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ABSTRACT

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Aging and International Capital Flows[1]

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Abstract: *Throughout the world, population aging is a major challenge that will continue well into the 21st century. While the patterns of the demographic transition are similar in most countries, timing differs substantially, in particular between industrialized and less developed countries. To the extent that capital is internationally mobile, population aging will therefore induce capital flows between countries. In order to quantify these international capital flows, we employ a multi-country overlapping generations model and combine it with long-term demographic projections for several world regions over a 50 year horizon. Our simulations suggest that capital flows from fast-aging industrial countries (such as Germany and Italy) to the rest of the world will be substantial. Closed-economy models of pension reform are likely to miss quantitatively important effects of international capital mobility.*

Keywords: *aging; capital mobility; pension reform*
JEL classification: *E27; F21; G15; H55; J11*

1. Introduction

In the vast majority of countries, populations are aging, and demographic change will continue well into the 21st century. While the patterns of population aging are similar in most countries, timing differs substantially, in particular between industrialized and less developed countries. It is well known that within each country, demographic change alters the time path of aggregate savings, even more so in countries where fundamental pension reforms – that is, a shift towards more pre-funding – are implemented (Börsch-Supan 1995a and b; Reisen, 2000). To the

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extent that capital is internationally mobile, population aging will also induce capital flows between countries.

In this paper, we present a quantitative analysis of the capital flows induced by differential aging processes across countries and by pension reforms. We develop a stylized multi-country overlapping generations model which is, to our knowledge, new to the literature, and we use long-term demographic projections for different sets of countries to project international capital flows over a 50 year horizon. For tractability, we focus on Germany as a country with one of the most severe aging problems in the world and with a public pay-as-you-go (PAYG) pension system in an ongoing reform process (e.g., Birg and Börsch-Supan, 1999; Börsch-Supan, 2000). We expect results for countries such as France and Italy to be very similar in patterns and quantity – Italy is a bit smaller than Germany but ages more, while France most likely will see less capital flows since the French aging process is less dramatic. To separate the direct effect of population aging on capital markets and potential feedback effects from pension reform, we present our projections for both two counterfactual scenarios: (a) maintaining Germany's current generous pension system, and (b) introducing a one-third transition to a funded pension system as described by Börsch-Supan (2000). The most likely development will be in between these two scenarios.

Our simulations predict substantial capital flows due to population aging. Our results confirm that population aging results, at least initially, in a higher capital stock, but when the baby boom generations begin to consume their retirement savings, the capital stock will decrease. International capital flows follow this trend. At the peak of savings around the year 2020, German capital exports to all other OECD countries will exceed 7% of GNP. Most of the capital flows will actually stay within the EU. 15 years later, capital flows will briefly decline to 2% but remain positive through the aging process.

Moreover, our simulations show that a transition to a partially funded system does not crowd out existing savings totally. Capital exports from Germany to the OECD countries – again, mainly to EU-countries – will be higher in this case, never falling below 2% after a peak of about 9% in the year 2020. The decrease in the rate of return, which results from both population aging and pre-funded pensions, is modest, approximately one percentage point if we assume a closed economy. The return on capital can be improved substantially by international diversification, that is, by investing pension savings in countries with a more favorable demographic transition path than Germany.

The effects of international diversification on savings behavior and its interaction with pension reforms receive rapidly increasing attention as the pension reform debate progresses. Deardorff (1985) contains an early analysis, and Reisen (2000) provides a comprehensive overview of these issues. Reisen argues strongly that there are pension-improving benefits of global asset diversification. In a theoretical paper, Pemberton (1999) highlights the importance of international

externalities caused by the effects of national pension and savings policies on the world interest rate. More recently, Pemberton (2000) goes a step further and shows that – while the switch from a pay-as-you-go system to a fully funded pension system implies that (at least) one generation necessarily loses – in a world where pension reform takes place in many small, open economies, an intergenerational Pareto improvement is possible (for some production technologies). Pemberton supports this finding by numerical simulations of a stylized model for the OECD countries. However, Pemberton's extremely stylized overlapping generations model cannot account for realistic paths of demographic change within different regions. Our model represents a significant improvement in the direction of a more realistic quantitative projection.

The remainder of this paper is structured as follows. Section 2 presents some facts – empirical evidence and theoretical explanations – for the effects of population aging on international capital flows. In section 3, we present a stylized overlapping generations model that can be used to evaluate these effects quantitatively. Section 4 contains our simulation results for two different pension policies and three different capital mobility scenarios. Section 5 concludes.

2. Some facts about population aging and international capital flows

At mid-1998, world population stood at 5.9 billion. While the world population has constantly grown, its annual growth rate has decreased from 2.04 percent during the period from 1965 to 1970 to 1.33 percent between 1995 and 2000. It is expected that this decrease in world population growth will continue. In the medium variant of the United Nations' current world population projections, the growth rate is projected to decrease to 0.3 percent by 2050. By then, world population will have increased to 8.9 billion. 97 percent of this increase takes place in less developed regions (United Nations, 2000).

These demographic changes – the so-called *demographic transition* (e.g., Birg, 1996) – are characterized by falling mortality rates followed by a decline in birth rates, resulting in population aging. While the patterns of population aging are similar in most countries, timing differs substantially, in particular between industrialized and less developed countries. Europe has almost passed the closing stages of the demographic transition process. It is now, and is projected to remain, the geographic region that is most affected by aging. By 2005, population growth is projected to be negative in Europe. The median age in Europe is projected to increase from 37.1 years in 1998 to about 47 years by 2050. The proportion of children is projected to decline from 18 percent to 14 percent while the fraction of older persons will increase from 20 percent to 35 percent by 2050. Other regions

of the world that are substantially affected by aging are Northern America, Oceania, Asia, Latin America and the Caribbean (United Nations, 2000).

Asia and Latin America are only at the beginning stages of the demographic transition. So far, characteristics of a demographic transition process cannot be identified in Africa – fertility is at the highest level worldwide, and even though child mortality is declining, life expectancy is still very low (Bloom and Williamson, 1998). The impact of AIDS is devastating: in a group of 29 African countries where the impact of AIDS has been studied by the United Nations, life expectancy is projected to decrease by seven years in the near future (United Nations, 2000).

The impact of population aging can be expressed in the old-age dependency ratio, defined as the ratio of the number of pensioners to the number of workers. In Germany, this ratio will increase from about 60 percent in 2000 to 90 percent in 2050, according to Birg and Börsch-Supan (1999).[2] Analogous calculations for the rest the European Union show an increase in the old-age dependency ratio from currently 45 percent to 60 percent in 2050 (Ludwig, 2001). The consequences of these increases are well-known and mirrored by the current debate on privatizing social security (e.g. Börsch-Supan and Brugiavini, 2001).

From a macroeconomic point of view, population aging will change the balance between capital and labor, in particular in industrialized countries. Labor supply will be scarce whereas capital will be relatively abundant. This will drive up wages relative to the rate of return on capital, reducing households' incentive to save (if the interest elasticity of saving is positive). In addition, some fraction of the capital stock may become obsolete due to the shrinking labor force and diminishing returns to scale, making the accumulation of capital even less attractive. Developing countries are less affected since their population age structure is younger; these countries are better characterized by a relatively low supply of capital and a relatively high supply of labor. As a result, the rate of return on capital is higher in developing countries. Capital exports to developing countries could therefore solve the aging problems of industrialized countries by reducing the pressure on the interest rate and by shifting the production of consumption goods towards developing countries.

