Aging, Asset Markets, and Asset Returns

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1. Introduction

Population aging will be a major determinant of long run economic development in industrial and developing countries. The extent of the demographic changes is dramatic in some countries and will deeply affect future labor, asset, and goods markets. The expected strain on public budgets and especially social security has already received prominent attention, but aging poses many other economic challenges that threaten productivity, growth, and financial stability if they remain unaddressed. There is no shortage of policy proposals to address population aging. However, most of those are focused on pension and labor market reform, and little is known about behavioral reactions to such reforms.

The paper shows that such behavioral reactions have important implications for predicting macroeconomic aggregates. It connects several strands of the literature. First, it investigates how strong "asset meltdown" effects are in an aging economy that is embedded in global financial markets. We therefore link a neoclassical model of returns to capital with a model of global financial equilibrium. Second, the paper investigates which effects pension and labor market reforms have on capital accumulation and rates of return. This links financial markets to labor force participation and saving behavior. Third, as it turns out, predicted financial market performance is quite sensitive to labor supply behavior which in turn is reacting to labor market and pension reform. We therefore finish the paper by modeling potentially adverse behavioral reactions to pension and labor market reform, and investigating the implications for asset market returns.

Most results of this paper refer to the union of the three largest Continental European countries. France, Germany, and Italy have large pay-as-you-go pension systems and vulnerable labor markets. They are aging quickly and have low labor force participation rates. In some respects (quickly aging and large pay-as-you-go pension systems) they very much resemble Japan. In other respects, they are quite different from Japan, particularly concerning old age labor force participation. Due to the low female labor force participation, however, the overall "support ratio" (working age population divided by adult population) is quite comparable to the union of France, Germany, and Italy, see figure 1. Our main lessons therefore also hold for Japan.

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Figure 1: Working age population divided by population age 15+
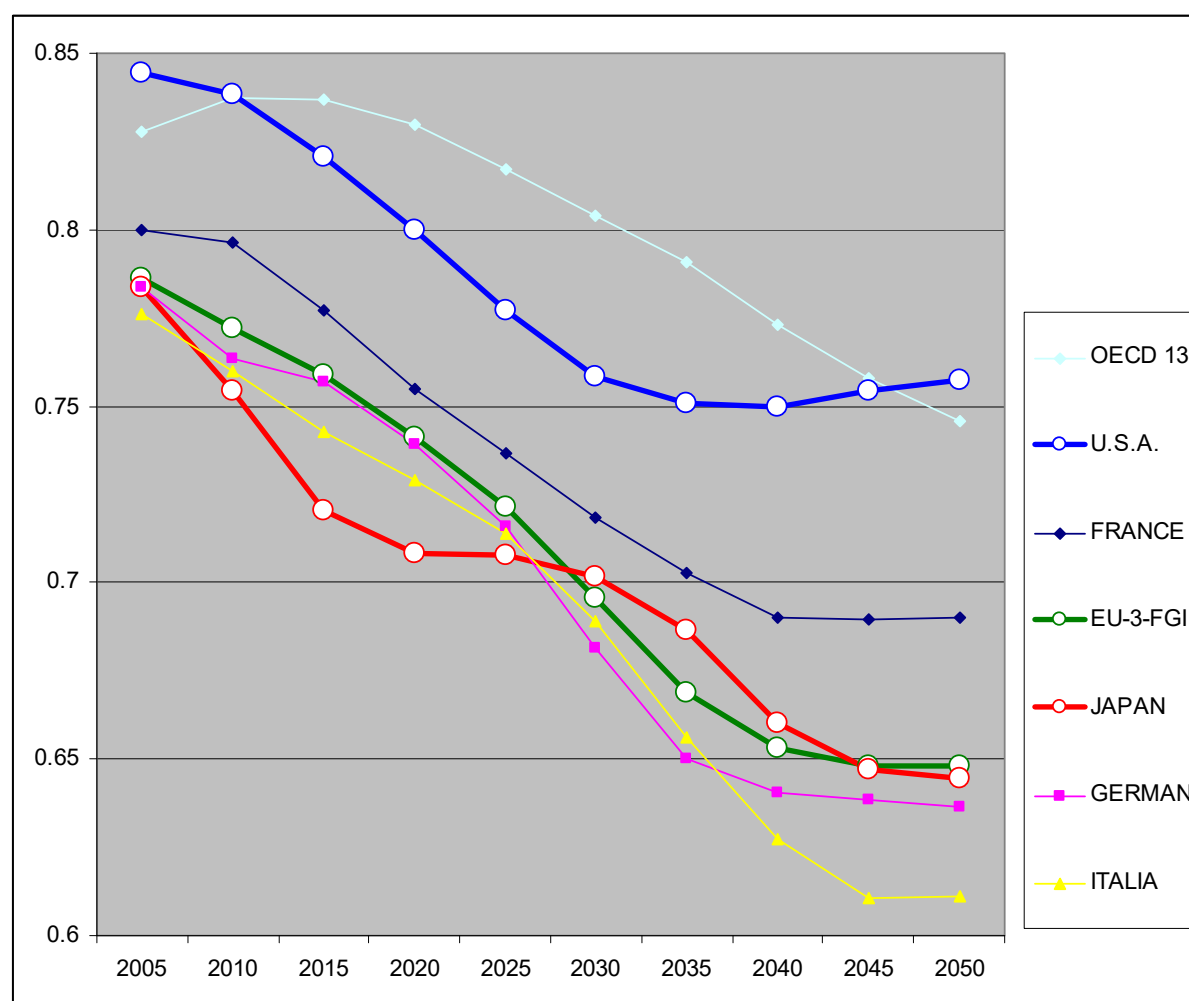
Source: Börsch-Supan, Ludwig and Winter (2007), based on demographic projections of the United Nations (2002).

Aging has complex effects on the markets for real capital – capital used in the production of goods and services, and housing capital. If elderly people save less than younger people, an aging society saves less. This should increase interest rates since supply of funds gets tight. At the same time, the younger generation becomes ever smaller, so there is also less demand for new investment. The equilibrium effect is thus uncertain.

Pessimists believe in the so-called "asset meltdown" hypothesis: households demand for financial assets will plummet between 2030 and 2040, when the baby boomers retire and die, asset values will melt down dramatically and the return on financial investments will fall sharply.

Optimists stress economic mechanisms which soften or even reverse the negative impacts of aging on capital markets. One such important counter-mechanism is an aging society's need for more capital since capital must increasingly substitute for labor. This rising demand for

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real capital increases the return to capital at exactly the same time as pessimists fear the prospect of an asset meltdown.

In order to be able to judge whether the pessimists or the optimists are right, we quantify the potential effects of aging on asset prices using a sophisticated overlapping generations (OLG) model with international diversification reflecting the global nature of the markets for productive capital. The results from this model indicate that there will be some decline in the value of productive capital, but it is small in any case and even smaller when capital is globally diversified. So aging is not as damaging as the pessimists make believe, but markets for productive capital are not immune to demography, as some optimists claim.

Returns on real estate will be more affected by the demographic trend because there is much less room for diversification and because housing cannot substitute for scarce labor. The pessimism of Mankiw and Weil (1989), however, who made the asset meltdown hypothesis popular in the USA, appears to be misguided. Since household size lags population size by about 20 years, housing demand will only begin to fall from 2025 onwards even if populations start declining today. Thereafter housing demand will drop very gradually such that house prices will not fall dramatically over the next 30 years. Mankiw and Weil's (1989) estimate of a housing price drop between 1990 and 2010 to half of their original levels will certainly not materialize.

In order to rest these findings on a solid foundation, the chapter proceeds as follows. Section 2 collects the major findings of earlier studies on this topic. Section 3 presents several variants of our model. Section 4 analyses accumulation and returns on the markets of productive assets under the common assumption that labor supply is fixed. Section 5 investigates the sensitivity to this assumption, and finds that results are highly sensitive to it. Section 6 therefore looks at behavioral reactions to pension and labor market reforms and its implications for asset market returns. Section 7 summarizes our results with a view on economic and social policy implications.

2. The asset meltdown debate

A spectacular fall in the price of assets as a result of demographics was predicted for the first time in 1989 by Mankiw and Weil for the real estate market in the United States. Mankiw and Weil used cross-sectional data on real estate assets from the 1970 US census to develop an age profile of the demand for property. Their demand forecast is based on the assumption that this age profile remains constant and it is only the size and age structure of the US population that will change. Based on the historical correlation for the growth in demand with the price

index for investments in residential buildings, Mankiw and Weil conclude that the demand for residential property must increase by approximately 1.5% per year to keep prices constant. However, the demographically controlled demand variable shows consistently lower growth rates for the period 1990 - 2010. This forecast discrepancy exercises enormous price pressure on the residential property market. The point estimate by Mankiw and Weil implies a 47% price fall within 20 years.

The study provoked a large number of very critical comments, which ultimately cast considerable doubt on whether the forecasts by Mankiw and Weil (1989, 1992) are sustainable. Woodward (1991) grouped together the main points of criticism in the first series of responses refuting the study. For instance, both Hamilton (1991) and Hendershott (1991) criticized the fact that the estimates of Mankiw and Weil imply that, even if demand remains at a constant level, the prices would fall by 8%. This implausible linear time trend has a much greater influence on the forecast than the decline in the growth for demand from 1.6% at the start of the 1980s to around 0.6% in approximately 2000. Swan (1995) criticized that not only were the effects of a long-term rise in real income completely ignored but the supply side of the residential property market was also not taken into account.

Engelhardt and Poterba (1991) also cast doubt on the findings of Mankiw and Weil. They made an equivalent analysis for Canada, a country with demographic trends that very largely mirror those in the USA. The age profile for real estate assets in Canada also broadly corresponds to the equivalent figures in the USA. In spite of this, Engelhardt and Poterba could not find that demography had any similar influence along the lines identified by Mankiw and Weil.

More recent research has shown how important cohort effects are. When Mankiw and Weil used cross-sectional data to analyse the demand for residential property over the life cycle they ignored the effects of income and the cohort group, which have proved to be very important in quantitative terms. In cross-sectional data, i.e. in data from many people at a single point in time of observation, it is not possible to decide whether a person saves too much because they are old (age effect) or because they were born a long time ago at a time when, for instance, thrift was considered to be particularly virtuous (cohort effect).

If one applies this approach to demand for residential property, it cannot be ascertained whether a person uses a small amount of living space because they do not need a large apartment when they are old or whether they do not need a large apartment in old age because at the time when they purchased their apartment they did not have enough real income to afford a large apartment. In their analysis, Mankiw and Weil present the cross-sectional

profile of real estate assets in 1980 by way of comparison. However, the assets values of census data in 1980 were on average more than 50% above the 1970 sample group for each age group. When it comes to using demand profiles for fairly long-term forecasts, the order of magnitude of 50% shows the quantitative significance of income-related effects, in particular, but also other cohort effects. The increase in the assets profiles of all age groups between 1970 and 1980 illustrate the dimension in which the demand for real estate could also change in the future.

Studies made in the United States of America that adopt a more careful approach than Mankiw and Weil verify that, for just these reasons, the estimates of age-specific demand for residential accommodation are distorted and a possible "asset meltdown" effect is greatly exaggerated - for example, see Venti and Wise (1990), McFadden (1994), and Skinner (1996). Section 4 will apply a similar approach for Germany.

The ultimate judge, of course, is time. Hence it is worth noting that the forecasted "asset meltdown" which should have occurred between 1990 and 2010 in the US has simply not occurred until 2006, neither during the boom in equity markets (which is easy to explain), nor since the bubble burst (which is more significant).

