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Abstract: In this paper, we present a quantitative analysis of international capital flows induced by differences in population aging processes across countries and by pension reforms. In the vast majority of countries, demographic change will continue well into the 21st century. 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 and shifts towards more pre-funding are implemented. While the patterns of population aging are similar in most countries, the 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 effects, we develop a stylized multi-country overlapping generations model, and we use long-term demographic projections for several world regions to simulate international capital flows over a 50 year horizon. Our simulations suggest that capital flows from fast-aging industrial countries such as Germany 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; pension reform; capital mobility
JEL classification: E27; F21; G15; H55; J11

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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, the 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. To the extent 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 a with public pay-as-you-go pension system in deep need of reform (e.g., Birg and Börsch-Supan, 1999, Börsch-Supan, 2000). To separate the direct effect of population aging on capital markets and the additional effects of a fundamental pension reform towards a partially funded system, we present our projections for both the (counterfactual) scenario of maintaining Germany's current generous pension forever, and under a fundamental pension reform as outlined by Börsch-Supan (2000).

Our simulations show that a transition to a partially funded system does not crowd out existing savings totally. The capital stock increases initially, but then decreases significantly when the baby boom generations enter retirement. The corresponding decrease in the rate of return, which results from both population aging and pre-funded pensions, is only modest, less than one percentage point if we assume a closed economy. We continue to show that the return on capital can be improved by international diversification, that is, by investing pension savings in countries with a more favorable demographic transition path than Germany. The intuition behind these findings is clear. If we allow for international capital mobility, the additional saving induced by a transition to a partially funded pension system can be invested in other countries with a more favorable age structure. This cannot make households worse off, and we argue below that the welfare increases from investing pension savings internationally will be substantial.

These effects of international diversification on savings behavior and the implementation of 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, the 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 this respect, and it allows for realistic quantitative projections.

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 different pension system and 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, 1998).

These demographic changes are determined by a process called *demographic transition* (e.g., Birg, 1996). This process is determined by the non-coinciding dynamics of mortality and fertility rates; it is most severe in the industrialized countries and in Asia. Three stages of the demographic transition can be distinguished: First, mortality declines as a result of technological progress and industrialization, second, and with a time lag, fertility rates also decline. As a result, population growth slows down and a decreasing relative share of children faces an increasing relative share of older persons. In the third stage, the speed of adjustment of both rates slows down, and it is possible that the level of the fertility rates settles below the mortality rates. In this case, population growth becomes negative. In the long run, the age structure of population is characterized by a relatively large share of older persons. Especially in industrialized countries, this process is exacerbated by the continuing increase in life expectancy. Therefore, the relative share of old persons will not only be very high, but these persons will also live longer.

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, 1998).

While the patterns of population aging are similar in most countries, timing differs substantially, in particular between industrialized and less developed countries. 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, 1998).

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 Börsch-Supan and Birg (1999).[1] 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).

[1] 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.

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 of 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 by this development 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 towards developing countries 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 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. Yet, international capital flows to developing countries are highly geographically concentrated. Only twelve developing countries, among them China, Mexico and Brazil, absorb around 80 percent of private net capital flows. The importance of private net capital flows is striking: in South East Asia and Latin America, they account for around 5 percent of GNP (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 (see Lührmann, 2001, for a review). 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 a 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 (1995) 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 a central question. 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).[2] 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 indica-

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

tion 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 OECD or EU 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. Approach 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. 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 presented in this paper model is new to the literature.[3] 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.[4]

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, 1998). Based on these demographic projections, we compute time paths for the number of workers and pensioners for each of the countries and world regions in our model. These projections are described in detail by Ludwig (2000).

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

[3] A detailed description and analysis of the model presented in this paper can be found in Ludwig (2000).

[4] 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.

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.[5] (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.

Despite these simplifications, our stylized model is sufficient to obtain the first-order effects of population aging on domestic capital formation and international capital flows. 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 the whole world).

In our simulations, the projected demographic transition for each country *i* enters via time-specific sizes of the 75 living cohorts, denoted by $N_{t,i}^{a}$, where *a* is age, exogenously given at every point in time, *t*. The economic life of a cohort begins at the age of twenty years, for which we set $a = 1$. For ease of presentation, we take $N_{t,i}^{a}$ to be number of workers, $L_{t,i}^{a}$, for $a = 1, ..., 39$, and the number of retired persons, $Z_{t,i}^{a}$, for $a = 40, ..., 75$. This implies that there is a fixed retirement age of 60 at which everybody stops to work, stops to pay pension taxes, and begins to collect pension benefits from the pay-as-you-go system. In our actual simulations, the retirement pattern is much more flexible: We include an age and time-specific weight that represents the fraction of the population that is retired, and 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. Also, the upper age of $a = 75$ is only chosen for ease of presentation. As noted before, in our actual calculations, the time horizon of each cohort is constrained by its life expectancy. Our weighting approach matches individual decisions to the demographic projections.

[5] 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 in Birg and Börsch-Supan (1999).

The current pension system of each region i enters the model through fixed time paths of the contribution rate, $\tau_{t,i}$. The contribution rate is calculated from an exogenously given time specific replacement rate, $R_{t,i}$, defined as the ratio of the average net pension and the average net wage $w_{t,i}$ at time t. Thus, the budget of the public pension system is balanced at any time t:

(1) $$\tau_{t,i} w_{t,i} L_{t,i} = R_{t,i} w_{t,i} (1-\tau_{t,i}) Z_{t,i} .$$

As a pension reform scheme for Germany, we use the 'freezing' reform proposal by Birg and Börsch-Supan (1999) and Börsch-Supan (2000b), 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, the freezing of 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.

In our simulations, we calculate the time path of the replacement rate which determines public pension payments endogenously from equation (1). The per-capita pension at time t is thus given by the product of the replacement rate and the net wage,

(2) $$P_{t,i} = R_{t,i} \cdot w_{t,i} (1-\tau_{t,i}) .$$

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.

General equilibrium in this overlapping generations is constructed via the production sector where, given factor inputs (capital and labor), output and factor prices are determined. The production sector in each country consists of a representative firm that uses a CES production function given by

(3) $$Y_{t,i} = F\left(K_{t,i}, A_{t,i} L_{t,i}\right) = \left(\alpha K_{t,i}^{1-1/\beta} + (1-\alpha)(A_{t,i} L_{t,i})^{1-1/\beta}\right)^{\frac{1}{1-1/\beta}} ,$$

where α and β are the factor share and the elasticity of substitution, respectively (which are assumed identical for all countries). $K_{t,i}$ denotes the capital stock of country i and time t and

$A_{t,i}$ is labor productivity, while $A_{t+1,i} = A_{t,i}(1+g)$. We assume that the growth rate of labor productivity is also constant for all countries and across time.[6] We divide equation (3) by $A_{t,i}L_{t,i}$ to obtain the representation of the production function in terms of efficiency units,

$$(4) \qquad y_{t,i} = f\left(k_{t,i}\right) = \left(\alpha k_{t,i}^{1-1/\beta} + (1-\alpha)\right)^{\frac{1}{1-1/\beta}},$$

where $y_{t,i}$ is output and $k_{t,i}$ is the capital stock per efficiency unit of labor of country i.