More generally, differences in timing of demographic change across countries and regions induce international capital flows, and there is some empirical evidence that this mechanism is already at work (e.g., Higgins, 1998; Lührmann, 2001). Private net capital flows have increased remarkably during the past ten years. In 1996, the volume of these flows was six times higher than at the beginning of the nineties. Private capital flows make up for around 80 percent of total world capital flows and clearly dominate public capital flows. 40 percent of private capital

[2] These projections are for a medium scenario of demographic change, characterized by modest aging, constant fertility and a modest increase in labor force participation rates.

flows is foreign direct investment, another 40 percent is portfolio investment and around 20 percent is banking credits (which are becoming less and less important). Due to the increasing role of institutional investors such as pension funds, the share of portfolio investment is likely to increase in future (World Bank, 1997).

In a recent empirical study, Lührmann (2001) uses a broad panel of 141 countries that covers the period 1960-95 to investigate the effects of demographics on national saving and capital formation, and on international capital flows. She confirms that cross-country capital flows are indeed influenced by demographic variables. While this has been shown in other studies before, she can also show that across countries, relative differences in the age structure are the most important determinants of capital flows, a finding that is even more important for the analysis of pension reform than the fact that the absolute age structure affects a country's capital balance. Moreover, as Lührmann (2001) shows, future changes in the age structure of countries are important determinants of current savings and investment decisions, a finding that confirms forward looking household behavior.

There are a number of theoretical arguments that establish a link between demographic change and international capital flows. The simulation model we present in this paper builds on the well-known life-cycle theory of consumption and savings by Modigliani, Ando and Brumberg (Modigliani and Brumberg, 1954; Ando and Modigliani, 1963). The aggregation of individual, cohort-specific life-cycle savings profiles leads to a decrease of national saving rates in an aging economy. Moreover, in a general equilibrium model of forward looking individuals, it is not only the current demographic structure that alters the time path of aggregate savings, but also future demographic developments. Empirical evidence on how demographic change has affected savings behavior across countries in the past is reviewed by Poterba (1998) and Brooks (2000).

In a general-equilibrium framework, there are two main channels for effects of demographic change on domestic capital formation. First, decreasing labor supply reduces demand for investment goods since less capital is needed. The magnitude of this effect depends on the elasticity of substitution between the production factors capital and labor. Börsch-Supan (1995a) estimates a CES production function and concludes that the elasticity of substitution between these two factors is close to one. This result indicates that production can be adjusted quite flexibly which reduces the impact of demographic change on investment. Second, in a closed economy, a decline in national saving leads to a decline in investment by definition. In an open economy, the link between these two aggregates is broken to the extent that capital is internationally mobile.

For quantitative projections of international capital flows induced by population aging, the degree of capital mobility is crucial. This is essentially an empirical question, and there has been no shortage of research on this isseue since the

famous puzzle of Feldstein and Horioka (1980).[3] In their original contribution, Feldstein and Horioka have shown that national saving rates are highly correlated among OECD countries. While the coefficient has fallen over time, it is still remarkably high. These findings have been interpreted as an indication that capital is imperfectly mobile. However, this interpretation has later been criticized both because there are a number of alternative explanations for the observed correlation (a recent example is Obstfeld and Rogoff, 2000, who focus on transport costs for goods) and because of econometric problems associated with simply regressing national saving rates on domestic investment rates (see for example Taylor, 1994). Even if capital is fully mobile, this does not necessarily imply that households do actually diversify their portfolios optimally. There is a large empirical literature on 'home bias' in international portfolio choice (e.g., French and Poterba, 1991), and it is not yet fully understood why households do not optimally diversify their portfolios across countries. A recent empirical study by Portes and Rey (1999) suggests that information asymmetries across countries are a major source of home bias effects, and that capital flows are affected by both geographic and informational proximity. Applied to pension reform policies, this literature suggests that households might be more willing to invest their retirement savings in 'similar' countries such as the EU or OECD countries than in, say, developing countries. Unfortunately, the latter are the countries where not only the highest returns are to be found over much of the next century, but which would also benefit themselves most from capital provided by the aging industrialized nations. Blommestein (1998) and Holzmann (2000) discuss theses issues, both concluding that investments in emerging markets can help to solve the OECD countries' pension crisis at the margin, but are unable to solve the demographic problem alone, and stressing that additional reforms are needed. Our simulations will shed more light on the role of capital flows to developing countries.

In most of our simulations, we assume that capital is freely mobile only within industrialized countries. This contrasts with Fougere and Merette (1999) and Miles (1999) who state that modeling European countries as closed economies in general equilibrium models is closer to reality than modeling them as open economies. Certainly, the truth is somewhere in the middle, but we believe that allowing for free capital mobility in a multi-country model is a better approximation to reality and warranted by the empirical evidence – at least when we restrict our model to perfect capital mobility in the OECD area.

[3] See Obstfeld (1995), Obstfeld and Rogoff (1996), and Coakley, Kulasi, and Smith (1998) for recent surveys.

3. Aging and pension reform in a stylized overlapping generations model

In this section, we present a dynamic macroeconomic model that allows us to analyze the effects of population aging and of a shift from a pay-as-you-go system to a (partially) funded pension system. The model is based on a version of the overlapping generations model (Samuelson, 1958; Diamond, 1965) introduced by Auerbach and Kotlikoff (1987, chapter 3). Overlapping generations models have been used extensively to study the effects of population aging on social security systems, a purpose for which they are well suited since they are based on households' and firms' optimal reactions to movements in the demographic structure and public policy measures. Recent examples include Kotlikoff, Smetters and Walliser (1999) and De Nardi *et al.* (1999) for the United States, Miles (1999) for Great Britain, and Fehr (2000) and Börsch-Supan, Heiss and Winter (2000) for Germany. Miles and Iben (1999) present a comparative analysis of pension reform schemes for the United Kingdom and Germany. Kotlikoff (1998) provides an overview of earlier applications of overlapping generations models.

To our knowledge, the multi-country version of the Auerbach-Kotlikoff model presented in this paper is new to the literature.[4] Our model builds on a closed economy model for Germany developed by Börsch-Supan, Heiss and Winter (2000). In particular, we extend their model along three dimensions: (i) we consider several countries with differential aging processes and assume perfect capital mobility between different regions; (ii) we implement technological progress; and (iii) we explicitly model variations of the planning horizon of different generations that are due to increasing life expectancy.[5]

Since the purpose of this paper is to study the macroeconomic effects of population aging and of a fundamental pension reform, we restrict the analysis to a very stylized version of the standard overlapping generations model that excludes many interesting aspects. However, we take great care to get the first-order effects of demographic change right by using 75 cohorts and annual demographic projections. In our simulations, we use two data sources for the demographic projections: Birg and Börsch-Supan (1999) provide several demographic projections for Germany; we use the medium scenario (characterized by modest aging, constant fertility and a modest increase in labor force participation rates). For the other world regions, we use the medium variant of the United Nations' World Development Prospects (United Nations, 2000). Based on these demographic projections, we compute time paths for the number of workers and

[4] A formal description of the model presented in this paper can be found in Ludwig (2001).

[5] Börsch-Supan, Heiss and Winter (2000) made the simplifying assumption of a constant planning horizon and implemented changes in life expectancy by weighting cohort sizes accordingly.

pensioners for each of the countries and world regions in our model. These projections are described in detail by Ludwig (2001).