Turning to productive capital, the most familiar study based on empirical data of saving behavior over the life cycle is the analysis by Poterba (2001). It derives a demand variable from the shift in the aging structure of the population, which is produced from an estimated life cycle savings profile. In contrast to Mankiw and Weil, Poterba estimates the demand from the various age classes in a model which permits explicit cohort effects. The estimated asset profile in old age is very largely flat - a result that has already been documented by other authors. Poterba uses a series of further demographic variables which can explain the accumulation of savings in a society. For long time series he finds hardly any indications that demography influences returns on equity investments and only minimal indications of such influences on the market for secure interest-bearing securities. It was only for the price-earnings ratio of equities that Poterba found demography had historical influences but these were not stable. The estimated parameters led Poterba to the conclusion that a demographically induced fall in prices on capital markets, as had been predicted by Mankiw and Weil for the real estate market, is extremely unlikely.

Abel (2001) criticized Poterba's analysis. He sets up a theoretical model in which the households are interested in the well-being of their heirs and thus possess an inheritance motive. He shows that it is entirely possible for an asset meltdown to be consistent with a flat asset profile in old age. Although the demand of the old generation for capital is not falling, a

demographically induced fall in prices could be brought about through lower savings by the younger generation. However, there is no evidence that the amounts to be inherited will fall with the number of children. Abel's theoretical countermechanism to Poterba's analysis thus seems to be of little empirical relevance.

3. The MEA-OLGA model variants

Savings, capital returns and international capital flows are the outcome of complex interactions between supply and demand on German and international capital markets, influenced by demography and the capital and goods markets. Initial theory-based models to estimate the effects of demographic changes on the development of returns on productive capital can be found in Cutler et al. (1990), Börsch-Supan (1996), and Reisen (2000). More recent work is based on models of overlapping generations (OLG). Such models have a long tradition. They were developed as theoretical models by Samuelson (1958) and Diamond (1964) and extended by Auerbach and Kotlikoff (1987) to be used for the first time in a near-reality computer simulation model. Since then, such models have undergone considerable development processes, enabling them to mirror reality more closely. The models have increasingly developed from semi-theoretical analytical tools to genuine forecasting and simulation models.[1]

In the sequel of this section, we employ the next generation of OLG models characterized by the implementation of realistic demographic data (Börsch-Supan, Ludwig and Winter, 2002; INGENUE, 2002; Börsch-Supan, Heiss, Ludwig and Winter, 2003; Börsch-Supan, Ludwig and Winter, 2003, Börsch-Supan, Ludwig and Winter, 2007, Börsch-Supan and Ludwig, 2008). The MEA-OLGA simulation model, as we call our incarnation of this model type, was the first that combines three crucial features:

- it has a detailed annual account of past and future demography;

- it is not restricted to one country but also covers international trade and capital movements;

- it features a variety of labor supply assumptions from fixed to fully flexible labor supply, including a mixture of exogenous and endogenous labor supply components.

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[1] Similar multi-country OLG models have been developed, among others, by Feroli (2002), Henriksen (2002), Brooks (2003), Domeij and Floden (2006), Attanasio, Kitao and Violante (2006, 2007) and Krüger and Ludwig (2007).

We are taking a long-term perspective, abstain from all short-term considerations which also justifies the assumption that exchange rates have no role to play in our real economic model.

(a) How households behave when labor supply is fixed

In a first simple version of the model households offer a fixed amount of work. They divide their income into consumption and savings according to the life cycle hypothesis. Consumption c_t is smoothed by long-term planning so that it greatly depends on consumption in the preceding period c_{t-1}. Impatient consumers (their discount rate ρ exceeds the market rate r_t) initially consume a large amount while patient households initially save and their discount rate of ρ is lower than the market interest rate r_t. Consumption c_t follows the well-known Euler equation in which the ratio between the discount rate and the market interest rate is weighted by the parameter σ, which states the extent to which households react to deviations between the discount rate and the market interest rate:

$$c_t = c_{t-1} \cdot \left(\frac{1+r_t}{1+\rho} \right)^{1/\sigma}$$

This consumption equation implicitly also describes the savings decision because current after tax and transfers income y^{net}, defined below in more detail, minus expenditure on consumption equals savings. This is added, with interest, to obtain the assets a_{t+1} of the next period:

$$a_{t+1} = a_t \left(1+r_t \right) + y_t^{net} - c_t$$

Savings are invested in productive capital. These investments can either be in the own country or abroad. Financial capital moves to where the returns, after adjustment for risk and tax, are the highest and this remains so until the balance between risk- and tax-adjusted returns is the same in all countries.

(b) How households behave when labor supply is endogenous

In a more sophisticated version of the model (see Börsch-Supan and Ludwig, 2008), labor supply has an endogenous and an exogenous component. While we treat labor market and pension reforms and the resulting variation in employment numbers as exogenous, households in this version of our model endogenously adjust hours worked and may thus counteract parts of the reforms.

Our main assumptions on this interplay between the exogenous variation of employment numbers and hours worked are as follows. We model the decision of a household with preferences over consumption and leisure. Total labor supply of a household of age j as derived from the household's optimization is the product of exogenous employment numbers

l_j, and the endogenous decision on hours worked at age j, h_j. The crucial difference between the two labor supply components is that hours worked may not exceed the time endowment (which we normalize to one) while employment numbers l_j, can take any positive value.

As the age-specific employment l_j is exogenously increased, e.g., due to an increase in the retirement age, the household endogenously decreases hours worked, h_j. In the absence of any constraints, the two components of labor supply are perfect substitutes such that the exogenous variation of l_j leaves the labor supply of the household unaffected. However, the exogenous variation of l_j affects total effective labor supply for those households for whom the time endowment constraint is binding. As a consequence, the exogenous employment variation of l_j has some effect on aggregate effective labor supply but the overall effect is substantially smaller than in an alternative specification of our model with fully exogenous labor supply where

We now describe this mechanism in detail. An exogenous fraction $l_{t,j,i}$ of each household supplies work. This fraction of the household endogenously decides on the hours of work $h_{t,j,i}$. The other fraction of the household, $1-l_{t,j,l}$, does not work and fully enjoys leisure. Accordingly, total labor supply of a household is given by the product of the two components, $l_{t,j,i} \cdot h_{t,j,i}$ and total leisure is therefore $1-l_{t,j,i} \cdot h_{t,j,i}$ whereby we restrict time endowment to one.

The household derives utility from consumption $c_{t,j,i}$ and leisure $1-l_{t,j,i} \cdot h_{t,j,i}$ and the household's per period utility function is given by

$$u(c_{t,j,i}, 1 - h_{t,j,i} \cdot l_{t,j,i}) = \frac{1}{1-\theta} \left(c_{t,j,i}^{\phi} \left(1 - l_{t,j,i} h_{t,j,i} \right)^{1-\phi} \right)^{1-\theta}.$$

The maximization problem of a cohort born in period t at $j=0$ is given by

$$\max \sum_{j=0}^{J} \beta^j \pi_{t,j,i} u\left(c_{t+j,j,i}, 1 - l_{t+j,j,i} h_{t+j,j,i} \right),$$

where β is the pure time discount factor. In addition to pure discounting, households discount future utility with their unconditional survival probability in period, $\pi_{t,j} = \prod_{k=0}^{j} s_{t+k,k}$.

A feature of our model is uncertainty about the time of death expressed in the term $\pi_{t,j,i}$ in equation (5). We assume that accidental bequests resulting from premature death are taxed by the government at a confiscatory rate and used for otherwise neutral government consumption.[2] We do not include intended bequests in our model.

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[2]   An alternative assumption would be to redistribute accidental bequests to the population according to some scheme. The redistribution would however not affect our results much and we therefore opted for this simplifying assumption.

Labor productivity changes over the life-cycle according to age-specific productivity parameters ε_j. Hence, the age-specific wage is $w_{t,j,i} = w_{t,i} \cdot \varepsilon_j$.

Denoting total assets by $a_{t,j,i}$, maximization of the household's intertemporal utility is subject to a dynamic budget constraint given by

$$a_{t+1,j+1,i} = a_{t,j}(1+r_t) + \lambda l_{t,j,i} h_{t,j,i} w_{t,j,i}(1-\tau_{t,i}) + (1-\lambda) p_{t,j,i} - c_{t,j,i},$$

where $\lambda=1$ for $j=0,\ldots,jr$ and $\lambda=0$ for $j>jr$ and jr is the exogenous retirement age. $\tau_{t,i}$ is the contribution rate to a PAYG financed public pension system and $p_{t,j,i}$ is pension income, see below.

Furthermore, maximization is subject to the constraint that hours worked are positive and may not exceed one, hence,

$$0 \le h_{t,j,i} \le 1.$$

(c) Pensions and government

The only purpose of the government in our model is to organize a prototypical public pension system that is pay-as-you-go financed and provides flat (i.e. not earnings-related) pension benefits. We assume that the budget of the pension system is balanced in all *t,i* such that

$$\tau_{t,i} w_{t,i} L_{t,i} = \sum_{j=jr+1}^{J} p_{t,j,i} N_{t,j,i} = \rho_{t,i} w_{t,i}(1-\tau_{t,i}) \sum_{j=jr+1}^{J} N_{t,j,i},$$

where $\rho_{t,i}$ denotes the net replacement rate and $\tau_{t,i}$ the contribution rate of the pension system in *t,i*. Households consider the contributions as pure taxes.

The main policy parameter is the net replacement rate ρ; the contribution rate τ responds passively to balance the pension system's budget. If ρ is large, public pensions crowd out private saving through the households consumption/saving decision. Moreover, since the benefits are not related to individual earnings, we consider the contributions to the pension system as pure taxes with the associated labor supply distortions which work through the households labor supply decision.

If $\rho = 0$, all old age provision will be private savings. This represents the textbook life-cycle model in which intertemporal consumption smoothing over the life cycle provides the retirement income through saving in young age and dissaving after retirement.

Pension reform is modeled as a reduction of the net replacement rate ρ. We will consider three cases:

- FLATSS: maintaining the current country-specific replacement rates also in the future ($\rho_{t,i} = \rho_{2005,i}$ for *t>2005*),

- FREFORM: freezing the contribution rates for the future ($\tau_{t,i} = \tau_{2005,i}$ for $t>2005$),

- SAVING: abolishing the public pension system altogether ($\rho_{t,i} = 0$) so that all age provision is private savings.

(d) Production side, capital market and overall economic balance

On the production side, capital and work are used as a substitute so that the wages correspond to work productivity and the capital return corresponds to capital productivity. We are modelling this using a so-called Cobb-Douglas production function, which converts GNP $Y_{i,t}$, - work $L_{i,t}$ and capital $K_{i,t}$ in units of goods and services produced. Here the indices t and i stand for year *t* and country *i*.

$$Y_{t,i} = F\left(K_{t,i}, \Theta_{t,i} L_{t,i}\right) = K_{t,i}^{\alpha} \left(\Theta_{t,i} \sum_{a=1}^{65} \varepsilon_a L_{t,a,i}\right)^{1-\alpha}$$

All countries have the same production technology F, but labor productivity varies $\Theta_{i,t}$. Also, the entire workforce $L_{i,t}$ is composed of the various age groups $L_{i,a,t}$, whose age-specific productivities ε_a correspond to the average wage profile.[3]

The different productivity levels $\Theta_{i,t}$ correspond to the different per capita gross domestic products. The available quantity of work $L_{i,a,t}$ is derived from the demographic assumptions.[4]

Wages and interest rates are determined in such a way that they correspond to work productivity and capital productivity, respectively. In particular, the interest is produced from the marginal productivity of the capital deployed minus the rate of depreciation δ:[5]

$$r_{t,i} = f'\left(k_{t,i}\right) - \delta$$

and the investments made in the domestic economy from the net change of the domestic capital stock:

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

Capital $K_{i,t}$, which is used in a country for production does not have to correspond to the assets that the inhabitants of this country have accumulated and which we have described as A_t. The difference

$$V_{i,t} = A_{i,t} - K_{i,t}$$

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[3] Rising until the age of 55 and then constant.
[4] See Börsch-Supan, Ludwig and Winter (2003) for a description of the demographic assumptions.