From static profit maximization, we obtain the interest rate which is identical for all countries due to our assumption of perfect capital mobility. It follows that the capital stock per efficiency unit is also equal for all countries,

$$(5) \qquad r_t = f'\left(k_{t,i}\right) - \delta \ \ \forall i \quad \Leftrightarrow \quad k_{t,i} = k_t \ \ \forall i,$$

where δ is the rate of depreciation of capital, assumed to be constant across time and identical for all countries. $f'(k_{t,i})$ is the first derivative of equation (4) with respect to capital. It follows that output per efficiency unit is also identical for all countries, i.e. $y_{t,i}=y_t \ \forall i$. Accordingly, the wage rate is given by

$$(6) \qquad w_{t,i} = A_{t,i}\omega_t = A_{t,i}\left(f(k_t) - k_t f'(k_t)\right),$$

where • $_t$ is the world wage rate per efficiency unit. Since efficiency might differ across countries, nominal wages can of course be different across countries.

In order to determine aggregate consumption, we next consider optimal household behavior derived from intertemporal utility maximization. By choosing an optimal consumption path, each generation a maximizes, at any point in time t, the sum of discounted future utility. We assume that preferences are identical for all countries. The within-period utility function exhibits constant relative risk aversion, and preferences are additive and separable over time. The target function of generation a's maximization problem at time t is given by

$$(7) \qquad U_{t,i}^{a} = \frac{1}{1-\sigma} \sum_{j=a}^{LE_{\kappa,i}} \frac{1}{(1+\rho)^{j-a}} \left(C_{t+j-a,i}^{j}\right)^{1-\sigma},$$

where σ denotes the coefficient of relative risk aversion, ρ is the discount rate and $LE_{\bullet,i}$ is the life expectancy of cohort • born in year t = • $+a$. Maximization is subject to a dynamic budget constraint which for generation a at time t is given by

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

(8) $$M_{t,i}^{a}=\sum_{j=a}^{LE_{\kappa,i}}\left(\prod_{z=a+1}^{j}\frac{1}{1+r_{t+z-a}}\left(w_{t+j-a,i}\left(1-\tau_{t+j-a}\right)+P_{t+j-a,i}^{j}-C_{t+j-a,i}^{j}\right)\right)+W_{t,i}^{a}\left(1+r_{t}\right)=0\,.$$

Here, $M_{t,i}^{a}$ is the life-time budget surplus, set to zero since we exclude bequests from our analysis, and $W_{t,i}^{a}$ is total wealth, both specific to generation a at time t.[7] The solution to the intertemporal optimization problem can be characterized by an Euler equation,

(9) $$C_{t+j-a,i}^{j}=C_{t+j-1-a,i}^{j-1}\left(\frac{1+r_{t+j-a}}{1+\rho}\right)^{1/\sigma},$$

which reflects households' trade-off between current and future utility. As in any life-cycle model, this trade-off is determined by the ratio of the interest rate and the time preference rate, and by the degree of risk aversion.

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 *i*:

(10) $$W_{t,i}=\sum_{a=1}^{75}W_{t,i}^{a}N_{t,i}^{a}\,,$$

while $W_{t,i}^{a}=W_{t-1,i}^{a-1}+S_{t-1,i}^{a-1}$ and S is savings. 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,

(11) $$K_{t}=W_{t}=\sum_{i=1}^{R}W_{t,i}\,,$$

where R is the number of regions considered. From equation (4), the capital stock of each country is determined as

(11) $$K_{t,i}=k_{t}A_{t,i}L_{t,i}\,.$$

Domestic investment in period *t* is the difference between the capital stock of each country in period *t* and period *t-1* plus depreciation:

(12) $I_{t,i} = K_{t+1,i} - (1-\delta)K_{t,i}$,

The difference between total wealth of a country $W_{t,i}$ and its capital stock $K_{t,i}$ is foreign assets, denoted as $B_{t,i}$. Equilibrium of the model therefore requires that the sum of all foreign assets across all regions is zero:

(13) $\sum_{i=1}^{R} B_{t,i} = 0$.

The current account surplus, $CA_{t,i}$ of country i at time t is the difference between foreign assets at times t and t-1. Together with equation (12) this also determines aggregate savings,

(14) $CA_{t,i} = B_{t+1,i} - (1-\delta)B_{t,i} = S_{t,i} - I_{t,i} \Leftrightarrow S_{t,i} = CA_{t,i} + I_{t,i}$.

Aggregate consumption is determined by taking the difference between the gross national product of country i and savings,

(15) $C_{t,i} = Y_{t,i} + r_t B_{t,i} - S_{t,i}$.

Note that we assume that labor is not mobile, and therefore the only income from abroad is asset income. Finally, note that we could alternatively aggregate over individual consumption and savings across cohorts for each country, but our approach turned out to be more robust against aggregation errors.

An equilibrium path of this overlapping generations model can be determined using a recursive numerical procedure, known as the Gauss-Seidel-Algorithm (see Auerbach and Kotlikoff, 1987). The solution algorithm starts with picking an arbitrary initial time path for the world capital stock per efficiency unit, k_t. Since labor supply is exogenous in our model, we can readily solve the static optimization problem of the representative firm for a given trial value of the world capital stock k_t and the labor inputs implied by the demographic projections. We can then compute time paths of the factor prices (i.e., the wage and interest rates). Given factor prices, we can solve the age and time-specific intertemporal optimization problems of all cohorts at all points in time, which yields, after aggregating across agents and countries, time paths of aggregate world asset holdings, which is just equal to the world capital stock. We use equations (10) and (11) to determine the new world capital stock per efficiency unit:

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[7] Our actual simulations are more complicated. The budget constraint (8) is based on a fixed retirement age for the sake of simplified notation, but as noted before, we allow for a flexible retirement window so that in our simulations, the budget constraint must include the appropriate weights.

(16) $$k_t = \frac{W_t}{\sum_{i=1}^{R} A_{t,i} L_{t,i}} = \frac{\sum_{i=1}^{R} W_{t,i} L_{t,i}}{\sum_{i=1}^{R} A_{t,i} L_{t,i}}.$$

This new capital stock is consistent with household optimization (conditional on factor prices) but will not necessarily coincide with the trial time-path that we specified initially. So we need to change the initial capital stock and repeat the entire computation recursively until convergence with respect to the time path of the capital stock is achieved, and an intertemporal equilibrium of the dynamic economy is found.

The parameter values used in the calibration of our model are standard in the literature on simulated overlapping generations models; they are summarized in table 1. We use GDP data for all countries to calibrate the technology parameter $A_{t,i}$ in the base year of our calculations. As noted before, $A_{t,i}$ then continues to grow at a constant rate g. This implies that the initial weight of each country in our simulations is determined by its relative share in current world GDP.

4. Simulation results for alternative pension and capital mobility scenarios

We now present the results of our macroeconomic simulation model. Our focus is mostly on the impact of population aging on the German economy. To separate the direct effects of population aging and the additional effects of a fundamental pension reform, we always present two scenarios, the current pay-as-you-go system and a fundamental pension reform. 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.

In addition to our pension reform 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.

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 8.1 and 8.6 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 9.3 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 1b also shows the discrete adjustments that occur when a pension reform is announced or implemented. The first jump occurs in 2002, one year after the announcement of the pension reform, the second in 2007, one year after the reform itself. This latter jump goes up, as expected, since the pension reform induces additional private savings. But with the same reasoning the first jump should also go up. The downward jump is therefore – at first sight – counterintuitive. The reason for this downward jump is that we aggregate across households which react very differently to the announcement of a fundamental pension reform. 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.