The most significant simplifications of our model relative to existing overlapping generations models are as follows. (i) We do not explicitly consider taxes (other than the contributions to the pay-as-you-go pension system). (ii) We do not include labor supply in the households' decision problem, but rather assume that all households supply one unit of labor until retirement.[6] (iii) We do not model intra-generational household heterogeneity and therefore cannot capture distributional effects. (iv) We assume perfect foresight. (v) The only factors of production are labor and real capital (i.e., we do not model human capital and therefore cannot account for endogenous growth). While these issues surely are important, especially if one wishes to analyze the effect of population aging on labor supply in the presence of distorting taxes, we restrict our attention to households' life-cycle savings decisions as their primary means to prepare for demographic change and decreasing generosity of public pensions.

The rationality of our agents – exemplified in their perfect foresight and their life-long planning horizon – is typical for economic models but also one of their main limitations. We are certainly aware that real-life saving and investment decisions at the micro level reveal many behavioral "anomalies". It is less clear, however, in how far these anomalies affect aggregate behavior of an economy. We have some confidence that our stylized model is sufficient to obtain the first-order effects of population aging on domestic capital formation and international capital flows. This view is substantiated, for instance, by the results of Börsch-Supan (1995a) who uses a similar "ultra rational" model to fit economic growth, saving and investment retrospectively for the 1960-1989 period and achieves a very satisfactory fit.

To keep the analysis tractable, our model focuses on Germany. We consider both the closed-economy case and alternative open-economy scenarios; the latter are different with respect to the regions within which capital can flow freely (within the EU, within the OECD, or across the whole world).

Our simulation model carries 75 overlapping cohorts. The economic life of a cohort begins at the age of twenty years and ends at a retirement age at which the model persons stop to work, stop to pay pension taxes, and begin to collect pension benefits from a pay-as-you-go system. We employ a flexible retirement pattern through age and time-specific weights that represent the fraction of the population that is retired. This fraction increases from 0 to 1 over an extended retirement window from age 47 through 80. The time paths of these weights are cohort-specific, reflecting shifts in labor supply and retirement behavior.

[6] However, we account for unemployment and labor force participation decisions since the aggregate workforce is adjusted according to the labor market scenarios behind the demographic projections.

Similarly, the life expectancy of each cohort is matched with the demographic projections.

The pension system of each country enters the model through a fixed time path of the contribution rate, calculated from an exogenously given time specific replacement rate, defined as the ratio of the average net pension to the average net wage, by balancing the budget of the public pension system.

As a pension reform scheme for Germany, we use the 'freezing' reform proposal by Birg and Börsch-Supan (1999) and Börsch-Supan (2000) but we should point out that the same mechanisms are at work in any scheme that involves the introduction of a funded component. The 'freezing' reform scheme assumes that the contribution rate to the pay-as-you-go pension system remains fixed – for Germany, at its current level of 21 percent. More specifically, we assume that the pension reform is publicly announced in the year 2001, and implemented by fixing the contribution rate in 2006. Thus, households that started their economic live before 2001 have a period of five years to adopt their life-time plans, while households that enter economic live after 2001 already face the new conditions. Since the pay-as-you-go pension system remains in place, freezing contribution rates results in lower public pension payments, given a rising old-age dependency ratio. This, in turn, results in lower replacement rates provided by the pay-as-you-go pillar of the pension system.

We do not explicitly model the funded component of the pension system. In our model, the funded component consists entirely of voluntary, private savings, as given by households' optimal life-cycle decisions. The rationality of our households implies that these voluntary savings increase exactly in proportion to the decrease of the pay-as-you-go pension replacement rate.

General equilibrium in this overlapping generations model is constructed via the production sector where, given factor inputs (capital and labor), output and factor prices are determined by a Cobb-Douglas production function with an exogenous growth rate of labor productivity that is constant for all countries and across time.[7] From static profit maximization, we obtain the interest rate which is identical for all countries due to our assumption of perfect capital mobility. In turn, the wage rate can be different since labor productivity might differ across countries.

In order to determine aggregate consumption, we derive optimal household behavior from intertemporal utility maximization. Departing from a utility function with constant relative risk aversion, we compute the optimal path of saving and consumption. As in any life-cycle model, the trade-off between consuming today and consuming tomorrow is determined by the ratio of the interest rate and the time preference rate, and by the degree of risk aversion.

[7] This implies that we abstract from any direct impact of demographic change on productivity; see Cutler et al. (1990) for a discussion.

Since factor prices (i.e., wage and interest rates) and both contribution rates to, and replacement rates of, the pay-as-you-go pension system are known, we can now determine the life-time consumption paths of all generations backwards, starting with zero wealth in the final period of life, and then iterating using the Euler equation and the budget constraint. The resulting time paths of consumption determine aggregate saving and wealth in the household sector for each country. This yields total world wealth holdings as the sum of the wealth of all regions, which in turn is equal to the world capital stock.

We carefully distinguish between the real capital located in each country, which might be owned by natives as well as foreigners, and the wealth owned by each country's inhabitants, which might be invested both domestically and abroad. The difference between total wealth of a country's inhabitants and the capital stock located within this country's borders is foreign assets. Note that we assume that labor is not mobile, and therefore the only income from abroad is asset income.

Equilibrium of the model requires that the sum of all foreign assets across all countries is zero. It is computed numerically using a Gauss-Seidel algorithm (see Auerbach and Kotlikoff, 1987). Because we lack appropriate historical data on some exogenous variables, we start calculations in 1997, which we will further refer to as the base year of our calculations. This implies that we implicitly assume that the economy is in a steady state in 1997. The final steady state is reached after 150 years when all the transitions in our model have settled. Below, we will report results only for the time period between 2000 and 2050 (even though the underlying simulations have a much longer horizon).

The parameter values used in the calibration of our model are as follows. The output share of capital in the production function (0.4099) is based on an estimation of the aggregate production function by Börsch-Supan (1995a). The annual rate of depreciation is 5 percent according to German national accounts. We further assume an annual growth rate of labor productivity of 1.4 percent.[8] Base year values of asset holdings are inferred from actual GDP data and inverting the production function. This implies that the initial weight of each country in our simulations is determined by its relative share in current world GDP. The households' preference parameters (the rate of time preference equals 8 percent, the coefficient of relative risk aversion equals 3) are chosen such that the calculations of the model match the empirical counterparts of the base year's aggregate households saving rate and net aggregate capital stock.

It is not easy to fit such a simplified model to historical data. In our model, the common conceptual difficulties of calibrating macroeconomic models is amplified by the fact that the 'world' we model changes with the number of regions that we consider in our capital mobility scenarios. On one hand, it would therefore make sense to adjust the calibration parameters each time we change the number of

[8] See e.g. Maddison (1987) and Cutler et al. (1990).

regions that we consider. On the other hand, this would change households reactions to changes in policy and it would therefore be more difficult to interpret our results with respect to a reform of the public pension system. For that reason we keep the parameters values constant across the capital mobility scenarios. As a base scenario for calibration, we assume perfect capital mobility within the European Union. It turned out that the saving rate deviates only marginally from the observed saving rate when we extend the capital mobility region to the OECD using the same parameters, but the deviation is larger when we apply these parameters to the closed economy case. We interpret this finding as a confirmation of our earlier statement that perfect capital mobility within the EU or the OECD is a better approximation to reality then modeling Germany as a closed economy.

While our model is capable of matching the empirical counterpart of Germany's net capital stock in our base year, the calculated rate of return to capital is well above our target value of 7.5 per cent.[9] For a better interpretation of our results, we normalize the following values of the rate of return to capital to 7.5 per cent in 2000. We carried out an extensive sensitivity analysis with respect to the values of households' preference parameters and the annual growth rate of labor force productivity which confirmed that the findings reported below do not change qualitatively under alternative parameter values; detailed results are available upon request.