[5] To be more precise: From the marginal productivity of capital deployed per efficiency unit of work, therefore k=K/ΘL. The depreciation rate δ is assumed to be constant and uniform.

is represented by the assets abroad. If more is saved than invested, the capital flows abroad - for instance, in the form of direct investments - as described above, in other words until the returns, adjusted for risk and tax, have converged in all countries. The current account surplus is therefore

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

If one takes all the regions of the world together, both the international capital flows and the net external positions of the various countries must cancel each other out overall, because the regions of the world form a closed economy. This is one of the key conditions for the equilibrium of international trade and our model:

$$\sum_{i=1}^{R} V_{t,i} = 0$$

(e) How international equilibrium is attained:

More precisely, given initial capital stocks $K_{0,i}$, a competitive equilibrium of the economy is defined as sequences of disaggregate variables for the households, $\{c_{t,j,i}, l_{t,j,i}, h_{t,j,i}, a_{t,j,i}\}$, sequences of aggregate variables, $\{C_{t,i}, L_{t,i}, K_{t,i}\}$, prices for labor as well as contribution rates to the pension system, $\{w_{t,i}, \tau_{t,i}\}$, in each country i, and a common world interest rate $\{r_t\}$ such that

1. given prices and initial conditions, households maximize life-time utility subject to their budget and hours constraints;

2. factor prices equal their marginal productivities;

3. pension policies satisfy the pay-as-you-go government budget equation in every period;

4. national labor markets clear in all time periods

$$L_{t,i} = \sum_{j=0}^{J} \varepsilon_j l_{t,j,i} h_{t,j,i} N_{t,j,i} \quad \text{for all } t,i$$

5. global capital markets clear in all time periods

$$\sum_{i=1}^{I} K_{t+1,i} = \sum_{i=1}^{I} \sum_{j=0}^{J} a_{t+1,j+1,i} N_{t,j,i}$$

6. global consumption plus global net investment equals global production in all time periods

$$\sum_{i=1}^{I} \sum_{j=0}^{J} c_{t,j,i} N_{t,j,i} + \sum_{i=1}^{I} K_{t+1,i} = \sum_{i=1}^{I} \Omega_{t,i} K_{t,i}^{\alpha} L_{t,i}^{1-\alpha} - (1-\delta) \sum_{i=1}^{I} K_{t,i}.$$

(f) How international capital movements are modeled:

We first applied the MEA-OLGA model to three scenarios for capital mobility: firstly, to Germany as a closed economy; secondly, to Germany as an open economy with perfect capital mobility within the other countries of the EU; thirdly, with perfect capital mobility within the other countries of the whole OECD. Perfect mobility of capital within the OECD may be an exaggerated assumption but not so within the EU, because by far most of the flows of capital are within the Eurozone where there is free movement of capital. This also justifies the assumption that exchange rates have no role to play in the MEA-OLGA model. In addition, the model describes the very long-term trends in capital movements. Whereas the short-term exchange rate induces flows of capital movements which, although considerable, are of short duration and of less interest to us in the context of demography, the long-term exchange rate and the long-term capital flows are determined jointly by the fundamental variables of demography and overall economic development.

(g) Calibration

The MEA-OLGA model is matched to the overall economic patterns from 1970 to 2000, i.e. the model parameters are selected in such a way that the historical development is mapped as successfully as possible ("calibration by backcasting").

In order to capture projected international differences in demographic change and the generosity of public pension systems, we distinguish seven world regions in the benchmark scenario: (i) France, (ii) Germany, and (iii) Italy as three large European countries severely affected by population aging, (iv) the remainder of the European Union, (v) North America (the US and Canada), (vi) the remaining OECD countries, and (vii) all other countries in the world. While we treat France, Germany, and Italy as separate regions in the simulations, we simplify the presentation of most of our simulation results by aggregating them into a combined France-Germany-Italy region.

Our demographic model for these regions is calibrated to fit the United Nations (2001) projections. These projections end in 2050. Between 2050 and 2100, we continue the linear increase in life-expectancy assumed by the UN and impose constant fertility rates at the levels reached in 2050. During the phase-out period of the model beyond 2100, demographic processes stabilize such that stable populations are reached at 2200.[6]

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[6] Population data for 1950-2050 are given at an annual frequency for five-year age-groups. Further input data such as age-specific mortality rates, life expectancy, and aggregate migration is only given at quinnquennial frequency. We interpolate between age groups and time intervals and "backfit" our population model to the UN population data for the time period 1950-2050.

PAYG pension systems are calibrated with data on replacement rates taken from Palacios and Pallarès-Miralles (2000) and employee's social security contributions taken from OECD (2001). We solve for equilibrium contribution rates using the PAYG budget constraint.

Further parameters of the model are the households' preference parameters, the parameters of the production function, and values of the age-specific productivity profile. For the latter, we use the cohort-corrected non-linear regression estimates by Fitzenberger, et al. (2001). This provides us with a representative age-wage profile that peaks at the age of 52 and then decreases slightly.

With two exceptions, technological and preference parameters are assumed to be constant and equal across all countries. The growth rate of productivity, g, is set to 1.5 percentage points which is slightly higher than the value of 1.4 percentage points suggested by Cutler, et al. (1990) and closer to the long-run projections suggested by the OECD. The capital share parameter, α, is set to an intermediate value of 0.35. The annual depreciation rate, δ, is assumed to be 5 percentage points per year.

The adjustment cost parameter, ψ, is set to the value of $\psi=1.5$ and results in a steady state value of Tobin's q of 1.0975 which is in the middle of the values used in the literature. As we show in an extensive sensitivity analysis (Börsch-Supan, Ludwig, and Winter, 2004), adjustment costs allow us to study the time paths of the price of capital, but otherwise do not affect the long-run equilibrium results much.

The discount rate in all countries, ρ, is set to 0.01 which is close to the estimate 0.011 of Hurd (1989). With this choice – and given all the other parameter values – our model produces an average capital to output ratio of about 2.9 for the region "European Union" in the calibration period 1960-2001. While comparable capital-output ratios for a large cross-section of countries are not available, a value of 2.9 is reasonable for many countries (OECD, 2003). The coefficient of relative risk aversion is set to 2. We follow Altig, et al. (2001) in choosing the value for the intra-temporal substitution elasticity $\xi = 1/(1+\gamma) = 0.8$.

Levels of total factor productivity, Ω_i, vary across countries and are calibrated such that the model replicates output data in each country for the period 1960-2001.[7] Consumption share parameters, $\omega_{i,a}$, vary across country and age such that the simulation model approximately replicates aggregate labor supply as well as labor supply profiles across ages in each country for the period 1960-2001.

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[7] Since there is no government consumption in our theoretical model, we define output as the difference between actual GDP and government consumption.

A final remark concerns the initial values of the model for the year 2002 under the different capital mobility scenarios. Conceptually, it is problematic to simulate a calibrated macroeconomic model under policy scenarios other than the one for which it was calibrated. In our case, the world for which we calibrate the model changes with the number of regions considered in the capital mobility scenarios. On the one hand, it would make sense to adjust the calibration parameters each time we change the number of 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 and since we are primarily interested in the reaction of households to demographic change and fundamental pension reform, we keep parameter values constant across all capital mobility scenarios. We calibrate the model under the assumption that the "OECD" capital mobility scenario correctly reflects the "true" world and therefore that all other capital mobility scenarios are "counterfactual" worlds. The careful reader will note that this procedure results in differences in the values of the simulated variables in 2002, the base year of our simulations.

4. Asset accumulation and asset returns when labor supply is fixed

How will demographic change affect asset accumulation and asset returns? Since speed and extent of demographic change varies across the world regions, we would observe differential impacts of demographic change on rates of return to capital in each region if the regions were closed economies.

In a world of open economies, however, these differences in rates of return will induce international capital flows which will reduce these differentials. In order to illustrate the influence of free capital mobility across regions, we build four capital mobility scenarios from the point of view taken by the three largest economies in continental Europe (France, Germany, and Italy). The first scenario corresponds to a closed economy where all investment of France, Germany, and Italy takes place within these three countries. The other three capital mobility scenarios open this closed economy sequentially up: France, Germany, and Italy diversify their investments (i) across all countries of the European Union, (ii) across all OECD countries, and (iii) across the entire world.

In order to build our results up step by step and maintain as much transparency as possible, this section begins with a world in which labor supply is fixed. Results are presented in

Figures 2 through 5 and display four lines representing these four capital mobility scenarios. The benchmark scenario assumes that capital mobility is restricted to the OECD area.[8]

In addition to these *direct* effects of demographic change, there are *indirect* effects due to the presence of (partially) PAYG financed social security systems. In order to separate the direct effects of population aging on capital markets and potential feedback effects from the existence of pension systems and pension reform, we present our main results for two hypothetical pension policy scenarios described above: (a) the "old system scenario" that maintains these countries' current generous public pension systems, and (b) the "reform scenario" that introduces a transition to a partially funded pension system by freezing contribution rates in these three countries. The other regions' pension systems remain unchanged. By comparing these polar scenarios, we can show that a good portion of the capital market effects of population aging arise even without a fundamental pension reform. Accordingly, the figures below have two panels. Panel (a) corresponds to the "old system scenario", i.e., the direct effects of demographic change, and Panel (b) shows the differences between these two scenarios, i.e., the indirect effects of a fundamental pension reform induced by demographic change.

The interplay between these direct and indirect effects of population aging on macroeconomic variables is complicated because they involve changes in *levels* and *trends*. *Direct level* effects are due to differences in the levels of working-age population ratios across countries. Younger economies, i.e. economies with higher working-age population ratios, have higher marginal productivities of capital that will be arbitraged away by international capital flows. Over time, *direct trend* effects are at work that are related to the speed of demographic change and affect the dynamics of macroeconomic variables: working-age population ratios decrease, capital-output ratios therefore increase and both the rates of return and the savings rates decline.

The indirect effects of PAYG financed pension systems are due to their "crowding out" effect on private savings by providing old-age pension income and their distorting taxation of labor income. By replacing private savings, the *indirect level effect* of PAYG financed pension income works in the opposite direction than the direct effect of demographic change. Relative to a situation without PAYG financed pension systems, the indirect effect decreases the

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[8] We choose this capital mobility scenario as our benchmark scenario for two reasons. First, as 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, adding the additional countries of the region "Rest of the World" does not affect patterns of aggregate variables much because roughly 80 percent of world GDP is produced in the OECD and hence the additional weight of all other world regions is small in relative terms.

differences in saving rates and rates of returns between countries. Over time, old-age dependency ratios increase and therefore contribution rates to the PAYG pension system increase as well (taking PAYG replacement rates as given as we do in the old system scenario). This *indirect trend effect* is stronger in the older regions that are more severely affected by the impact of demographic change.

