms of initial GDP - $\beta = 1.05$



Note: Changes are measured versus the benchmark scenario of pure aging.

7.2 Labor supply elasticities

Households take two types of decisions, related to consumption and related to labor market activities. The previous section considered the first type of decisions. This section considers the second type. We compare outcomes in the baseline scenario and in a scenario where the labor elasticities for hours decisions and for participation decisions are 15% smaller than in the baseline scenario. Because labor market decisions play a smaller role than savings decisions, we only consider the selected reforms and the long-run outcomes. Table 4 provides the comparison of long-run simulations.

With a few exceptions, outcomes are nearly identical. Exceptions are related to the net foreign asset positions for reforms (3) and (9). Since reform (9) is a combination of reforms (3) and (7), the exception for reform (9) is a consequence. The net foreign asset position declines more in the sensitivity analysis case when the retirement age is increased, as in reform (3), for the following reason. The increase in retirement leads to an exogenous increase in effective labor supply, which depresses wages and per worker labor supply. Feedback counteracts the effect so that wage rates stabilize to a moderately higher value. Because wages are bargained and households are less responsive in the sensitivity analysis case, firms can initially push wages further down, so that wages and labor costs stabilize at a lower level in the sensitivity analysis case. Labor costs increase 2.3% instead of 2.4%. Labor supply per worker is thus lower in the sensitivity analysis case (at 1690 yearly hours, instead of 1691; not reported), GDP per capita grows less (1.5% instead of 1.7%). Since output is lower, consumption and savings are also lower and the country relies more on foreign assets to finance investment. Small differences accumulate over time, explaining why the net foreign asset position in the sensitivity analysis case drops nearly 170% of GDP, compared to a drop of 95%. Qualitatively however, outcomes in reforms (3) are similar. To obtain the same quantitative outcomes in reform (9) in the sensitivity analysis case, one can use the same policy reform approach except with a smaller capital-funded pillar to neutralize the effect of aging and retirement age increases on foreign assets (similar to the case of a lower β; see previous section).

Table 4: Sensitivity analysis w.r.t. labor supply elasticities - long-run results comparison

	(1)	(1)	(3)	(3)	(7)	(7)	(9)	(9)
Hours and participation elasticities (%)	100	85	100	85	100	85	100	85
Aging	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Increase in retirement			+6 years	+6 years			+6 years	+6 years
Pension cut							Yes	Yes
Contribution increase								
Capital-funded pillar (3rd pillar)					Yes	Yes	Yes	Yes
	FSS	FSS	FSS	FSS	FSS	FSS	FSS	FSS
Hours/capita	769	768	887	887	784	782	897	898
Labor costs (Δ%)	0.09	0.08	2.43	2.30	-1.87	-1.89	0.55	0.43
Pension expend./retiree (all pillars) (Δ%)	-3.86	-3.99	-5.65	-5.74	6.62	6.43	-3.24	-3.30
GDP/capita (Δ%)	-13.03	-13.16	1.73	1.53	-11.97	-12.15	2.17	1.98
Private Consumption/capita (Δ%)	-2.45	-2.57	1.70	-0.16	-1.14	-1.30	0.50	-1.33
Government Consumption/capita (Δ%)	-114.83	-115.12	-23.57	-25.73	-107.68	-108.13	-0.14	-2.31
Pens. Exp (% of GDP)	22.23	22.23	14.95	14.97	24.36	24.37	15.27	15.29
Share 3rd pillar (% of total pensions)	0.00	0.00	0.00	0.00	26.31	26.29	42.98	42.95
SS deficit (% of GDP)	15.68	15.68	8.34	8.35	15.69	15.70	6.22	6.23
PAYG deficit (% of GDP)	9.93	9.92	3.55	3.56	8.60	8.60	-0.29	-0.28
TB (Δ absolute)	-0.11	-0.14	1.36	2.45	-0.77	-0.80	-0.32	0.78
D^F (Δ absolute)	8.61	11.07	-107.81	-194.77	61.25	63.92	25.16	-61.70
A (Δ absolute)	5.35	7.13	16.98	-64.37	-79.50	-77.45	-31.97	-113.47
$(A + A^F)$ (Δ absolute)	5.35	7.13	16.98	-64.37	142.48	144.04	238.87	157.14
V^F (Δ absolute)	-3.26	-3.94	124.80	130.40	81.24	80.12	213.71	218.85

Notes: Hours and participation elasticities (%) = fraction of baseline values (100 correspond to the baseline case); see also notes in table 2.

8 Concluding remarks

As is well-known, increasing the retirement age provides the best compromise to ensure the financial sustainability of pay-as-you-go pension systems with an aging population, maintain output growth and protect against the risk of old-age poverty. Our analysis shows however that it comes at a cost, increasing dependence on foreign assets. Indeed, the need to save to finance consumption after retirement is reduced while the increase in labor supply pushes domestic investments, pushing up demand on foreign capital. In our baseline scenario with an increase of the effective retirement age to its statutory level (+ 6 years), Austria would no longer be a net creditor on the international capital market, holding foreign assets summing up to about 70% of GDP in 2013, and would become a net debtor over the long run.

We show that the introduction of a capital-funded pillar and small adjustments to the pay-as-you-go pension system would eliminate the drawback over the long-run. Specifically, with a capital-funded pillar replacing about 25% of the pay-as-you-go pension pillars, and moderate pension cuts so that the average total pension payment is the same as in a status quo case, added to the increase of the effective retirement age to its statutory level, Austria would remain a net creditor on the international capital market. The main reason is that the contributions to the capital-funded pillars are savings and can be use to satisfy domestic investment demand.