This argument also explains the difference in the magnitudes of the jumps under alternative capital mobility scenarios. The increase in aggregate income is higher when the capital mobility region is larger. Therefore, the downward jump in the aggregate saving rate is slightly higher if capital is freely mobile within the OECD (-0.43 percentage points) than if Germany is assumed to be a closed economy (-0.39 percentage points). Accordingly, the upward jump after the reform is lower in the OECD scenario (+0.19 percentage points) than in the closed-economy scenario (+0.22 percentage points).

Next, we aggregate savings to obtain a 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 labour 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 if Germany is assumed to be a closed economy. In the open economy case, the growth of the capital stock almost disappears, but the growth rate never becomes negative. In the open economy scenarios, the German capital stock increases to about 140 or 144 percent of its current value if capital is freely mobile within the EU or within the OECD, respectively, and to 138 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.

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 about double. The net capital flows from Germany to other regions are shown, as a percentage of GNP, in figure 4. When the aging process peaks, Germany almost becomes a net capital importer in 2038, besides the more attractive investment opportunities abroad, since the saving rate is at its bottom.

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. 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 Europe except Germany, denoted as “EU 14”. We further assume that the net exports of country *i* to country *j* are equal to the product of the export share of a country *i*, expressed as net capital exports as a percentage of total ‘world’ exports, and net imports of country *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 60 percent of total German exports until 2025. Then, the United States becomes the most important import destination of German capital exports. In 2030, the US itself imports around 60 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 9 percent to 30 percent, at the expense of the export shares of all other countries.

Next, we show the effects of population aging on the return on capital. As can be seen from figure 6a, the return on capital in the closed economy scenario decreases by 0.5 percentage points between the years 2012 and 2026 – this is the direct effect caused by aging. This decrease is only around 0.3 percentage points when capital is freely mobile within the European Union, and only 0.1 percentage points 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 0.5 percentage points in 2050 relative to the rate of return under current pension system. This decrease is much less than often claimed in the public debate, and similar in magnitude to earlier findings 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 0.12

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 mobility do already show up under very modest capital mobility scenarios. Indeed, there is virtually no difference between the OECD scenario and a scenario where we allow for perfect capital mobility in the entire world, as can be seen from figure 7 where we include the entire world as a forth capital mobility scenario for the first time.

The final step of our analysis focuses on welfare aspects of population aging, pension reform, and capital mobility. We consider two measures of welfare, aggregate consumption and discounted life-time utility of individual cohorts. 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 8a 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 (figure 8b). Moreover, in the long run, consumption gains due to fundamental pension reform are higher in the open economy case.

Aggregate consumption captures welfare aspects only partially, since population aging and a fundamental pension reform affect generations differently. We therefore turn to a cohort-specific measure of welfare, discounted life-time utility. Figure 9 shows, by birth year, changes in total life-time utility induced by a fundamental pension reform. These projections use the preference structure outlined in the previous section. Some generations (mainly those who are currently working and still some years away from retirement) experience utility losses, while the younger and yet unborn generations benefit. The comparison between the two different capital mobility scenarios yields interesting and important results. First, utility losses induced by a fundamental pension reform are smaller in the open economy scenario, and less generations are affected. Second, utility gains are smaller in the open economy scenario – despite the fact that aggregate consumption increases are higher.

In our simulations, the change in life-time utility induced by a fundamental pension reform is negative for all generations born between 1929 and 1960 in the closed economy. If capital is freely mobile within the OECD, two generations (born 1959 and 1969) become net winners. Generations experience welfare losses for two reasons under the fundamental pension reform. First, transfers of the public pension system are reduced and therefore savings must be increased which crowds out consumption. Second, the decrease in rate of return on capital affects those generations that have already accumulated a large stock of assets relatively more, namely the older generations. In the open economy, the decrease in the rate of return on capital is smaller and therefore the utility losses are also smaller. This confirms that closed economy models overestimate the transitional burden of pension reform.

The underlying problem for this transitional burden is well known: Since at the time of the introduction of a pay-as-you-go system, at least one generation received pension benefits without contributing to the system, the system carries an implicit debt that is rolled over from one generation to the next. Reducing or abolishing the pay-as-you-go systems requires that this debt be paid back, so at least one generation is worse off. This raises political economy issues: It is obvious that when a Pareto criterion is applied, a pension reform which reduces or even abolishes the a pay-as-you-go pension system is politically not feasible.[8]

This is, however, not the full story, and a fundamental pension reform is possible for several reasons. First, a pension reform induces efficiency gains which, over long horizons, might be large enough to compensate the pay-as-you-go system's implicit debt. In our framework, such efficiency gains could translate into a rate of return that is higher than under a pure pay-as-you-go system. An increased efficiency of international capital markets and corporate governance effects are possible mechanisms as discussed in Börsch-Supan, Heiss and Winter (2000) and Börsch-Supan and Winter (2001). Efficiency gains might also arise on labor markets from changes in tax-induced incentive effects (e.g., Fenge, 1995). Second, if a Pareto improvement is not required and a majority vote is assumed instead, feasible transition policies might exist (see Hirte, 2000, for a simulation analysis using a median-voter framework for Germany).

In both cases, it is crucial that a fundamental pension reform distributes the transition burden across generations, shifting at least some of the cost to unborn generations. In practice, this could be achieved by temporary debt financing of benefits. Cooley and Soares (1999) show that, in the absence of efficiency effects, all politically feasible transition policies use debt to finance benefits during the transition period; Feldstein and Samwick (1998, 2000) provide

[8] We do not attempt to review the theoretical literature on political feasibility of pension reforms here. See, e.g., Fenge (1995) and the review in Hirte (2000).

calculations of how debt finance is used in their framework for Social Security reform in the United States.

Even without debt finance, the transition burden can be distributed across generations such that a reform is politically feasible – provided that some generations are willing to accept small losses relative to the status quo. The simulations depicted in figure 9 suggest that even those generations which are hit hardest only suffer decreases of less than 1 percent in total life-time utility. The increase in life-time utility for younger generations is striking, and this suggests that even a modest degree of altruism (and less in the open economy) among currently working generations might make a fundamental pension reform politically feasible. Recent polls by Boeri et al. (2001) suggest that this assumption is indeed warranted in Germany.[9]

So far, our analysis was focused on the effects of pension reform for German households. Now, we analyze the implications of a pension reform in Germany for foreign households. Households in other countries are affected by a fundamental pension reform because of changes in relative prices. The rate of return on capital decreases relative to the labor income, and capital income is reduced by the increase of German assets. In the long run, households benefit from the increased income generated by the higher world capital stock, while in the short run those generations lose for whom the decrease of the rate of return on capital has the strongest effects (figure 10). This contrasts with a finding of Bräuninger (1999) who analyzes a simple two-period model. In his model, the young generation of a country where no pension reform takes place do not experience any utility losses. Our model shows that two-period models cannot fully capture the dynamic effects of population aging, pension reform, and capital mobility. From figure 10b, one can see that the utility gains and losses in other European countries are much smaller when capital is perfectly mobile within the OECD, because then the additional savings of German households are invested more broadly. Also, utility gains and losses are much smaller in foreign countries than in Germany.

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

[9] While we do not allow for bequests in our stylized model, we should note that a pension reform is likely to result in variations in bequests, in particular in the absence of mandated intergenerational transfers. Based on an overlapping generations model, Miles and Iben (1999) provide estimates of such changes in bequests.

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 0.12 percentage points in the EU scenario. As can be seen from figure 11, the decrease in the rate of return on capital is slightly larger in magnitude (0.2 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.