In order to illustrate the complicated superimposition of all these direct and indirect level and trend effects, the presentation of our results proceeds in several steps. Throughout, we focus on the economic consequences of aging and of fundamental pension reform on the continental European region consisting of France, Germany, and Italy. As our point of departure, we analyze the impact of the exogenous demographic change on working age population and old-age dependency ratios. We then analyze the two channels of reaction of households to demographic change and fundamental pension reforms by analyzing how labor supply and savings patterns are affected. We next turn to the firm sector and analyze the evolution of wage rates and the return to capital as well as its price, Tobin's *q*. We then focus on the difference between national saving and investment that generates international capital flows and describe how they are affected by demographic change. While our results show substantial differences of international capital flow patterns between countries of the European Union and the other world regions, there are also significant differences between countries within the different world aggregates. To highlight this aspect, we further present results on saving patterns and international capital flows for the three European countries on which we focus (France, Germany, and Italy). We conclude this section with a brief welfare analysis for households living in Germany.

4.1 Labor supply, contribution and replacement rates

These demographic changes have immediate effects on labor supply and the balance of the pension system. Labor supply shares in the three European countries France, Germany, and Italy decrease from currently 42 percent to below 36 percent in 2050. The economic dependency ratio, defined as the ratio of pensioners to workers, is projected to increase from roughly 50 percent in 2002 to about 80 percent in 2050.[9]

As a result of the decrease in labor supply shares and the resulting increase in the economic dependency ratio, the contribution rate to the PAYG pension system increases sharply under the old system scenario ("FLATSS"), i.e. if current flat PAYG pension systems were

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[9] The total sum of pensioners ("effective pensioners") as used in this section is defined as the sum of actual pensioners weighted by their age-specific pension entitlements.

maintained. These contribution rates are equilibrium contribution rates such that the budget of the pension system of each country is balanced at every point in time (implicitly including tax subsidies to the pension system).

If current generous replacement rates were maintained, our model predicts that the equilibrium contribution rate in Germany would increase from its current level of roughly 27 percent to 41 percent in 2050 – more than a 50 percent increase. The stylized pension reform ("FREFORM") freezes contribution rates at the level reached in 2006, roughly at 29 percent. As a result of this reform, average pension levels decrease: the net pension replacement rate is projected to decrease from 70 percent in 2000 to about 50 percent in 2050. Hence, for Germany, our model predicts a one-third transition towards pre-funding until 2050. Results for the other countries are similar, compare Table 2.

Households respond to these decreases in pension benefit levels not only by increasing savings, but also by increasing labor supply. The stylized pension reform would lead to quite substantial increases in aggregate labor supply. Labor supply shares are predicted to increase by more than 6.5 percent or 2.5 percentage points until 2050. This increase is roughly the same for all capital mobility scenarios. For instance, labor supply shares in the France-Germany-Italy region increase from about 36 percent in the year 2050 under the "old system scenario" to 38.5 percent under the "freezing reform scenario". As a consequence, the economic dependency ratio is projected to decrease by almost 6 percentage points. Endogenous labor supply is therefore a helpful mechanism to dampen the effects of population aging. This effect holds over the entire range of the crucial elasticity parameters in the MEA-OLGA model (Börsch-Supan, Ludwig and Winter, 2004).

4.2 Savings and capital stock

Panel (a) of Figure 2 shows the aggregate average saving rate of France, Germany, and Italy in the four capital mobility scenarios. In the year 2000, savings rates are substantially higher in the open economy scenarios than in the closed France-Germany-Italy region. This is in line with the higher rates of return realized in an open economy (see next subsection). An open economy diversifies a great deal of the demographic effects (such as a large share of older persons) that create lower saving rates and rates of return.

Figure 2: Saving rates

Figure 2a: Old system scenario
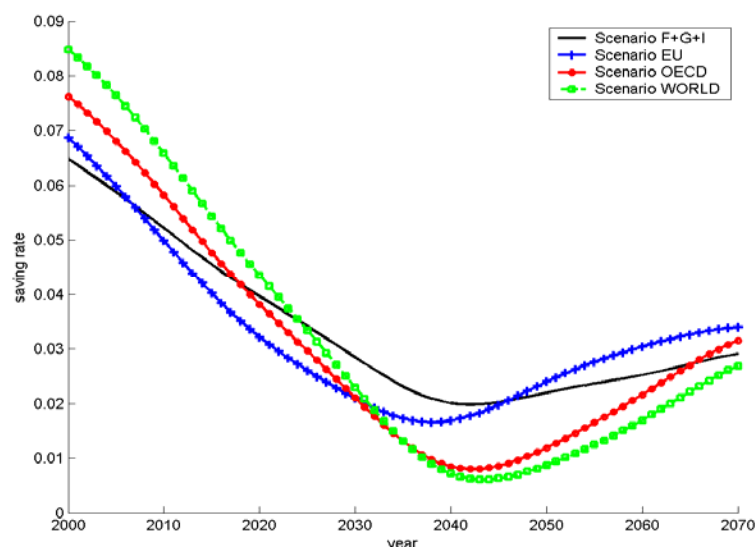
Figure 2b: Difference between freezing reform and old system scenario
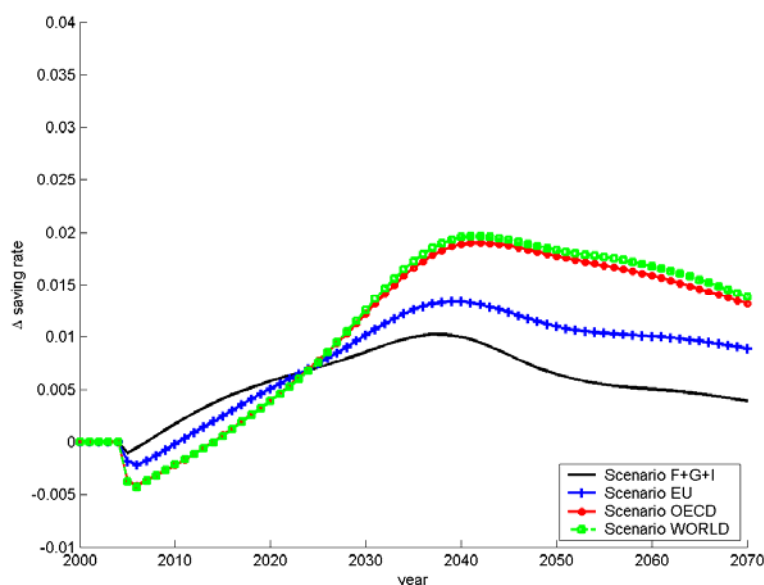
Notes: These figures show the projected aggregate saving rate of households living in France, Germany, and Italy. Scenario F+G+I: perfect capital mobility within France, Germany, and Italy; Scenario EU: perfect capital mobility within the European Union; Scenario OECD: perfect capital mobility with the OECD; Scenario WORLD: perfect capital mobility across all world regions.

Source: Börsch-Supan, Ludwig and Winter (2007).

This direct level effect is superseded by the demographic changes during the 2000 to 2070 prediction window. Saving rates decrease until 2050 across all capital mobility scenarios since the baby boom generation decumulates assets. Saving rates are projected to rebound after the year 2050. The decrease of the savings rate caused by population aging – the difference between the value in 2000 and the minimum reached just after 2040 – is roughly 4.5

percentage points if capital mobility is restricted at most to the EU region (scenarios "F+G+I" and "EU"). If we allow for capital mobility within the OECD or the entire world, this decrease is 6.5 or 8 percentage points, respectively. This larger decrease in the open economy scenarios is explained by the indirect trend effect described above. The diversification advantages of worldwide capital mobility thus decline, and saving rates respond accordingly.

Projected aggregate saving rates under a fundamental pension reform are substantially higher and the effect of a pension reform is stronger in the OECD / World open-economy scenarios (the saving rate is projected to increase by slightly more than one percentage point in the EU scenario as compared to 2 percentage points in the OECD / World scenarios). An increase in national savings leads to an increase in the capital stock and thereby to a decrease in the rate of return to capital, which then crowds out further savings. In those scenarios with a larger international capital market, substantially more savings is generated since – as we show below – the rate of return decreases by much less. 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 has often been claimed.

We also accumulate aggregate savings to obtain the world region's asset holdings and capital stocks and the related capital-to-output ratios (figures not shown). As a consequence of decreasing labor supply, the capital-to-output ratio increases from its current level of about 3 until it reaches a level of about 3.25 around 2040 and then decreases slightly when baby boomers decumulate assets (capital mobility scenario "OECD"). This decrease is much more pronounced if we restrict the international capital market to the EU area only. The simultaneous fundamental pension reform of France, Germany, and Italy leads to substantial increases in the capital-to-output ratio if we restrict capital mobility to these countries or the EU area. The increase is much lower if we relax this constraint which suggests that the additional savings shown in Figure 2 are largely invested abroad.

### 4.3 The rate of return and the price of capital

Much of the political and academic debate on the capital market consequences of demographic change and of pension reforms has focused on the rate of return to capital to which we turn next. First, we observe the same level effects as already described in the previous section. It is noteworthy that the demographic effect is larger than a second level effect. Since the PAYG systems are slimmer in the aggregate rest-of-the-world region than in

France, Germany, and Italy, the capital stock accumulated for retirement savings is larger which depresses rates of return.

Second, as a consequence of population aging and the resulting increase in capital-to-output ratios, our model predicts the rate of return of return to capital to decrease by a bit less than one percentage point if capital moves freely within the OECD, see Figure 3. This decrease is less than would be associated with a "meltdown of asset prices". Third, while the rate of return decreases across all capital mobility scenarios, substantial gains would be possible by shifting investments to 'younger' countries since our model predicts higher returns if we allow for free capital mobility across all world regions. However, as demographic processes are highly correlated across countries (compare Figure 1), differences in demographic processes across countries more or less only affect the level of the rate of return. Furthermore, diversification advantages decrease over time since the above mentioned indirect trend effects are at work as well.