4. Simulation results for alternative pension and capital mobility scenarios

We now present the results of our macroeconomic simulation model. For tractability, we focus on Germany as a country with one of the most severe aging problems in the world and with a pension system in an ongoing reform process (e.g. Birg and Börsch-Supan, 1999; Börsch-Supan, 2000). We expect results for countries such as France and Italy to be very similar in patterns and quantity – Italy is a bit smaller than Germany but ages more while France most likely will see less capital flows since the French aging process is less dramatic.

To separate the direct effect of population aging on capital markets and potential feedback effects from pension reform, we present our projections for both two pension policy scenarios: (a) maintaining Germany's current generous pension system, and (b) introducing a one-third transition to a funded pension system as

[9] For the twenty years between 1974 and 1993, the annualized aggregate rate of return to capital was 9.1 percent in the United States and 7.4 (7.1) percent in Germany (Japan) (McKinsey Global Institute, 1996; Börsch-Supan, 1999). We therefore define a rate of return of 7.5 percent as the target value for calibration. This is also in the range of reasonable values as suggested by Pemberton (1999).

described by Börsch-Supan (2000). These are two extreme cases, and they are both counterfactual: The current system is politically unsustainable and cannot survive, while the German pension reform that was passed in February 2001 is by no means as fundamental as the one we consider in our simulations. So the most likely scenario for Germany's future pension system is somewhere between our extreme scenarios. However, by comparing two polar scenarios, we can show that a good portion of the capital market effects of population aging arise even without a fundamental pension reform. Hence, all figures have two panels: In panel (a), the forces of population aging are shown under the assumption that the current pay-as-you-go pension systems stay as they are. In panel (b), we always show the *differential* effect if Germany implements a fundamental pension reform of the "freezing" type as lined out in the earlier sections.

In addition to our pension policy scenarios, we consider three alternative capital mobility scenarios: investment only within Germany (the closed-economy case), investment in the EU countries, and investment in the OECD countries. There are two reasons for choosing these rather modest capital mobility scenarios: first, as already noted in section 2, there is a broad consensus that capital is quite mobile among OECD countries while this is much less clear for developing countries. Second, as we will show below, beneficial effects of capital mobility do already show up when capital is freely mobile among countries of the European Union, and including more countries does not change our results substantially. Finally, while we initially assume that a fundamental pension reform is implemented only in Germany, we end this section with a brief analysis of simultaneous pension reforms in other countries of the world.

4.1 Savings and capital stock

We begin with looking at aggregate savings rates. Figure 1 shows that projected aggregate savings rates under a fundamental pension reform would be substantially higher than under the present system. For example, in the year 2035, when the peak of the aging problem occurs, savings rates are projected to be very low under the current pay-as-you-go system. Depending on the capital mobility scenario, the aggregate savings rate declines from currently around 12.1 percent (1998) to between 8.3 and 8.8 percent. This is the pure effect of population aging in the current system. In contrast, under a fundamental pension reform, the aggregate saving rate settles at around 10.4 percent under the assumption of perfect capital mobility within the EU. These projections show that optimal life-cycle behavior generates additional saving under a fundamental pension reform – in our model, it is not the case that additional retirement saving induced by a pension reform crowds out other saving totally, as often claimed. Our projections indicate a substitution of about one third, leaving two thirds to new saving. Note that all variations of the aggregate saving rate shown in Figure 1 are in the range of historical variations in German saving rates.

Figure 1: Projections of the German aggregate saving rate under alternative pension systems and capital mobility scenarios.

Figure 1a: Current pension systems

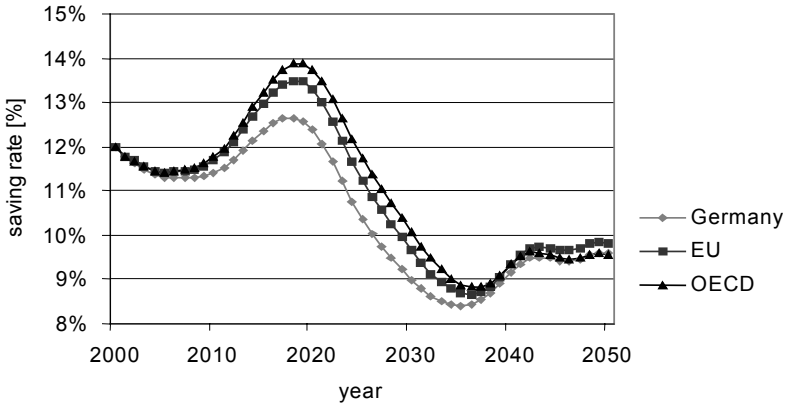
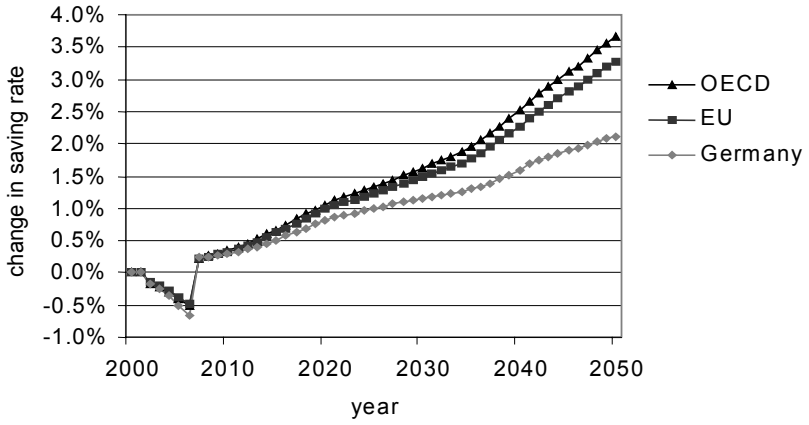


Figure 1b: Fundamental pension reform



Notes: This figure shows projections of the aggregate saving rate of German households as a percentage of GNP. Pension reform only in Germany. Germany: Germany as a closed economy, EU: perfect capital mobility in the EU area, OECD: perfect capital mobility in the OECD area.
Source: Own calculations, based on demographic projections by Birg and Börsch-Supan (1999) and the United Nations (2000).

Figure 1b shows the difference in the savings rate, in percentage points, that is due to a fundamental pension reform. One important result is that considerable adjustments occur both when a pension reform is announced and when it is implemented. These adjustments reflect rational behavior of households who react instantaneously to changes in their economic environment (and a fundamental pension reform is of course a major change). The first adjustment occurs in 2002, in the year after the announcement of the pension reform, the second in 2007, in the year after the reform itself. This latter adjustment is an upward jump, as expected, since the pension reform induces additional private savings. The reason for the first adjustment, a decrease in savings after the announcement of the fundamental pension reform, is that we aggregate across households which react very differently to this announcement. Such a reform induces additional retirement savings for all households. But contrary to older households, young households have the prospect of higher net wages after the reform is implemented. This future income effect dominates, and younger households therefore decrease savings during the period from 2002 to 2006. In aggregation, the weight of these young households is higher than the weight of older households which have less time to exploit higher net wages, or are already dissaving.