6. 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. This effect is exacerbated by a fundamental pension reform. 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 than one percentage point, and only if pension funds invest exclusively in Germany. However, capital markets these days are anything but closed national markets, and the return on capital can be improved by international diversification.

While all OECD countries are affected by aging, there are important differences in the timing of these demographic effects as well as the bulk of the aging process. These differences generates capital flows, as capital moves towards countries with a more favorable capital/labor ratio. Our simulations suggest that international diversification (i.e., allowing for investment in all EU and OECD countries) can reduce the decline of the rate of return on capital to just about 0.5 percentage points around the year 2035, when baby boomers' dissaving is most pronounced. If investment is allowed also in developing countries, this effect would initially be about the same, but over very long horizons, when countries such as China and India reach the peak level of demand for capital on world markets, the rate of return would increase further.

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 aspect 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. More research on this issue is certainly warranted, but our simulations suggest that significant positive 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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Figure 1: Projections of the German aggregate saving rate under alternative pension systems and capital mobility scenarios

Figure 1a: Current pension systems

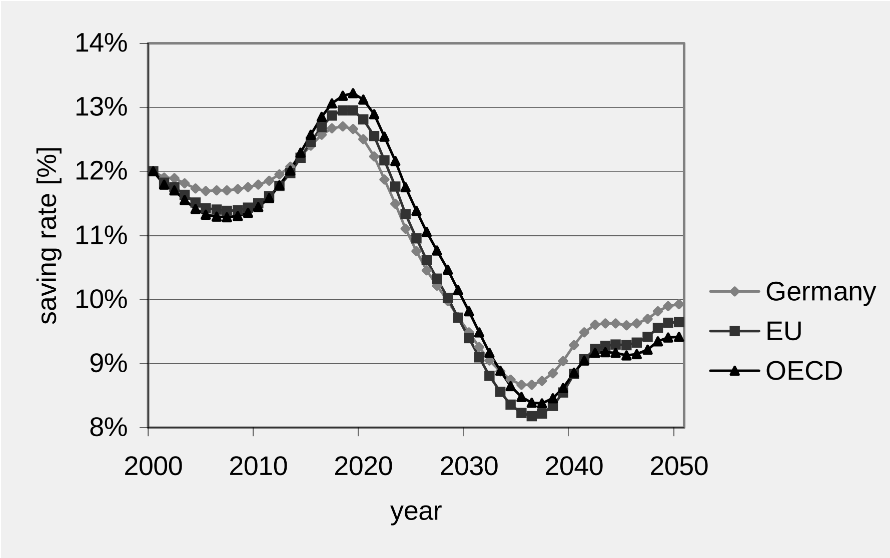
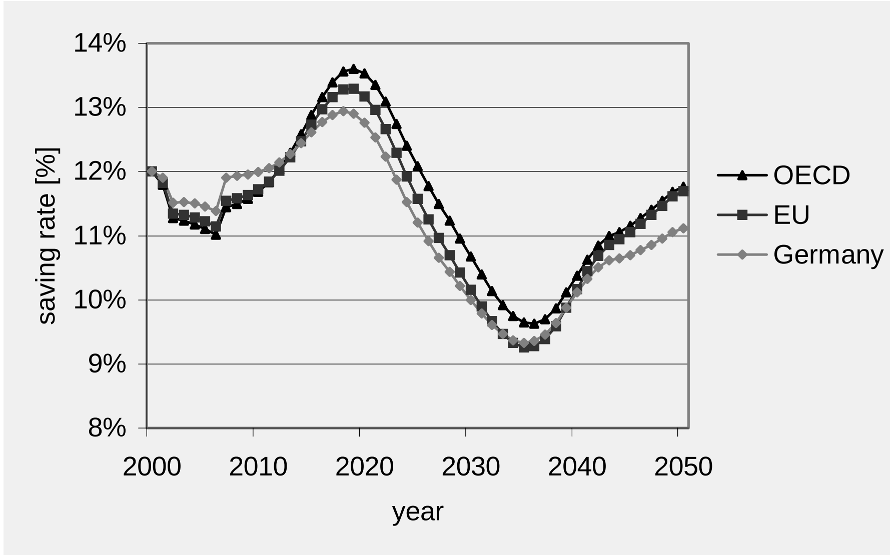


Figure 1b: Fundamental pension reform



Notes: This figure shows projections of the aggregate savings 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 (1998).

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

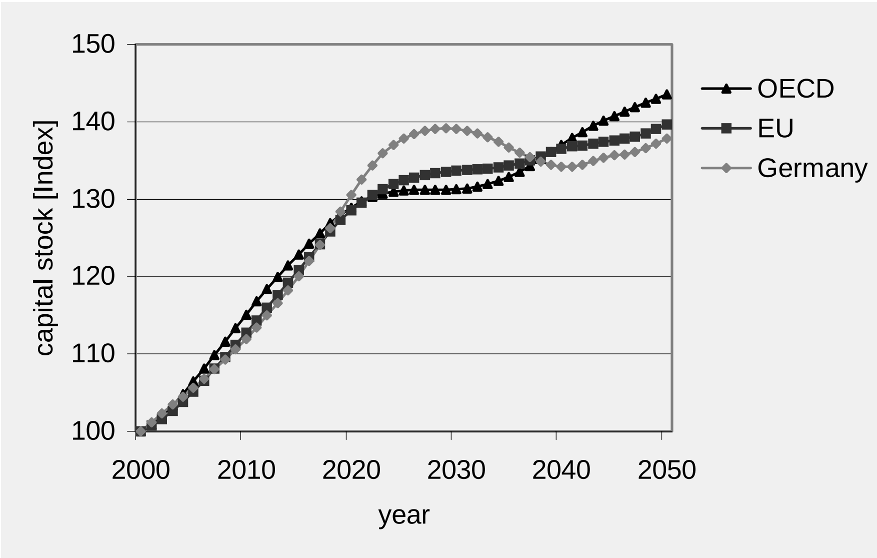
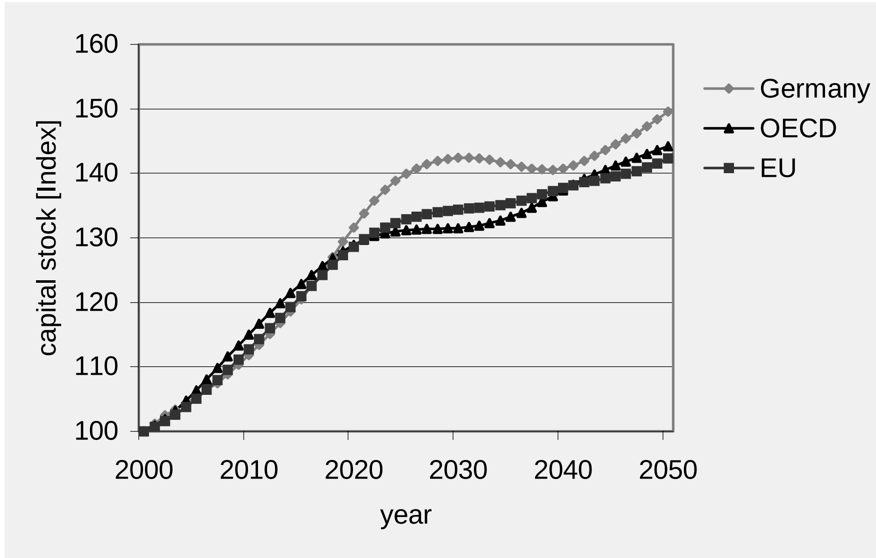


Figure 2b: Fundamental pension reform



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 (1998).