Figure 3: Rate of return

Figure 3a: Old system scenario
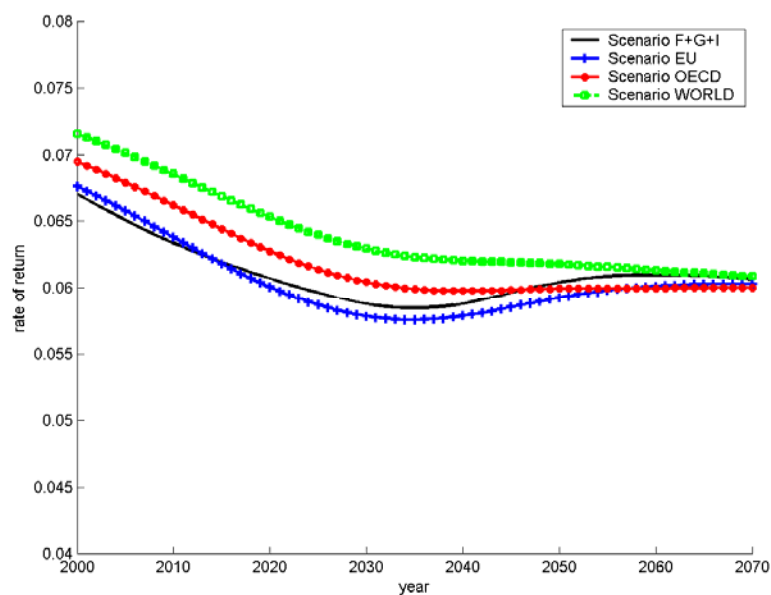
Figure 3b: Difference between freezing reform and old system scenario
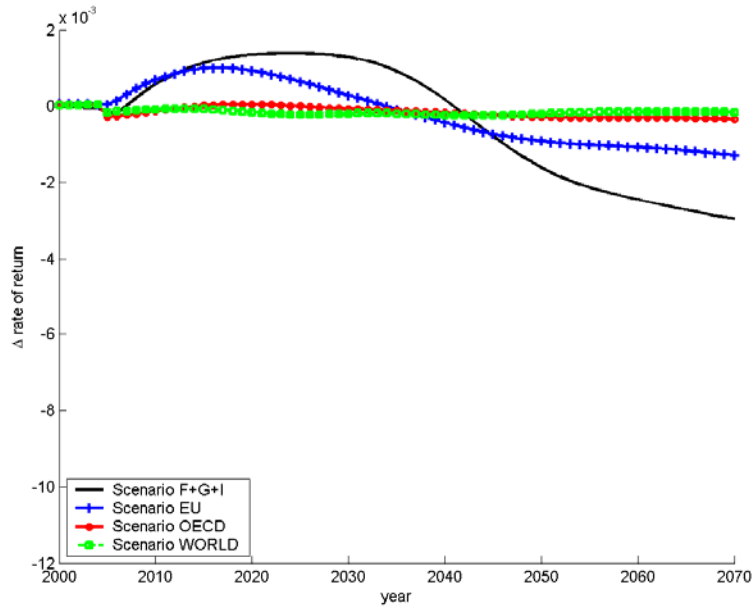
Notes: These figures show the projected rate of return of the aggregate capital stock in France, Germany, and Italy. Scenario F+G+I: perfect capital mobility within France, Germany, and Italy; Scenario EU: perfect capital mobility within the European Union; Scenario OECD: perfect capital mobility with the OECD; Scenario WORLD: perfect capital mobility across all world regions.

Source: Börsch-Supan, Ludwig and Winter (2007).

As Panel (b) of Figure 3 suggests, there would be an additional decrease in the rate of return to capital if France, Germany, and Italy simultaneously reformed their pension systems in a fundamental way. This decrease would amount to about 0.25 percentage points until 2070 if capital was freely mobile within these countries only. Due to the increase in labor supply, this long-run decrease in the rate of return is lower than a model with exogenous labor supply would suggest, see Section 6. In contrast to a model of exogenous labor supply, the present model even predicts an increase in the rate of return until about 2030 or 2040 (as a result of the endogenous labor supply reaction). While saving rates immediately start to increase after the reform, labor supply increases as well. As a net effect, this initially leads to a decrease in the capital to output ratio and an associated initial increase in the rate of return to capital. Moreover, and in line with our earlier results in Börsch-Supan, Ludwig and Winter (2002), the decrease in the rate of return is negligibly small if capital moves freely across OECD countries (or the entire world).

Tobin's q, the price of capital, also decreases as a consequence of population aging but its level is higher in the demographically younger regions. Results on Tobin's q for the France-Germany-Italy region are depicted in Figure 5. Notice that the relative decrease of q-values is lower under the pure PAYG scenario if the capital mobility region is broadened (Panel a). As a consequence of fundamental pension reforms, q-values are predicted to increase slightly
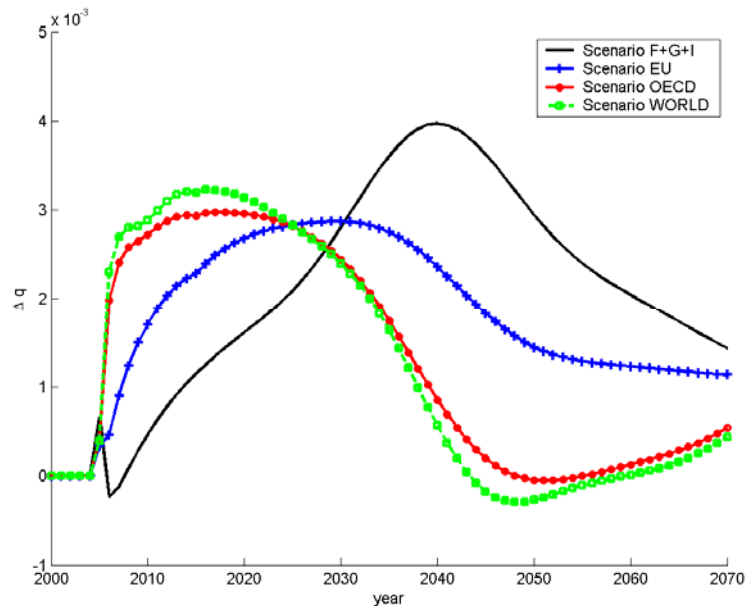
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since the investment to capital ratio increases (Panel b). The long-run effect is stronger if capital mobility is restricted to a smaller region.

Figure 4: Tobin's q

Figure 4a: Old system scenario
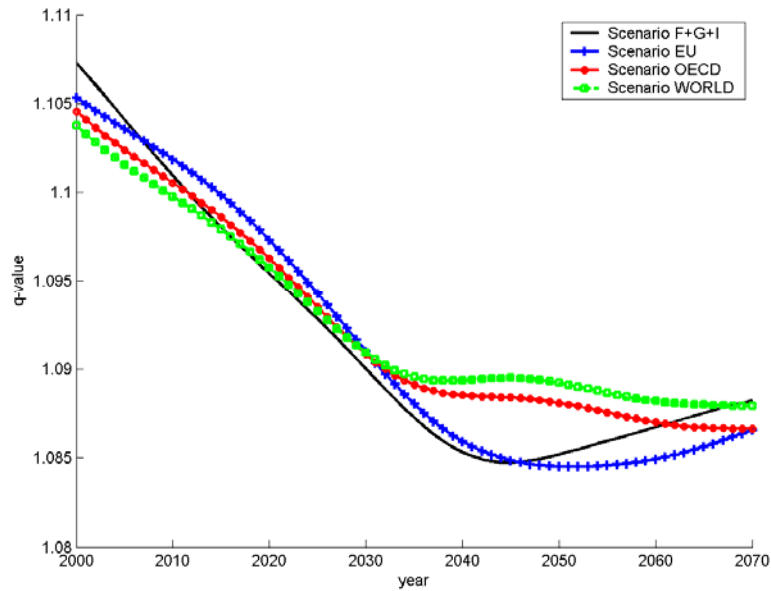
Figure 4b: Difference between freezing reform and old system scenario

Notes: These figures show the projected *q*-values in France, Germany, and Italy. Scenario F+G+I: perfect capital mobility within France, Germany, and Italy; Scenario EU: perfect capital mobility within the European Union; Scenario OECD: perfect capital mobility with the OECD; Scenario WORLD: perfect capital mobility across all world regions.

Source: Börsch-Supan, Ludwig and Winter (2007).

4.4 International capital flows

International capital outflows from France, Germany, and Italy to other OECD countries roughly follow the pattern of savings and decrease steadily until 2050, see Figure 5. In the OECD and World capital mobility scenarios, they are initially positive at about 2 and 3.2 percentage points of output and turn negative to -2 and -2.5 percentage points of output in 2050, respectively; see Figure 5(a). Hence, the model predicts reversals in current account positions for fast aging countries such as France, Germany, and Italy.

Figure 5: Current account to output ratios

Figure 5a: Old system scenario
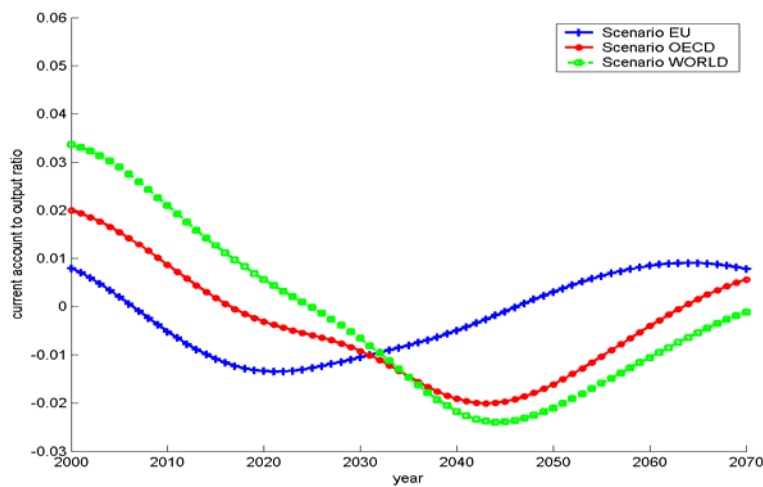
Figure 5b: Difference between freezing reform and old system scenario
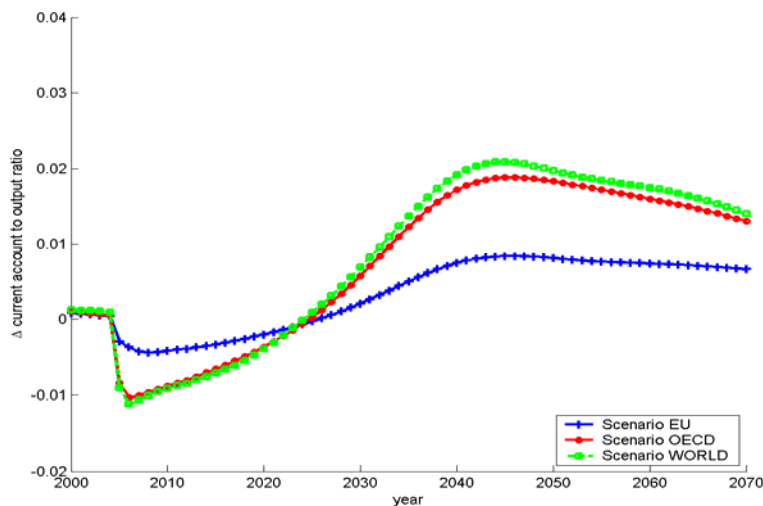
Notes: These figures show the projected current account to output ratio in France, Germany, and Italy. Scenario EU: perfect capital mobility within the European Union; Scenario OECD: perfect capital mobility within the OECD; Scenario WORLD: perfect capital mobility across all world regions.

*Source:* Börsch-Supan, Ludwig and Winter (2007).

So far, our analysis concentrated on France, Germany, and Italy as a country aggregate. However, there are substantial differences across countries, even within continental Europe. To highlight this aspect, we next analyze savings patterns and international capital flows within the region of EU countries under the assumption that the international capital market is restricted to the OECD area.

Figure 6(a) shows saving rates for France, Germany, and Italy, the remaining EU countries and the EU average. The time pattern of German saving rates roughly equals the EU average. Germany's saving rate is projected to decrease from current levels of 7 percent to about 2 percent in 2050. In France, as the demographically youngest among the three regions, decreases in savings rate only last until 2030 and the overall decrease is smaller than in other EU countries. Italy, faced with the strongest population aging process within Europe, is at the other extreme: Italian household's saving rates are projected to become substantially negative in 2050.