Next, we aggregate savings to obtain Germany's foreign position and capital stock. Figure 2a shows projections of the total capital stock under the current pension system. A first observation is that movements in the aggregate capital stock are by far less pronounced in the open economy. These movements are caused by the alternating dominance of demographic effects and of growth in labor productivity. The economy gradually accumulates capital until the peak of the aging process is reached in 2030. After 2030, when the aging process has almost reached its peak, the capital stock decreases. In the open economy scenarios, this decrease in the domestic German capital stock is by far less pronounced. The German capital stock increases to about 114 or 109 percent of its current value if capital is freely mobile within the EU or within the OECD, respectively, compared to 128 percent if Germany is assumed to be a closed economy. Under a fundamental pension reform, the decrease in the capital stock in the closed economy scenario, caused by aging, is less pronounced since more capital is accumulated as a result of the pension reform (figure 2b). The increase of the aggregate capital stock is now higher than in both open economy scenarios. This result confirms that under a pension reform, relatively more capital is invested abroad.

Finally, under a fundamental pension reform, there is a small downward blip in the aggregate German capital stock between 2000 and 2010 (figure 2b). This blip results from a complicated interaction between the adjustments made by different cohorts during the announcement and implementation phase of a fundamental pension reform: As discussed above, dissaving of younger cohorts dominates for a brief period. This effect carries through into all figures shown below, where similar blips can be found.

Figure 2: Projections of the aggregate German capital stock under alternative pension systems and capital mobility scenarios (Index, 2000=100)

Figure 2a: Current pension systems

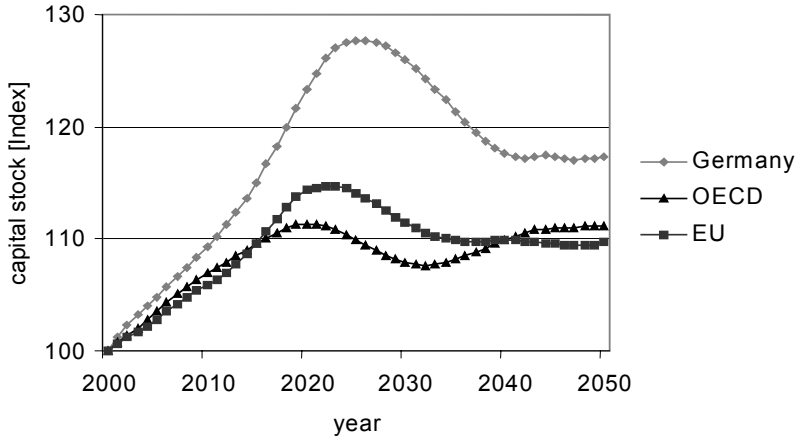
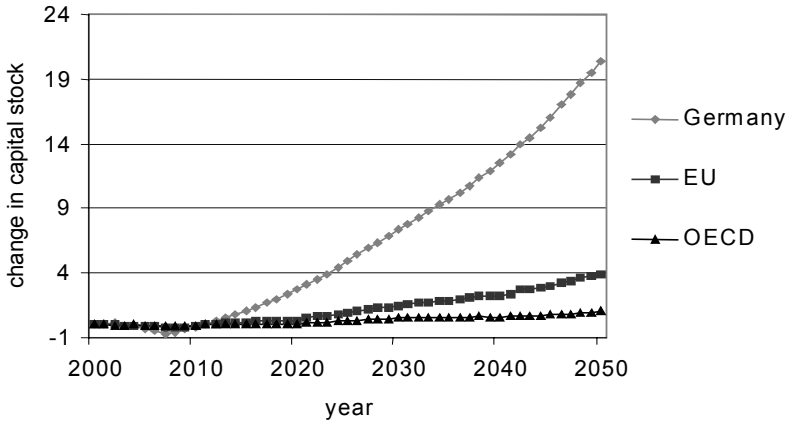


Figure 2b: Fundamental pension reform



Notes: This figure shows projections of the aggregate German Capital stock. Pension reform only in Germany. Germany: Germany as a closed economy, EU: perfect capital mobility in the EU area, OECD: perfect capital mobility in the OECD area. *Source:* Own calculations, based on demographic projections by Birg and Börsch-Supan (1999) and the United Nations (2000).

Figure 3: Projections of the aggregate German foreign assets under alternative pension systems and capital mobility scenarios (Index, 2000=100)

Figure 3a: Current pension systems

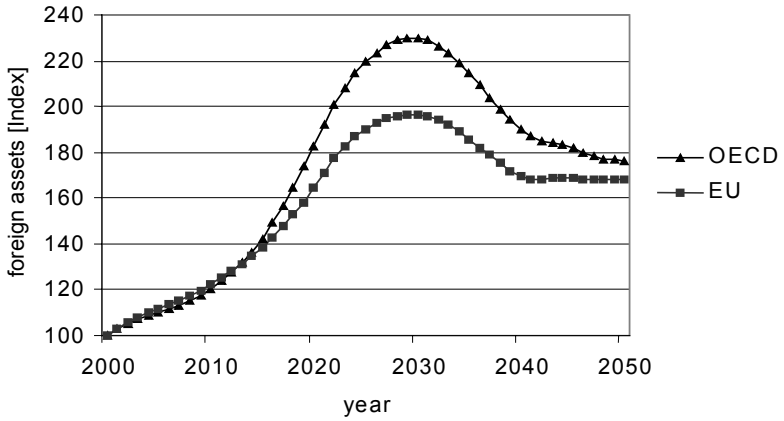
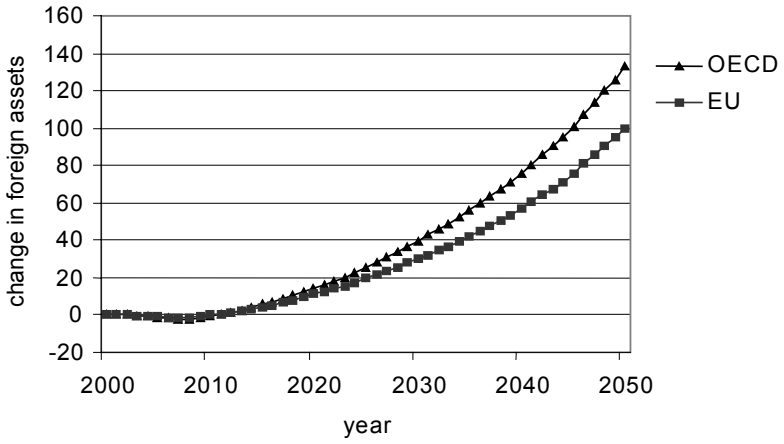


Figure 3b: Fundamental pension reform



Notes: This figure shows projections of the aggregate German foreign assets. Pension reform only in Germany. Germany: Germany as a closed economy, EU: perfect capital mobility in the EU area, OECD: perfect capital mobility in the OECD area. *Source:* Own calculations, based on demographic projections by Birg and Börsch-Supan (1999) and the United Nations (2000).