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

Figure 3a: Current pension systems

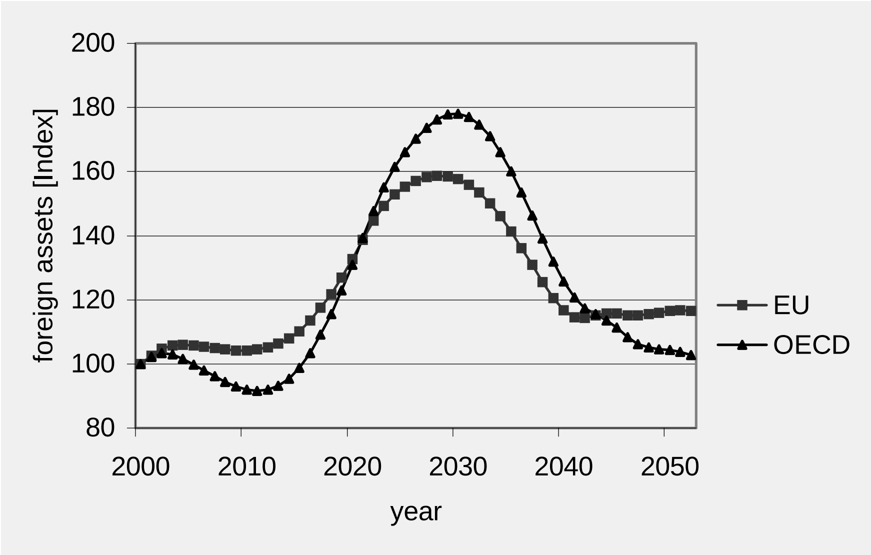
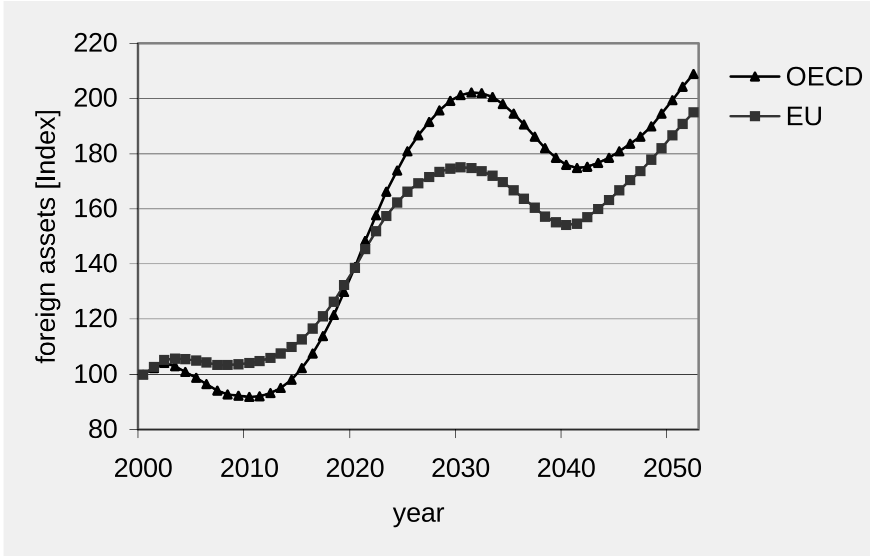


Figure 3b: Fundamental pension reform



Notes: This figure shows projections of 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 (1998).

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

Figure 4a: Current pension systems

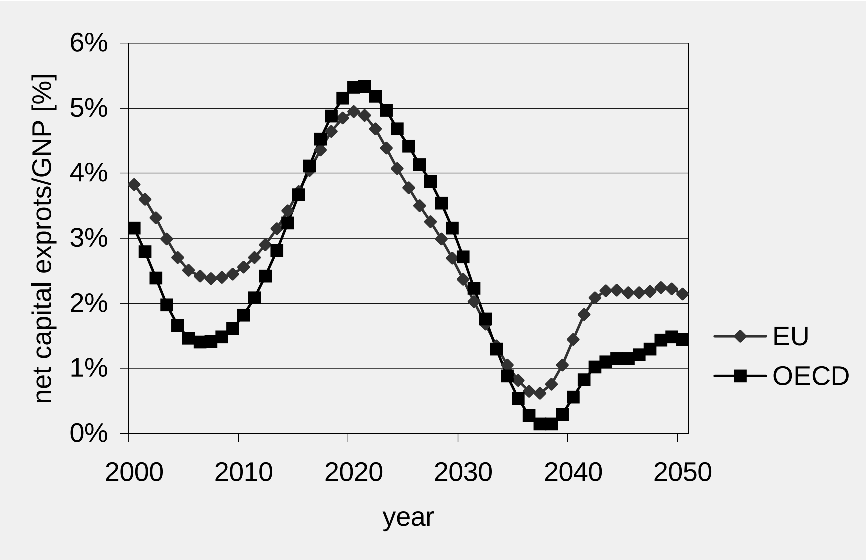
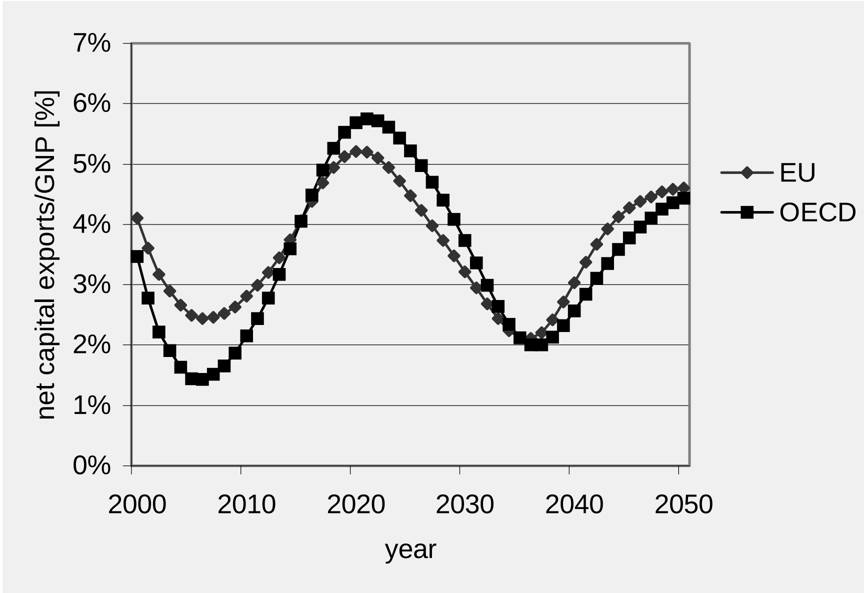


Figure 4b: Fundamental pension reform



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 is capital mobility only within the European Union,
OECD: Net German capital exports to the other countries of the OECD when there is capital mobility only within the OECD.
Source: Own calculations, based on demographic projections by Birg and Börsch-Supan (1999) and the United Nations (1998).