Figure 6: Saving rates and capital flows in the European Union for the OECD scenario

Figure 6a: Saving rate (old system scenario)
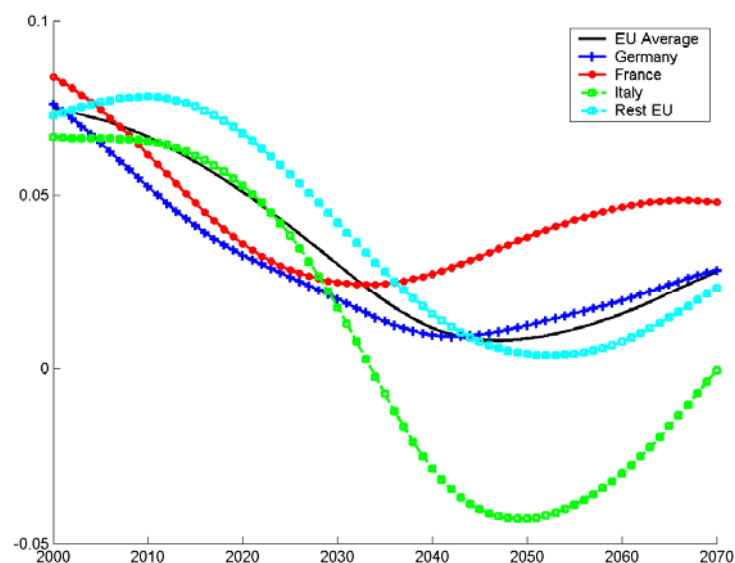
Figure 6b: Current account to output ratio (freezing reform scenario)
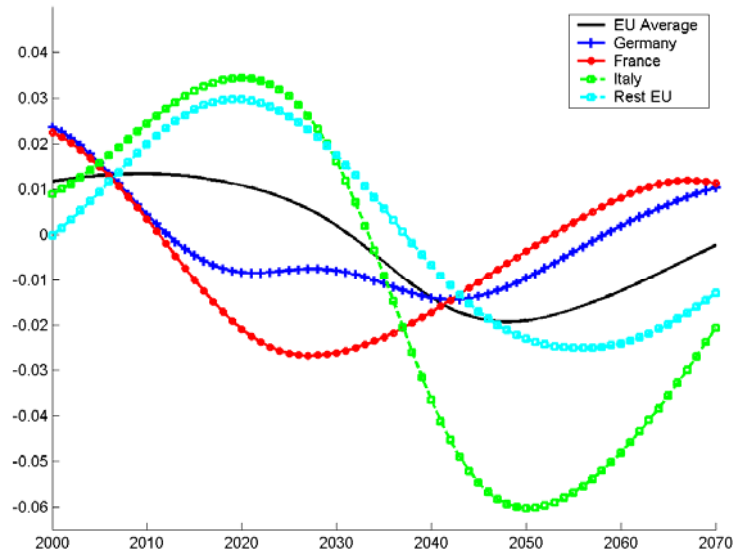
Notes: This figures show the projected saving rates and the current account to output ratios within countries of the European Union if capital mobility is restricted to the OECD area. EU Average: Average of all EU countries; Rest EU: all EU countries excluding France, Germany, and Italy.

Source: Börsch-Supan, Ludwig and Winter (2007).

5. Sensitivity analysis

One of the weaknesses of computational general equilibrium analysis is the dependence of the results on modeling strategies and parameter values. The usual response is an extensive sensitivity analysis. The existing literature has mostly concentrated on sensitivity analysis of simulation results with regard to values of structural (deep) model parameters, see, e.g., Altig, et al. (2002). This sensitivity analysis shows that results change very little when we vary the main elasticity parameters in their usual ranges. Our politically probably most contentious conclusion, the absence of a serious asset market meltdown, is robust with respect to the choice of these elasticity parameters.[10]

In addition to this conventional sensitivity analysis, we also investigate the robustness of our results with respect to four key dimensions of our model specification: What difference does it make whether labor supply is endogenous or exogenous? Whether investment incurs adjustment costs? Whether perfect annuity markets absorb all accidental bequests? Whether part of retirement income is provided by a PAYG pension system? We find that the first dimension – whether labor supply is endogenous – matters a lot for assessing the effects of a

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[10] We provide such standard sensitivity analysis in Börsch-Supan, Ludwig, and Winter (2004).

pension reform, while the other three dimensions – adjustment costs, annuity markets, and accidental bequests – matter very little.

In the sequel, we therefore only report on the role of endogenous labor supply. For simplicity, we ignore adjustment costs to capital and concentrate on a three-region rather than a seven-region model as in the previous section, summarizing the world regions to (i) France, Germany, and Italy, (ii) all other EU countries, and (iii) all other OECD countries. We focus on the differential effects between the old system and the reform scenario because this is were the endogeneity of labor supply matters most.

Figure 8 compares these effects on the saving rate and the rate of return generated by models with endogenous and exogenous labor supply. In the exogenous labor supply specification, we hold age-specific labor supply shares constant at levels obtained in the endogenous labor supply scenario in the year 2000. We first show the reaction of savings to the fundamental pension reform. As depicted in Figure 8(a), the increase of the saving rate is much larger if labor supply is exogenous. Unlike to the case of endogenous labor supply, households cannot simultaneously adjust their labor supply and their saving behavior to the change in policy. They can only react by decreasing consumption such that the saving rate immediately jumps to a higher level after the announcement of the reform.

This difference in behavior directly translates into substantial differences in the time paths of the rate of return to capital, depicted in Figure 8(b). If labor supply is endogenous, the rate of return initially increases since households increase their labor supply as a reaction to the change in policy. This effect is absent when labor supply is exogenous. Hence, the rate of return to capital immediately decreases. As a result, the overall decrease of the rate of return to capital is much larger.

Figure 8: The influence of modeling endogenous labor supply: Saving rates and rate of return

Figure 8a: Saving rates: Difference between the freezing reform and the old system scenarios

Endogenous labor supply   Exogenous labor supply
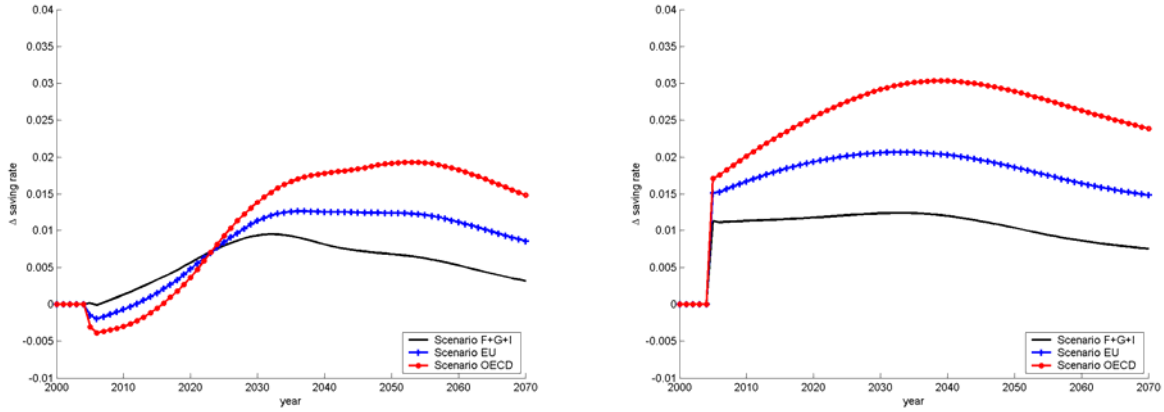
Figure 8b: Rate of return: Difference between the freezing reform and the old system scenarios

Endogenous labor supply   Exogenous labor supply
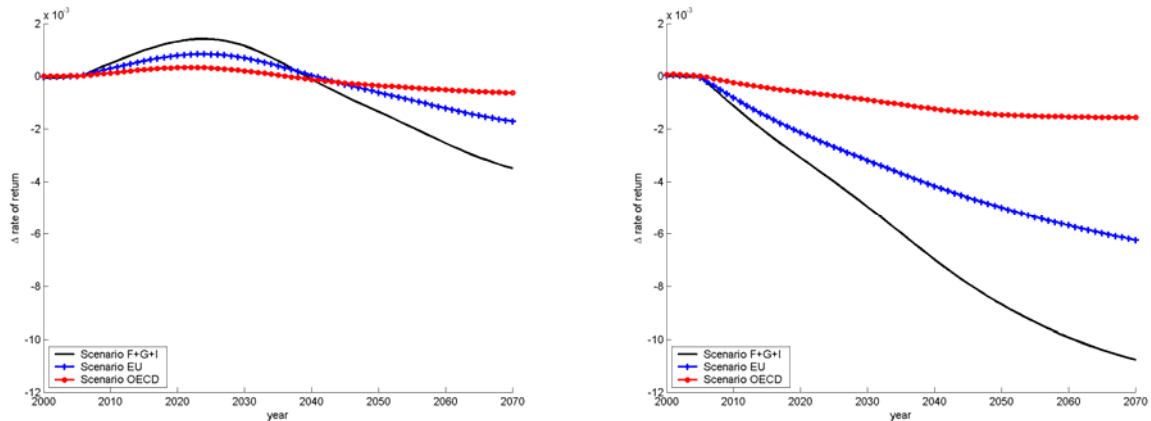
Notes: These figures show projections of the differential effects of the freezing reform on saving rates and rates of return for the endogenous and the exogenous labor supply models of Section 6. F+G+I: France, Germany, and Italy; REST EU: the remaining countries of the European Union; USA+CAN: the United States and Canada; REST OECD: the remaining OECD countries.

Source: Börsch-Supan, Ludwig and Winter (2007).

The size of this endogenous labor supply effect of course depends on the elasticity of substitution between consumption and leisure, ξ. This is shown in Figure 9, where we vary the parameter ξ by ±0.2 around its benchmark value of 0.8 and re-calibrate $\overline{w}$, the consumption share parameter, such that initial labor supply shares are held constant. We thereby focus on the case where capital mobility is restricted to the France-Germany-Italy region. We choose this case because it exhibits the strongest sensitivity, see Figure 8. In this "closed economy" case, the increase of labor supply resulting from the fundamental pension reform is only slightly higher if $\xi=1$ (Cobb-Douglas utility), but quite significantly lower if $\xi=0.6$. As a
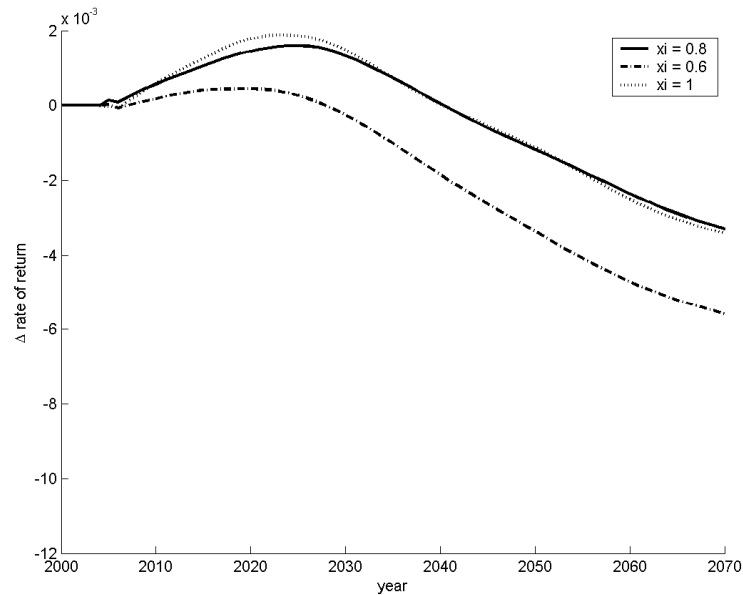
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result, the decrease in the rate of return to capital is much stronger for $\xi=0.6$ than for the benchmark calibration of $\xi=0.8$.