Figure 4: Projections of German net capital exports under alternative pension systems and capital mobility scenarios

Figure 4a: Current pension systems

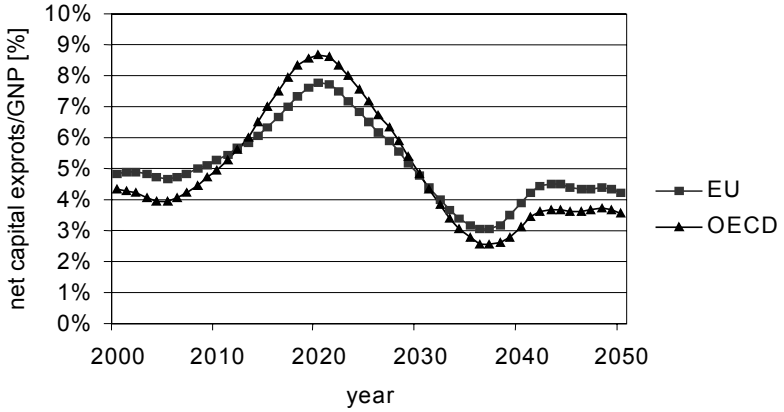
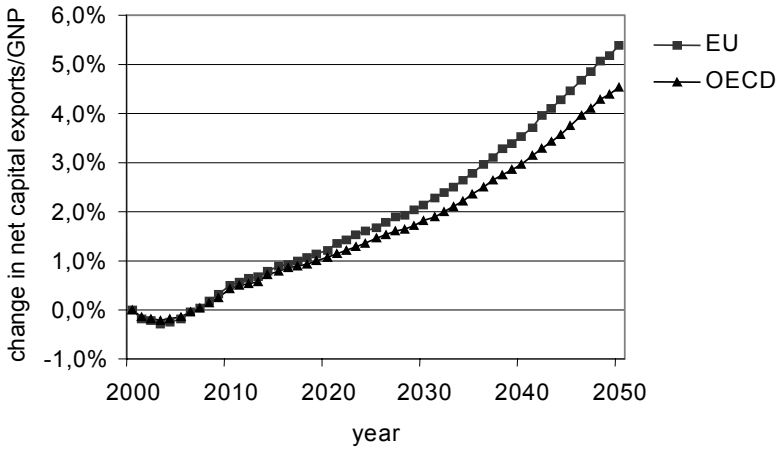


Figure 4b: Fundamental pension reform



Notes: This figure shows projections of German net capital exports as a percentage of German GNP towards the EU and the OECD respectively. Pension reform only in Germany. EU: Net German capital exports to the other countries of the European Union when there's capital mobility only within the European Union, OECD: Net German capital exports to the other countries of the OECD when there's capital mobility only within the OECD.
Source: Own calculations, based on demographic projections by Birg and Börsch-Supan (1999) and the United Nations (2000).

4.2 International capital flows

We now turn to the main topic of this paper, international capital flows. The effect of aging on German capital exports is shown in figure 3. Under the current pension system, foreign asset holdings of German households first increase and then, after a peak is reached in 2030, decrease again to about their current levels. The decrease in foreign asset holdings is less pronounced under a fundamental pension reform. Until 2050, German foreign asset holdings are projected to more than double. Net capital flows from Germany to other regions are shown, as a percentage of GNP, in figure 4. When the aging process peaks, Germany's capital exports are reduced substantially, even though there are more attractive investment opportunities abroad. The reason for this is that in this period, the saving rate is at its lowest. During our simulation period, Germany never becomes a net capital importer.

Our model tends to overestimate German foreign assets holdings since the only driving forces of international capital flows are the return differentials between world regions that are caused by the demographic transitions. In reality, many other factors generate and, most importantly, restrict international capital flows. These factors are discussed in our conclusions.

Next, we take a closer look at net capital flows in the OECD scenario. Figure 5 shows net capital exports of different regions within the OECD, as a percentage of total capital flows. The region named "OECD 12" includes all OECD countries except for Japan, the United States and the countries of the European Union. Like Germany, Japan is projected to be a net capital exporter due to the effects of aging. In Japan, the ratio of the number of persons aged over 65 and the number of workers is expected to increase from currently slightly above 20 percent to more than 50 percent by 2050. At the same time, Japan has implemented a social security reform program, that, among other things, intends to increase retirement age by five years by the year 2050.[10] We implement this reform program in our simulations and thus the increase of the old-age dependency ratio is by far less pronounced than the direct effect of population aging. Therefore, our model predicts decreasing net capital exports of Japan.

Figure 5 also shows that the main capital import region is the European Union except Germany, denoted as "EU 14". We further assume that the net exports of region *i* to region *j* are equal to the product of the export share of a region *i*, expressed as net capital exports as a percentage of total 'world' exports, and net imports of region *j*. This assumption is consistent with our model, since households are indifferent between regions with respect to their portfolio choice. Under this assumption, the region EU 14 absorbs about 36 percent of total German

[10] See Leibfritz, Roseveare, Fore and Wurzel (1996).

Figure 5: Projections of net capital exports of the OECD area under the assumption of perfect capital mobility within the OECD

Figure 5a: Current pension systems

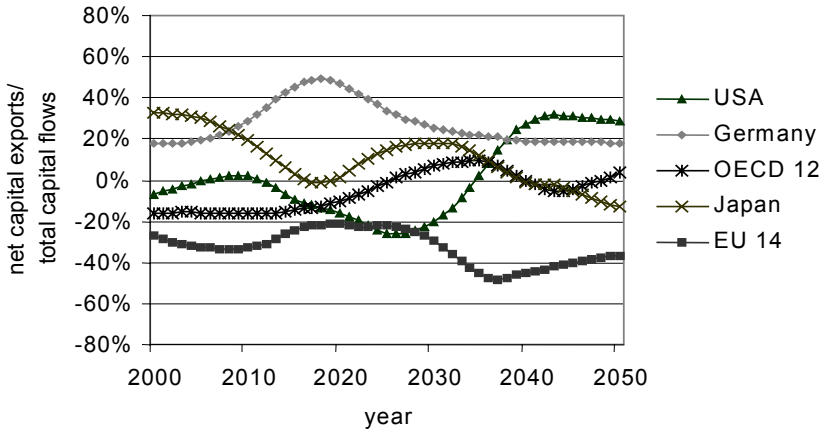
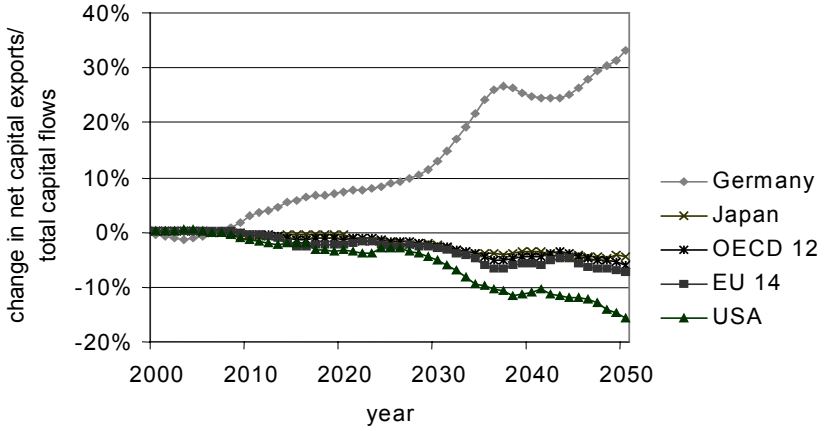


Figure 5b: Fundamental pension reform



Notes: This figure shows projections of net capital exports of the respective region as a percentage of total capital flows under the assumption of perfect capital mobility within the OECD. Pension reform only in Germany. EU 14: All countries of the European Union except Germany. OECD 12: All OECD countries except for the countries of the European Union, Japan and the United States.
Source: Own calculations, based on demographic projections by Birg and Börsch-Supan (1999) and the United Nations (2000).

exports until 2008. Then, the United States becomes the most important import destination of German capital exports. In 2026, the US itself imports around 26 percent of total German exports. After 2038, the region EU 14 again takes over this position. The United States is less affected by the aging process than are Germany and Japan. As for Japan, we implement reform proposals aimed to increase retirement age by 2 years in our simulations. Therefore, the United States is a capital importer initially but takes over the role of a capital exporter when Japan becomes an import country due to the reform proposal. As Figure 5b indicates, a fundamental pension reform in Germany would lead to an enormous increase in Germany's export share. By 2050, it is projected to have increased from 19 percent in 2001 to above 30 percent, at the expense of the export shares of all other countries.