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

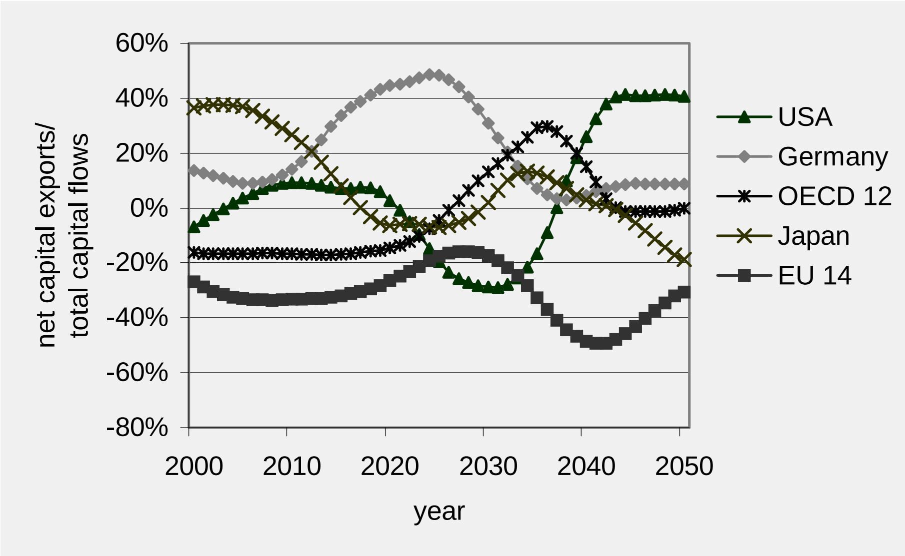
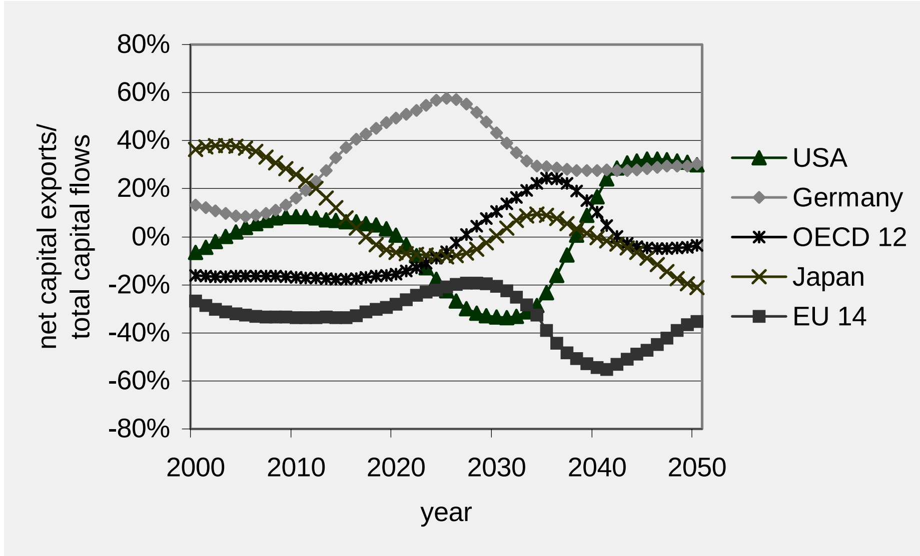


Figure 5b: Fundamental pension reform



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 (1998).

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

Figure 6a: Current pension systems

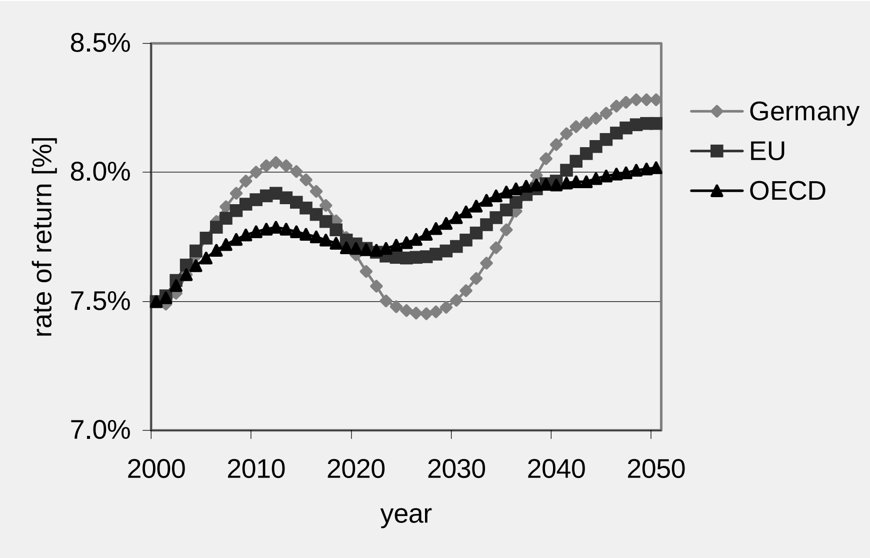
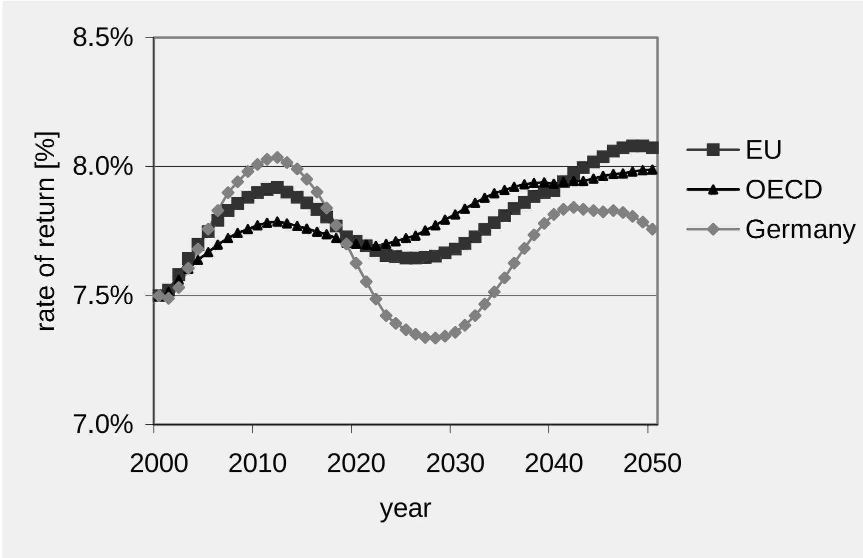


Figure 6b: Fundamental pension reform



Notes: This figure shows projections of the rate of return on 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 (1998).

Figure 7: Comparison of the projections of the rate of return on capital with a worldwide capital mobility scenario