Figure 9: Endogenous labor supply: The role of the intra-temporal substitution elasticity

Figure 9a: Difference in labor supply: Freezing versus pure PAYG
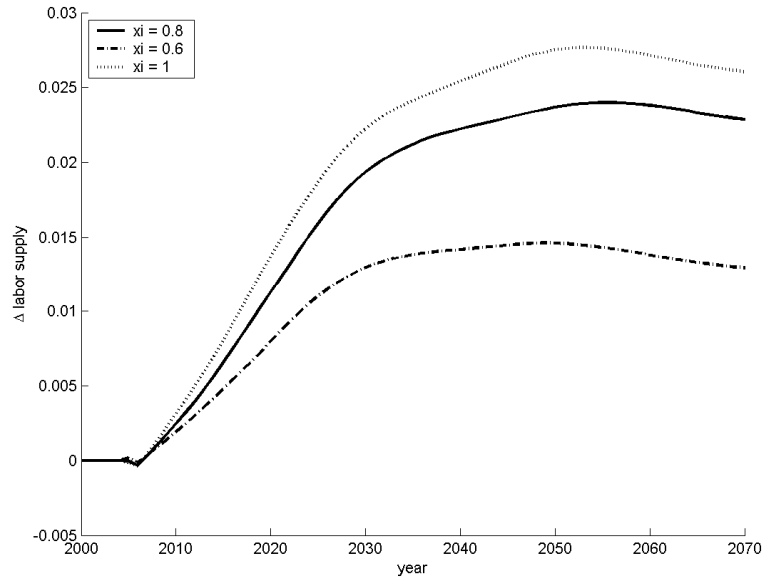
Figure 9b: Difference in the rate of return: Freezing versus pure PAYG

Notes: These figures show projected differences in labor supply and the rate of return to capital between the freezing and the pure PAYG scenario under the assumption that capital mobility is restricted to the France-Germany-Italy region. Results are shown for alternative parameterizations of the intra-temporal substitution elasticity between consumption and leisure, ξ.

Source: Börsch-Supan, Ludwig and Winter (2007).

6. Interactions between Labor and Asset Markets

The sensitivity of asset returns to labor supply is an important insight. We therefore investigate further how labor supply could evolve over the course of demographic change.

Total labor supply is a result of labor market entry age, female labor force participation, unemployment rates, and labor market exit age, to name the four most important parameters. These parameters are strongly governed by institutional restrictions. Labor market entry age, e.g., is a function of the school system. Germany, e.g., has a regulations that generate late entries into the school system, a long duration in high schools and universities, and thus a late labor market entry age. Similarly, female labor force participation is a function of institutions such as kindergarten and afternoon school which tend to be provided by public entities in Europe. Unemployment is a function of the duration and generosity of unemployment compensation. Labor market exit, finally, is strongly governed by pension regulations that effectively make the early eligibility age also the effective age of labor market withdrawal. Our main point is that from an individual's point of view, labor supply has important exogenous components which restrict possible endogenous labor supply decisions.

It is unlikely that these exogenous components remain unchanged over the course of population aging and the general change of society over the next two decades. We therefore define two polar scenarios representing the potential changes in the institutional framework restricting households' labor supply decisions:

- In the status quo scenario (STATQUO), age and gender specific labor force participation rates will remain as they are at baseline in 2005; this was the scenario underlying figure 4.

- The labor market reform scenario (LREFORM) includes four reform steps:
    - RETAGE: an increase in the retirement age by 2 years;
    - JOBENTRY: a decrease in the job entry age by 2 years;
    - FEMLFP: an adaptation of female labor force participation rates to those of men;
    - UNEMP: a reduction of unemployment to 40% of its current level.

The increments are motivated by actual policy proposals: in Germany, the statutory retirement age has been raised from 65 to 67 years in a serious of transitions until about 2020; in France and Italy, similar steps will follow with some delay. The change in the European high school and university system (the so called Bologna process) is expected to decrease duration in schooling by about 2 years. Finally, 40% of current unemployment represents the conventional estimate of the NAIRU (Ball and Mankiw, 2002).

These reform steps will be phased in linearly between 2010 and 2050. Overall, these reform steps do not appear to be overly radical; in fact, their combination would lead in 2040 to labor force participation rates fairly similar to those in Denmark today. They result in a substantial increase in labor force participation $L_{t,i} = \sum_{j=0}^{J} l_{t,j,i} N_{t,j,i}$, as depicted in figure 10:

Figure 10: Employment, indexed to 2005=100%, EU-3 (France, Germany, and Italy)
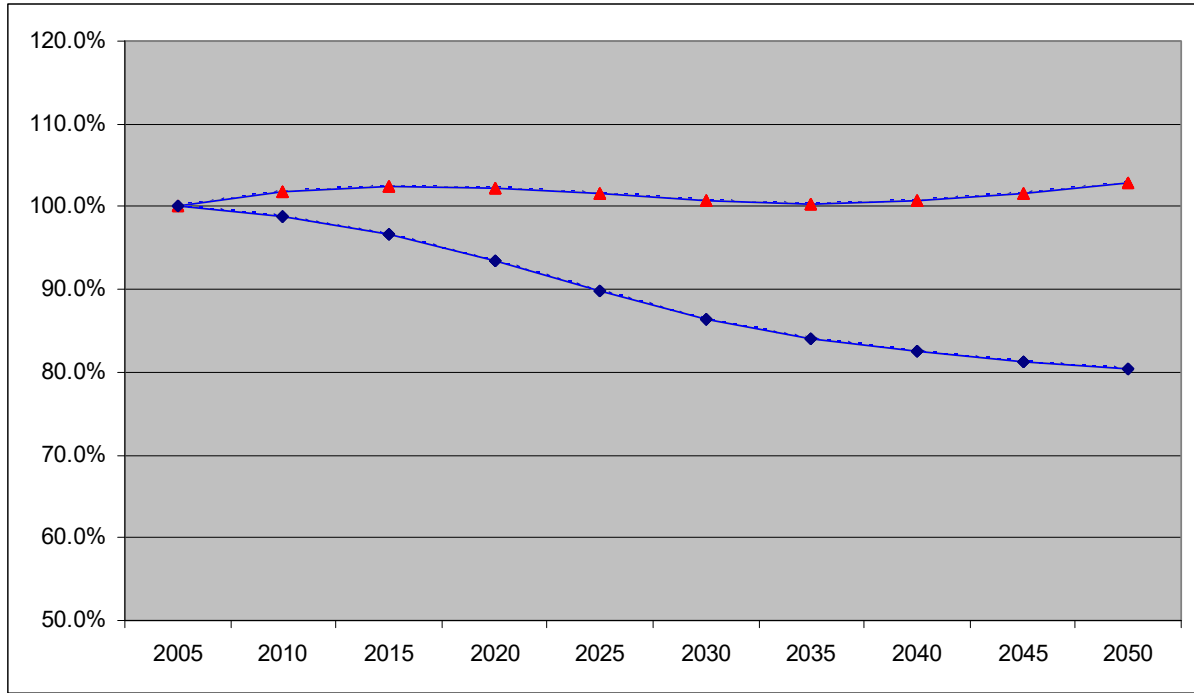
Attempts to actually execute reforms with those goals have faced stiff opposition in France and Italy, and more recently and to a somewhat lesser extent also in Germany. Hence, while we treat the reforms and the resulting variation in employment numbers as exogenous, households in our model endogenously adjust hours worked and may thus counteract parts of the labor market reforms, see the more sophisticated household model specified in section 3(b). As we will show, these reactions lead to a lower number of total hours worked than would be implied by figure 10, and they have repercussions on asset markets and asset returns.

We structure our results by investigating three dimensions, each with two polar assumptions:

- Labor market reforms: no reform at all, resulting in future labor force participation rates that equal the current ones (STATQUO or SQ) versus the implementation of all four reform steps described in section 3 (LREFORM or RF)

- Pension reform: a prototypical pension system of Continental Europe, purely pay-as-you-go, providing flat social security benefits financed by distorting contributions (FLATSS

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or FL) versus a fully-funded, voluntary private accounts system which generates no distortions (SAVING or SA) as described in subsection 4.5.

- Labor supply reaction: Fixed hours supply (EXOGENOUS or EX) versus endogenous supply of working hours (ENDOGENOUS or EN) as described in the households optimization problem, subsection 4.3, equations (5) to (7).

This set-up yields a two-by-two-by-two table of underlying assumptions displayed in table 1. The eight resulting combinations are labeled, e.g., by "FL-SQ-EX" to denote a flat benefit pay-as-you-go social security system (FL) with status quo labor force participation (SQ) and an exogenously given hours supply (EX), by "SV-RF-EN" to denote a fully-funded private savings based old-age provision system (SV) with a comprehensive labor market reform (RF) and an hours supply which reacts endogenously to ageing and policy changes (EN), etc.

Table 1: Set up of scenarios

	Extensive margin: Labor market regime			
	Constant age and gender specific labor force participation (STATQUO, blue diamonds)		Increasing age and gender specific labor force participation (LREFORM, red triangles)	
	Intensive margin: Hours' supply			
Pension system	EXOGENOUS hours supply (dashed line)	ENDOGENOUS hours supply (solid line)	EXOGENOUS hours supply (dashed line)	ENDOGENOUS hours supply (solid line)
Pay-as-you-go with flat benefits (FLATSS, blue line)	*FL-SQ-EX*	*FL-SQ-EN*	*FL-RF-EX*	*FL-RF-EN*
Fully funded voluntary accounts (SAVING, yellow line)	*SV-RF-EX*	*SV-RF-EN*		

On the following pages, we develop how the main outcome variables of our general equilibrium model emerge from the three exogenous changes that drive our model:

- the demographic aging process in the background,
- lifting of labor supply restrictions as described in section 3, and
- a fundamental change in the type of pension system.

We display results for total labor supply, domestic capital stock, and asset returns. We refer the reader to Börsch-Supan and Ludwig (2008) for results on living standards, especially GDP and consumption per capita. All figures refer to the aggregate of France, Germany, and Italy

(EU-3). The U.S. is modeled in the background with similar changes in retirement age and female labor force participation, but no other exogenous policy changes.

All figures have the same design (cf. table 3). We denote exogenous labor supply by a dashed line and endogenous hours' supply by a solid line. The high labor force participation scenario (LREFORM) is marked by red triangles, the constant labor force participation scenario (STATQUO) by blue diamonds. Finally, the flat benefits pay-as-you-go social security system (FLATSS) features a blue line, while the fully funded pension regime (SAVING) is identified by a yellow line.

6.1 Total labor supply

Total labor effective supply is the product of working persons (figure 10) and hours per person (resulting from household optimization): $L_{t,i} = \sum_{j=0}^{J} l_{t,j,i} h_{t,j,i} N_{t,j,i}$.

Its evolution under the eight scenarios is displayed in figure 11. If hours are exogenous, there is no difference between figures 10 and 11, and there is no difference between the two pension scenarios. Hence, the lines for FL-RF-EX and SV-RF-EX at the very top overlap as well as the lines representing FL-SQ-EX and SV-SQ-EX at the very bottom. If hours are endogenous, the increase in the number of working persons in the LREFORM scenario is only partially reduced by the decline in hour's supply.