4.3 Rates of return to capital

Population aging will affect the return on capital because labor will become more scarce relative to capital, thereby decreasing the price of capital relative to labor. As can be seen from figure 6a, the return on capital in the closed economy scenario decreases slightly more than 0.7 percentage points between the years 2010 and 2026 – this is the direct effect caused by aging.[11] This decrease is only around 0.2 percentage points when capital is freely mobile within the European Union, while the return does not decrease at all in the OECD scenario. A fundamental pension reform leads to an additional reduction in the rate of return on capital, caused by the increasing supply of capital and diminishing returns. In the closed economy scenario, the rate of return is reduced by roughly 1 percentage point in 2050 relative to the rate of return under the current pension system. This decrease is much less than often claimed in the public debate, and similar in magnitude as in the closed-economy model by Börsch-Supan, Heiss and Winter (2000). Moreover, the decrease in the rate of return on capital reduces to only 0.2 percentage points if capital is freely mobile within the EU. In the OECD scenario, the yield difference almost disappears.

These results suggests that household savings induced by a fundamental pension reform should be invested internationally, not only for reasons of risk diversification (which are of course not present in our deterministic model), but also for the sake of higher returns that are available in other countries with different aging processes and more favorable capital-labor ratios. Our results also confirm our earlier claim that the most important beneficial effects of capital

[11] The general upward tendency in the rate of return results from the exogenous growth in labor productivity. It is amplified in the open economy scenarios since other world regions are generally younger than Germany. When the process of demographic change ends, and as the economies approach the steady state, the return on capital decreases again (this effect cannot be seen in our figures which have a shorter time horizon).

Figure 6: Projections of the rate of return to capital under alternative pension systems and capital mobility scenarios

Figure 6a: Current pension systems

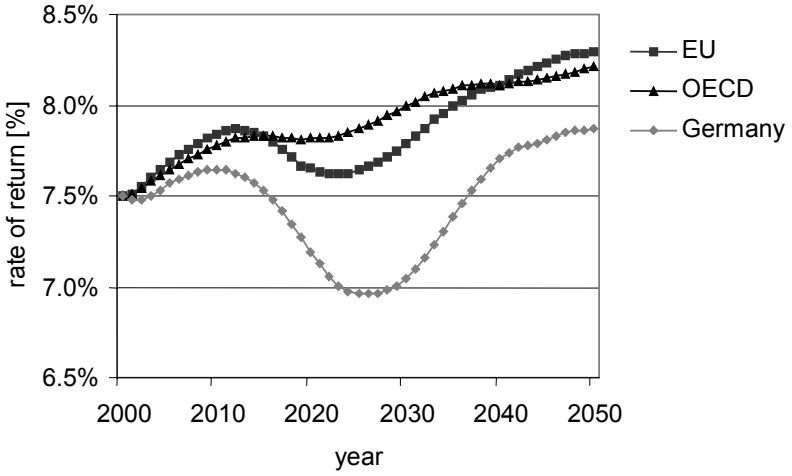
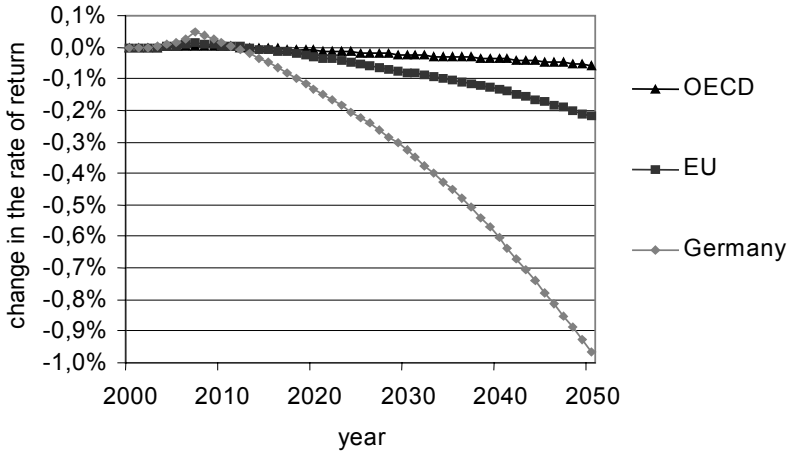


Figure 6b: Fundamental pension reform



Notes: This figure shows projections of the rate of return to capital. Pension reform only in Germany. Germany: Germany as a closed economy, EU: perfect capital mobility in the EU area, OECD: perfect capital mobility in the OECD area.
Source: Own calculations, based on demographic projections by Birg and Börsch-Supan (1999) and the United Nations (2000).

mobility do already show up under very modest capital mobility scenarios. Indeed, there is almost no difference between the OECD scenario and a scenario where we allow for perfect capital mobility in the entire world, including developing countries, as can be seen from figure 6a, where we add the entire world as a forth capital mobility scenario.

4.4 Welfare aspects of population aging, pension reform and capital mobility

The final step of our analysis focuses on welfare aspects of population aging, pension reform, and capital mobility. Here, we focus only on the effects of pension reform and international capital flows on aggregate consumption. For ease of presentation, we restrict the analysis to a comparison between the closed economy scenario and free capital mobility among the OECD countries. Figure 7a shows that aggregate consumption in the open economy scenario exceeds aggregate consumption in the closed economy scenario from the year 2030 on. These differences in aggregate consumption are higher under a fundamental pension reform scheme. Moreover, in the long run, consumption gains due to a fundamental pension reform are higher in the open economy case (figure 7b).

We conclude this section with a brief discussion of the effects of simultaneous pension reforms in several countries. We constrain the analysis to the effects of stylized pension reforms in other countries of the European Union. For simplicity, we assume that all pension systems are simultaneously reformed in the same manner, by freezing contribution rates to the public pay-as-you-go pension system, as in the reform scenario for Germany. We further assume that capital is perfectly mobile within the European Union. Here, we concentrate on the effects on the rate of return on capital. Recall that when Germany was assumed to be the only country that implements a pension reform, the rate of return on capital decreased by 0.2 percentage points in the EU scenario. As can be seen from figure 8, the decrease in the rate of return on capital is slightly larger in magnitude (0.3 percentage points) when all European economies simultaneously reform their pension systems. This effect is small, and we therefore conclude that the international capital market is strong enough to absorb additional capital that is generated by pension reforms throughout the world, the main reason for this strength being differences in the timing of population aging across countries.