Figure 7a: Current pension systems

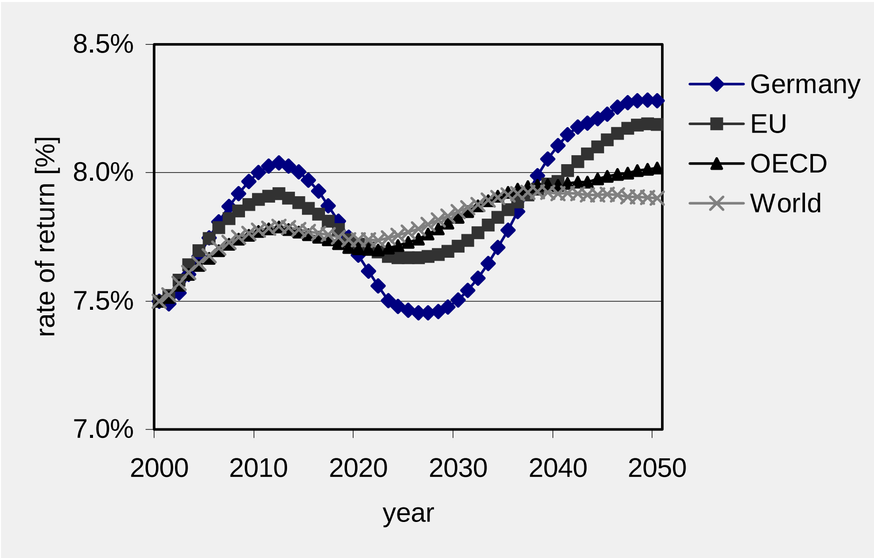
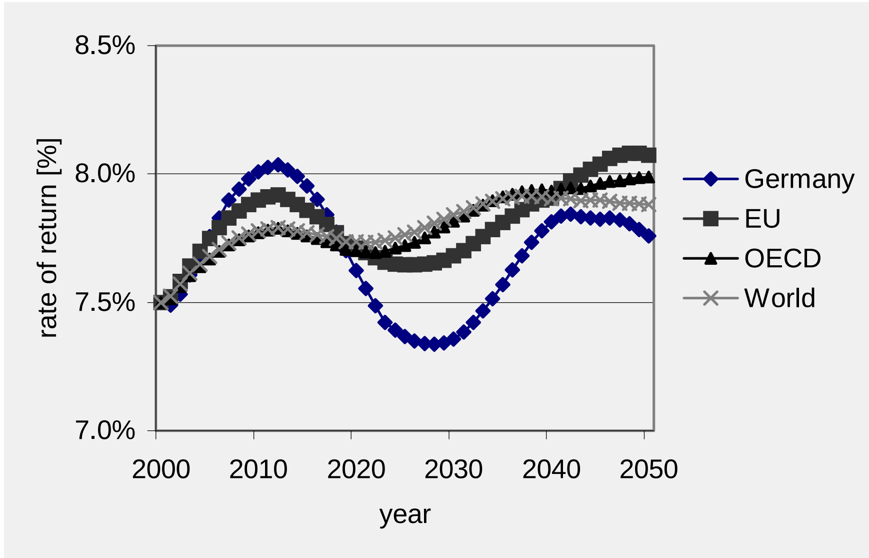


Figure 7b: Fundamental pension reform



Notes: This figure shows projections of the rate of return on 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, World: perfect capital mobility in the entire world.
Source: Own calculations, based on demographic projections by Birg and Börsch-Supan (1999) and the United Nations (1998).

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

Figure 8a: Current pension systems

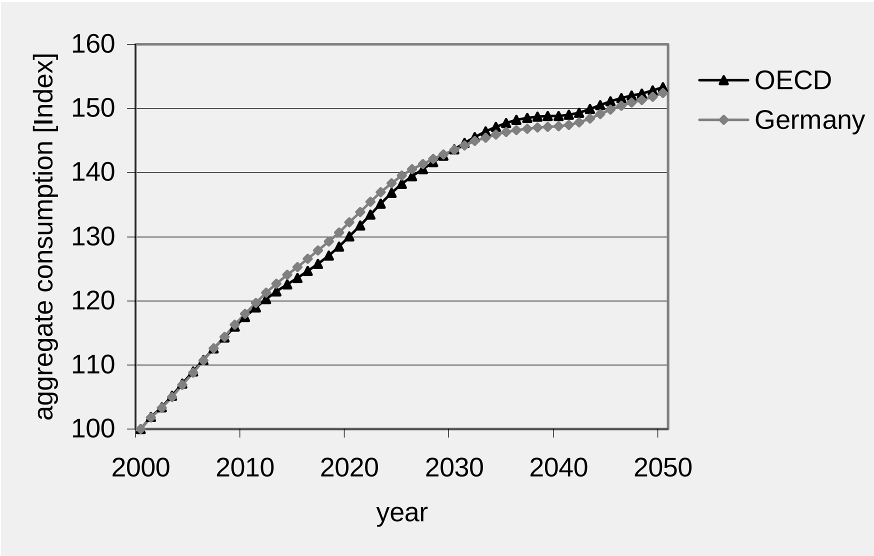
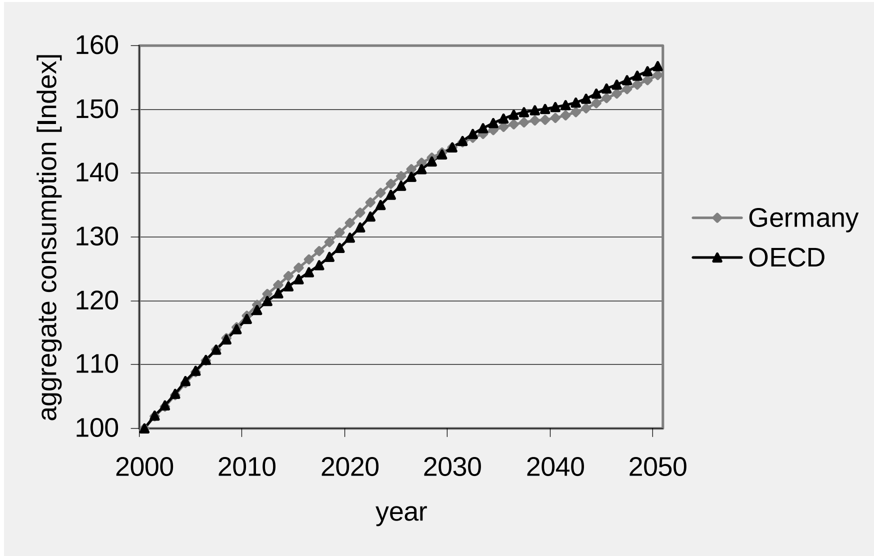


Figure 8b: Fundamental pension reform



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 (1998).

Figure 9: Changes in discounted life-time utility of German households induced by a fundamental pension reform

Figure 9a: Cohorts born between 1925 and 2050

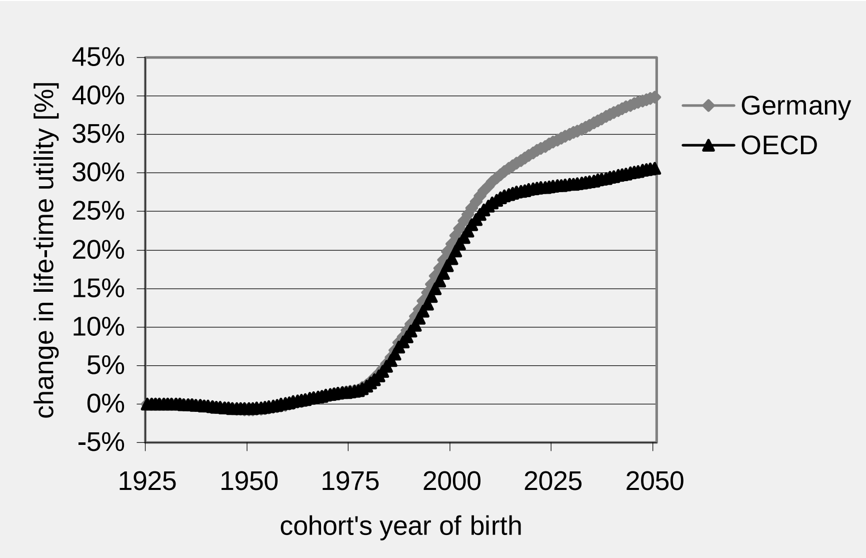
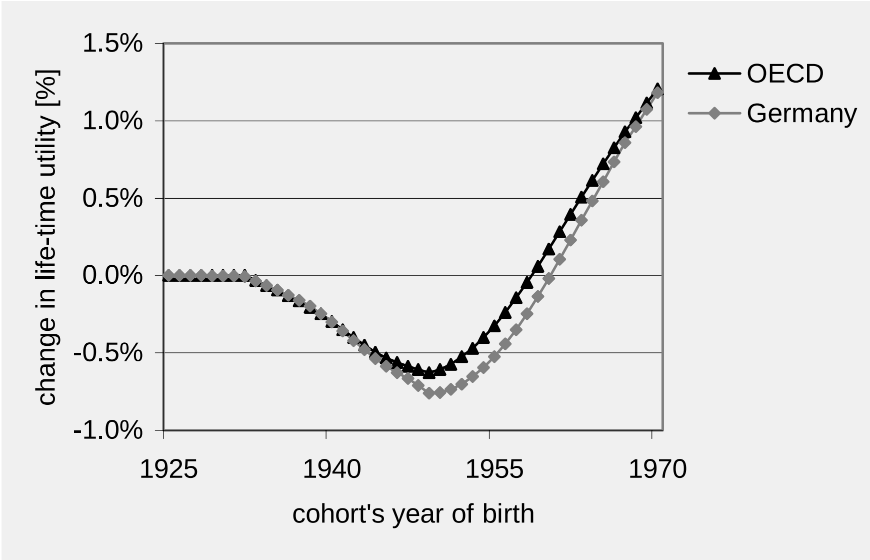