Consistent with the literature, we also find that such a reform would have costs over the short-run, in particular because the partial shift of contributions from the pay-as-you-go to the capital-funded pillars would decrease the financing of the current pay-as-you-go pension system. From a policy perspective, our analysis does not eliminate any such hurdle associated with the introduction of a pre-funded element in the pension system. However, it shows that there can be additional benefits.

A Appendix: details for different discount factors

Table 5: Long-run results - $\beta = 0.97$

		(1)	(2)	(3)	(4)	(5)	(7)	(8)	(9)
Aging		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Increase in retirement			+2 years	+6 years				+6 years	+6 years
Pension cut					Yes				Yes
Contribution increase						Yes			
Capital-funded pillar (3rd pillar)							Yes	Yes	Yes
	2013	FSS	FSS	FSS	FSS	FSS	FSS	FSS	FSS
Population (normalized)	100	112	112	112	112	112	112	112	112
Hours/capita	897	769	809	887	762	747	784	905	897
Labor costs (Δ%)		0.08	0.92	2.45	0.43	2.45	-1.87	0.29	0.58
Pension expend./retiree (all pillars) (Δ%)		-3.86	-4.29	-5.65	-15.77	-3.59	6.65	18.87	-3.19
GDP/capita (Δ%)		-13.20	-8.27	1.65	-14.05	-15.55	-12.15	3.14	2.10
Private Consumption/capita (Δ%)		-3.92	-2.46	1.12	-7.28	-8.70	-2.56	4.60	-0.07
Government Consumption/capita (Δ%)		-116.77	-86.32	-24.20	-100.04	-103.62	-109.55	-26.26	-0.63
Pens. Exp (% of GDP)	14.20	22.28	19.60	14.96	19.71	22.96	24.41	18.58	15.29
Share 3rd pillar (% of total pensions)	0.00	0.00	0.00	0.00	0.00	0.00	26.33	35.25	43.00
SS deficit (% of GDP)	3.58	15.68	13.25	8.34	13.27	13.20	15.69	9.82	6.22
PAYG deficit (% of GDP)	2.25	9.93	7.82	3.55	7.40	8.23	8.60	3.46	-0.29
TB (Δ absolute)		1.02	1.52	2.11	0.11	-0.17	0.36	1.75	0.39
D^F (Δ absolute)		-80.73	-120.74	-167.52	-8.35	13.71	-28.79	-139.13	-30.78
A (Δ absolute)		-83.72	-80.70	-44.46	-28.63	-88.87	-170.51	-181.69	-90.53
$(A + A^F)$ (Δ absolute)		-83.72	-80.70	-44.46	-28.63	-88.87	52.36	92.00	181.10
V^F (Δ absolute)		-3.00	40.04	123.06	-20.29	-102.58	81.15	231.14	211.88

Notes: Absolute deviations are expressed in terms of gross value added being normalized to 100 in 2013 and are measured versus the initial value in 2013. Gross domestic product is 112.

Table 6: Long-run results - $\beta = 1.05$

		(1)	(2)	(3)	(4)	(5)	(7)	(8)	(9)
Aging		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Increase in retirement			+2 years	+6 years				+6 years	+6 years
Pension cut					Yes				Yes
Contribution increase						Yes			
Capital-funded pillar (3rd pillar)							Yes	Yes	Yes
	2013	FSS	FSS	FSS	FSS	FSS	FSS	FSS	FSS
Population (normalized)	100	112	112	112	112	112	112	112	112
Hours/capita	897	761	802	890	759	736	785	915	913
Labor costs (Δ%)		0.54	1.29	0.47	0.65	3.12	-1.86	-1.69	-1.62
Pension expend./retiree (all pillars) (Δ%)		-0.60	-1.66	-4.59	-4.24	-0.53	21.84	31.83	11.88
GDP/capita (Δ%)		-12.84	-7.77	5.96	-13.12	-15.44	-10.84	8.11	7.67
Private Consumption/capita (Δ%)		5.18	6.30	36.36	4.28	0.98	9.16	41.59	38.07
Government Consumption/capita (Δ%)		-160.12	-115.81	17.51	-152.60	-140.23	-173.97	-5.37	31.71
Pens. Exp (% of GDP)	14.20	22.94	20.03	14.52	22.17	23.66	27.49	19.67	16.76
Share 3rd pillar (% of total pensions)	0.00	0.00	0.00	0.00	0.00	0.00	23.81	32.52	38.24
SS deficit (% of GDP)	6.48	19.29	16.82	11.99	18.55	16.76	21.63	15.30	11.93
PAYG deficit (% of GDP)	4.07	12.44	10.25	5.96	11.67	10.66	13.53	7.78	4.32
TB (Δ absolute)		-7.72	-7.15	-27.53	-7.88	-8.50	-7.94	-27.89	-28.43
D^F (Δ absolute)		613.64	568.52	2187.07	626.35	675.49	630.79	2216.27	2259.31
A (Δ absolute)		591.77	597.02	2438.41	598.89	546.60	486.62	2300.08	2338.69
$(A + A^F)$ (Δ absolute)		591.77	597.02	2438.41	598.89	546.60	714.59	2579.02	2617.01
V^F (Δ absolute)		-21.87	28.51	251.34	-27.46	-128.90	83.79	362.75	357.69

Notes: Absolute deviations are expressed in terms of gross value added being normalized to 100 in 2013 and are measured versus the initial value in 2013. Gross domestic product is 112.

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