Figure 8: Projections of aggregate consumption of German households under alternative pension systems and capital mobility scenarios

Figure 8a: Current pension systems

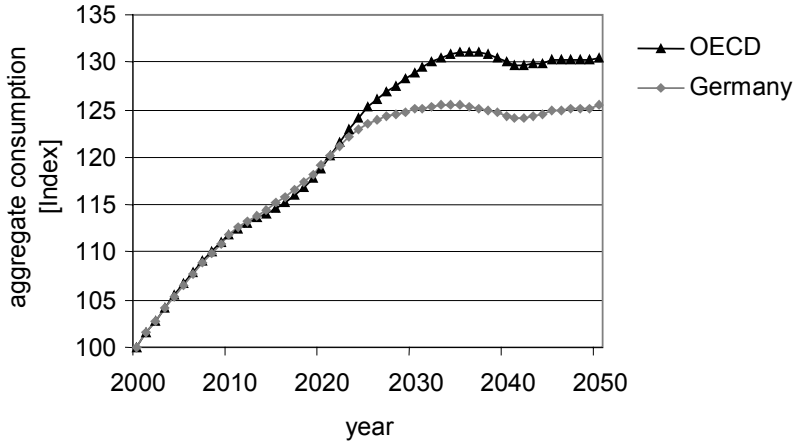
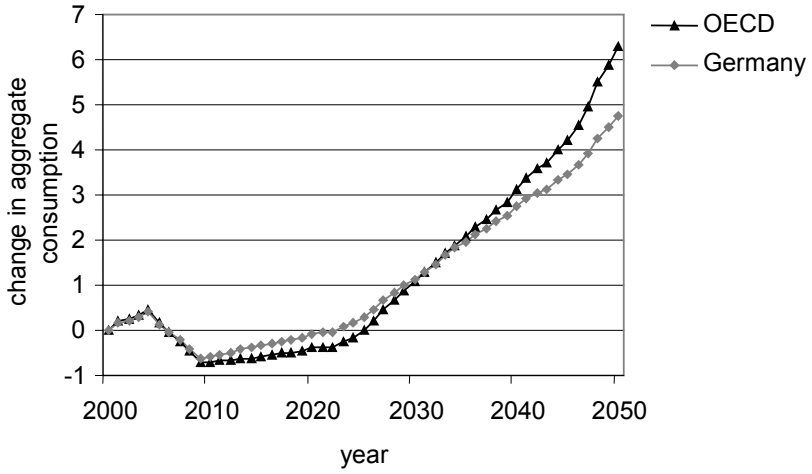
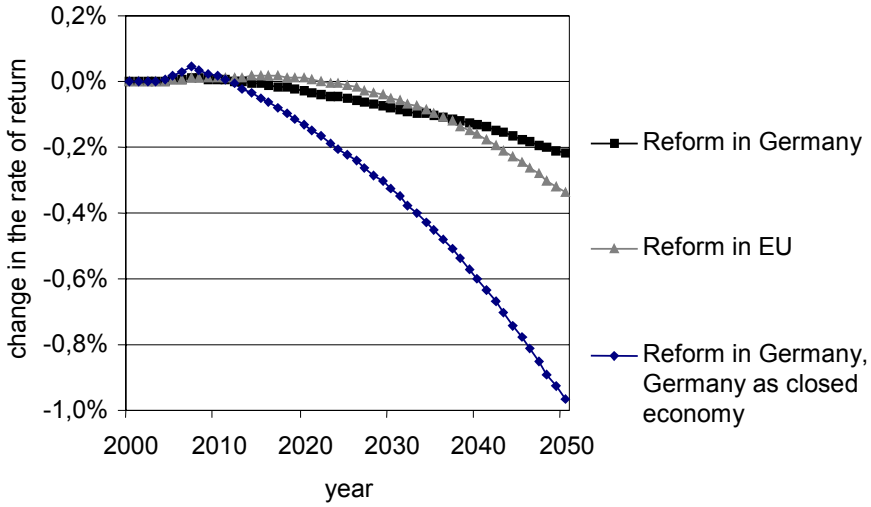


Figure 8b: Fundamental pension reform



Notes: This figure shows projections of aggregate consumption of German households. Pension reform only in Germany. Germany: Germany as a closed economy, OECD: perfect capital mobility in the OECD area.
Source: Own calculations, based on demographic projections by Birg and Börsch-Supan (1999) and the United Nations (2000).

Figure 9: Projections of the rate of return to capital under alternative pension system scenarios and perfect capital mobility in the EU



Notes: This figure shows projections of the rate of return to capital. Pension reform in Germany or simultaneous pension reforms in all other countries of the European Union respectively. Perfect capital mobility in the EU. Current Systems: current PAYG pension systems, Reform in Germany: pension reform only in Germany, Reform in EU: simultaneous pension reforms in the entire EU.
Source: Own calculations, based on demographic projections by Birg and Börsch-Supan (1999) and the United Nations (2000)

5. Conclusions

In this paper, we have analyzed the consequences of population aging and a fundamental pension reform – that is, a shift towards more pre-funding – for capital markets in Germany and for international capital flows. We developed a stylized overlapping generations model to predict capital formation and movements over a long horizon, taking demographic projections as given. Our results confirm that population aging results, at least initially, in a higher capital stock, but when the baby boom generations begin to consume their retirement savings, the capital stock will decrease after 2030. Our simulations suggest that the decrease in the rate of return on capital, which results from secular shifts in the capital-labor ratio associated with an aging population and retirement saving, is

less about 1 percentage points by 2050, and only if all capital is invested exclusively in Germany.

However, capital markets these days are anything but closed national markets, and the return on capital can be improved substantially by international diversification. International capital flows induced by population aging and pension reform follow the time path of saving just described. At the peak of savings around the year 2020, German capital exports to all other OECD countries are projected to exceed 7% of GNP. 15 years later, they will briefly decline to below 2% but remain positive through the aging process. Our simulations show that a transition to a partially funded system does not crowd out existing savings totally. Capital exports from Germany to the OECD countries will be higher in this case, never falling below 2% after a peak of about 9% in the year 2021.

Our analysis has shown that the decrease in the rate of return to capital due to aging between 2010 and 2026 is moderated substantially when capital is invested abroad. Moreover, the decrease in the return to capital due to a fundamental pension reform is only 0.2 percentage points if capital is freely mobile within the countries of the European Union versus 1 percentage point if Germany is modeled as a closed economy. This suggests that closed economy overlapping-generations models overestimate the transitional burden of such a fundamental pension reform.

A few remarks on the economic model we used to simulate the macroeconomic effects of a fundamental pension reform are in order. We have already mentioned that our overlapping-generations model is very stylized and some important economic mechanisms are not taken into account, most importantly, endogenous labor supply decisions and taxation. While it would certainly be interesting to explore these issues in our model, we do not anticipate that they would change the basic message of our analysis.

An important feature which is not reflected by the overlapping generations model of sections 3 and 4 is financial markets risk. Our analysis concentrated on the long-term path of the rate of return on capital in a model with no stochastic aggregate fluctuations, so there was no role for risk. However, real-world investments are risky, and in their savings and portfolio decisions, households are concerned not only about the (expected) rate of return, but also about its variance, that is, about portfolio risk. This raises the question whether countries such as Germany are really willing to invest substantial fractions of their retirement wealth abroad.

Finally, our multi-country model operates using the explicit assumptions of (i) perfect capital mobility, and (ii) a world-wide monetary union (we have no exchange rates in our model). First, the fact that we have free capital mobility implies that there are no institutional restrictions on capital exports, and that households are willing to hold unlimited foreign assets. Both assumptions might not be warranted in the real world (we only mention the literature on home bias in

international capital holdings; for example French and Poterba, 1991). Second, while a monetary union is a realistic assumption for capital flows within the EU, exchange rate reactions between major regions of the world are an important aspect that we did not address. They have, indeed, no role in these one-good economies. However, a distinction between home and tradable goods, demanded differentially by the various age-groups, would imply real exchange rate effects due to population aging.

While more research on these issues is certainly warranted, we are confident that our simulations are informative about the main effects of population aging on international capital flows. Our simulations suggest that significant effects of capital mobility arise even if capital flows are restricted to Europe or the OECD, and this does not appear to be an unrealistic scenario.

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