Figure 9b: Cohorts born between 1925 and 1970



Notes: This figure shows percentage changes in discounted life-time utility of German households by cohorts' year of birth. 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 (1998).

Figure 10: Changes in discounted life-time utility of households in the EU 14 area (without Germany) induced by a fundamental German pension reform

Figure 10a: Cohorts born between 1925 and 2050

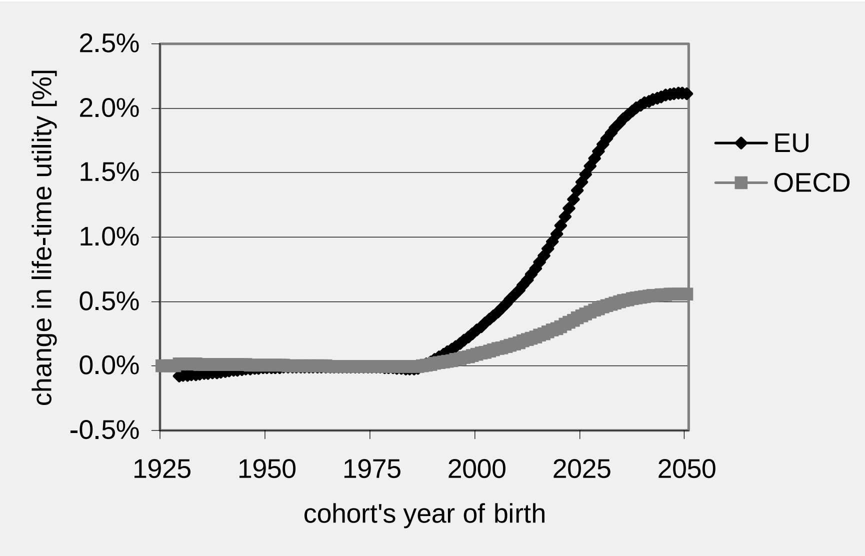
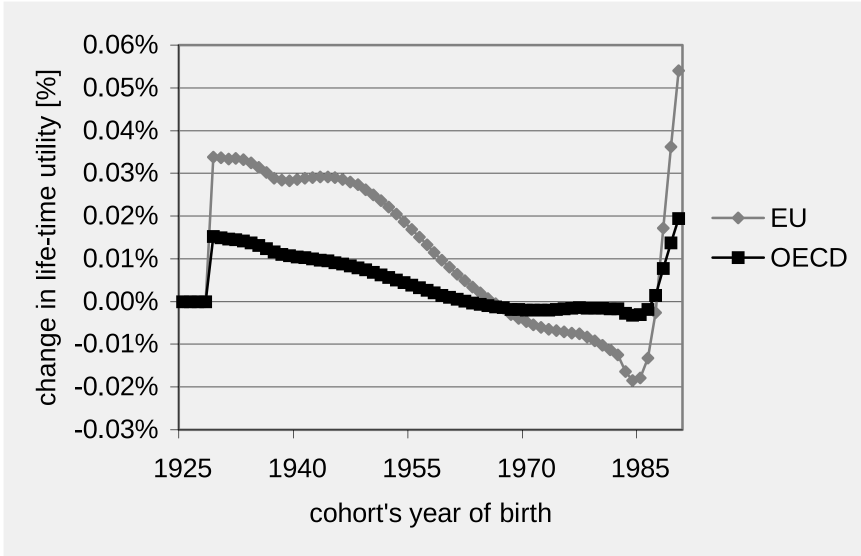
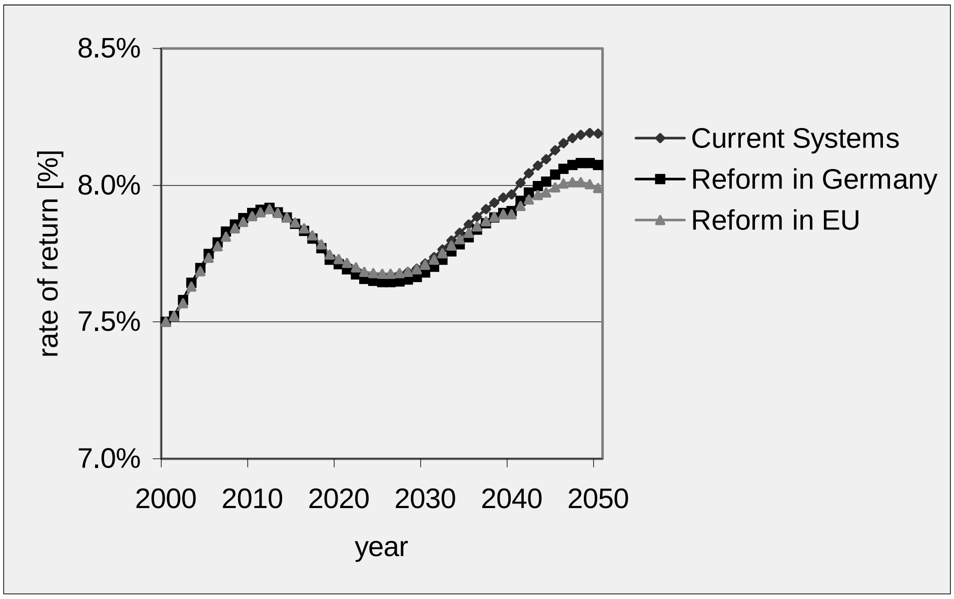


Figure 10b: Cohorts born between 1925 and 2000



Notes: This figure shows percentage changes in discounted life-time utility of households of the European Union by the cohort's year of birth. Pension reform only in Germany.
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 (1998).

Figure 11: Projections of the rate of return on capital under alternative pension system scenarios and perfect capital mobility in the EU



Notes: This figure shows projections of the rate of return on 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 (1998).

Table 1: Calibration of parameters in the overlapping generations model

α: output share of capital in the CES production function	0,4099
β: elasticity of substitution in the CES production function	0,9990
g: rate of technological progress	0,014
δ: depreciation rate of capital	0,05
ρ: rate of time preference	0,08
σ: elasticity of intertemporal substitution in consumption	3

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