Figure 11: Total labor supply, indexed to 2005=100%, EU-3
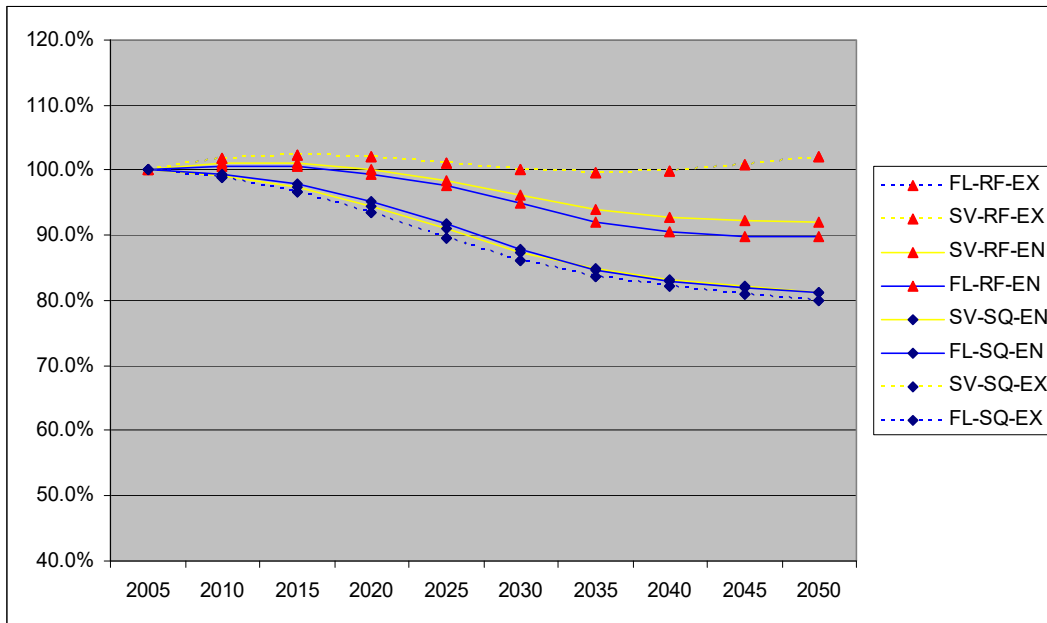
6.2 Capital accumulation

Figure 12 depicts the first main outcome variable of interest in this paper: the evolution of the combined domestic capital stock of France, Germany, and Italy. As expected, capital accumulation is much higher under a funded pension system than in a pay-as-you-go system. There is also substantially more capital accumulation in the high labor force participation scenario (LREFORM) as compared to constant participation (STATQUO). Finally, capital accumulation is higher if endogenous hours' supply is not dampening the effect of a higher labor force participation. Combining these three effects yields the eight trajectories of figure 12. Capital accumulation is highest under a fully-funded system with high labor force participation and no dampening effect of endogenous hours (SV-RF-EX). It is lowest in a pay-as-you-go system with status-quo labor force participation and the full force of negative incentive effects (FL-SQ-EN).

Figure 12: Evolution of the capital stock in EU-3, indexed to 2005=100%
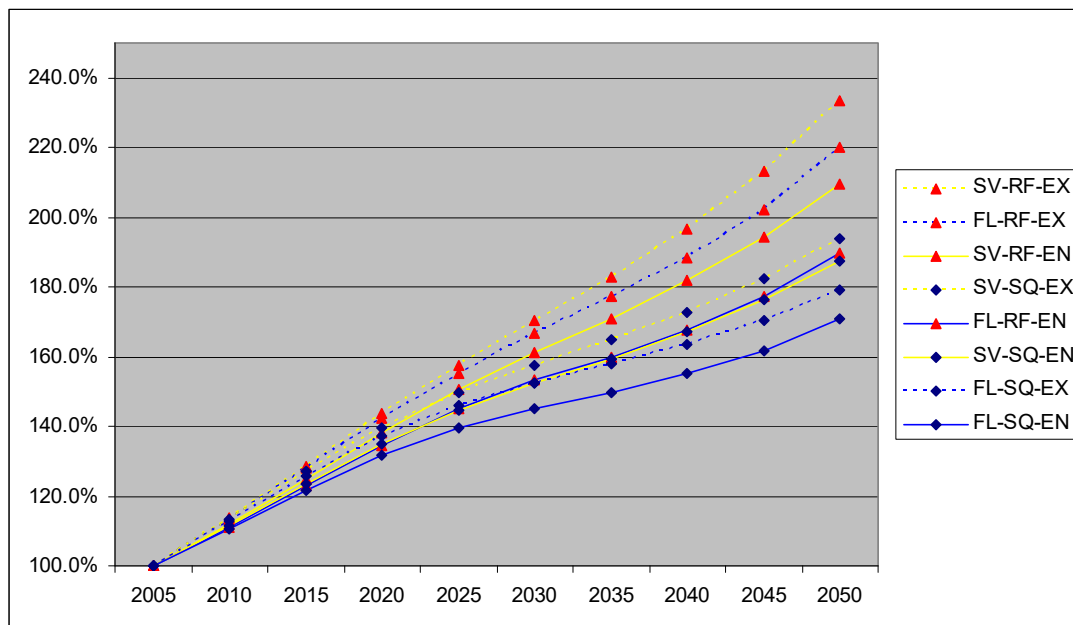

6.3 Asset returns

Figure 13 depicts the second main outcome variable of interest in this paper: the rates of return to productive assets. The figure shows the strong interactions between asset markets and labor supply. The rates of return are normalized to 100% in 2005 in order to purge them from level effects at the initial date.

The general message is similar to that of section 4: there will be a decline in asset returns due to population aging but there will be no devastating "asset meltdown". The extent of the decline, however, strongly depends on labor supply. Three general lessons emerge from figure 13. First, as shown earlier, a fundamental pension reform increases the capital stock and thus reduces rates of return (yellow lines vs. blue lines). This effect dominates all other effects after about 2035. Second, lifting labor supply restrictions increases rates of return (red triangles vs. blue diamonds) in almost all circumstances. The third effect is more complicated. Endogenous hours' reactions dampen total labor supply and thus have a tendency to reduce rates of return. On the other hand, capital accumulation is slower, see figure 12, which overcompensates this effect.

The demography-induced decline in asset returns is therefore lowest in a pay-as-you-go system with high labor force participation and the full force of the hours' reaction (FL-RF-EN), and highest under a fully-funded system with status-quo labor force participation and no dampening effect of endogenous hours (SV-SQ-EX).

Figure 13: Asset returns, indexed to 2005=100%
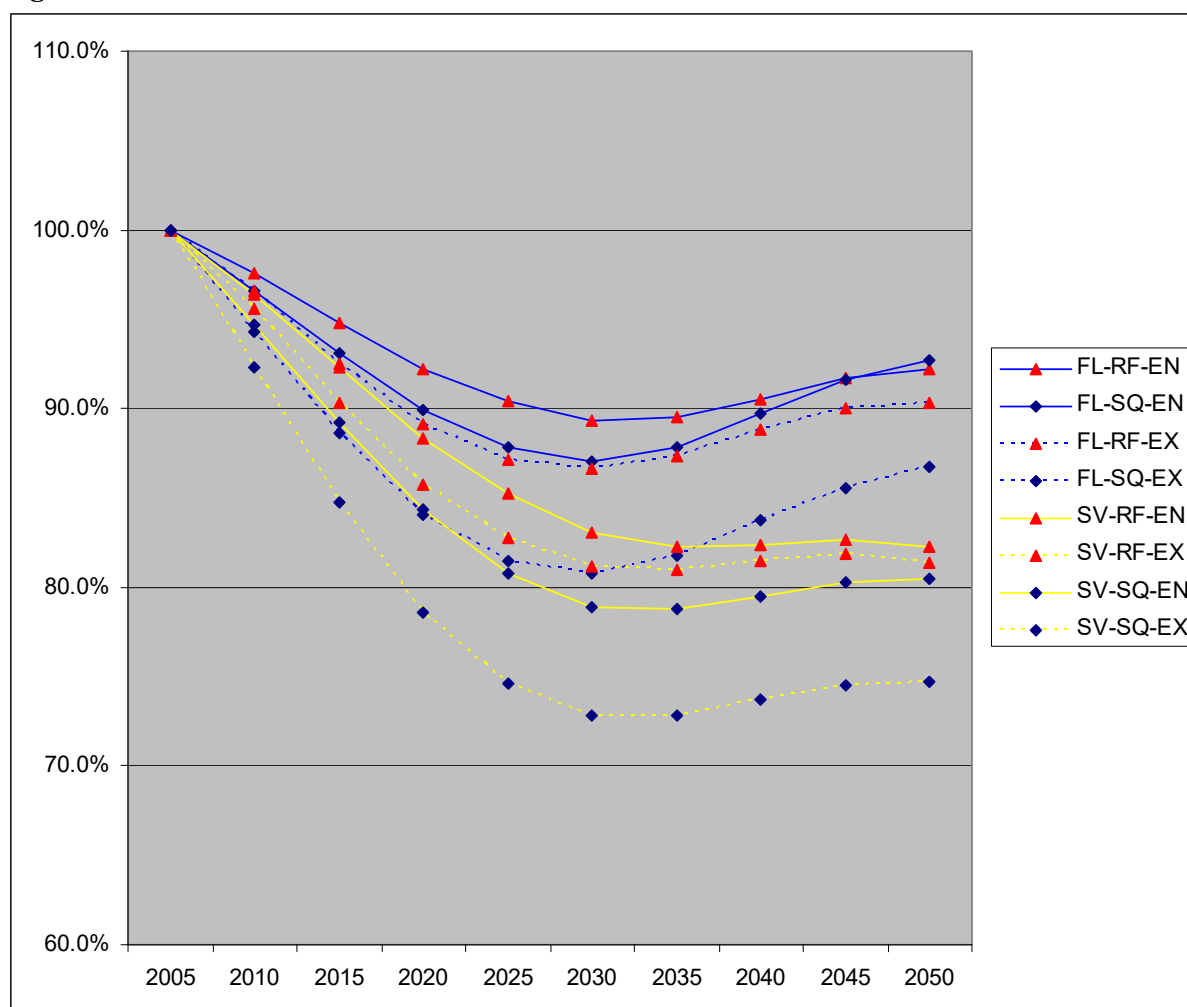
7. Summary and Outlook

Aging is affecting markets for productive assets in a complex way. Only a general equilibrium analysis can separate the various diverging trends. The results of our analysis are thus subtle: neither the pessimists with their catastrophic "asset meltdown" hypothesis are right, nor the optimists who claim that capital markets are immune against demographic change.

The key reason behind this is that aging societies need more productive capital to take the place of labor, which is scarce, so the demand for capital is increasing. Moreover, the internationalization of capital markets allows finance to be provided for those production facilities abroad in "younger" countries (notably the United States) from which, in future, consumer goods will be imported to the "older" countries (the most prominent being Germany, Italy and Japan). Complete internationalization of capital markets considerably dampens a decline in asset returns prompted by pension reform.

There are strong interactions between asset markets and asset returns on one side, and labor supply behavior on the other side. Capital accumulation is much higher under a funded pension system than in a pay-as-you-go system. This effect is strengthened by a labor market reform that reduces labor supply restrictions. In turn, a fundamental pension reform reduces rates of return, while lifting labor supply restrictions increases them. The effects of endogenous hours' reactions are complicated. They dampen total labor supply and thus have a tendency to reduce rates of return. On the other hand, they slow down capital accumulation which drives asset returns up.

Even if capital markets are not threatened by a devastating "asset meltdown", economic policymakers cannot afford to relax. The development of employment looks much less rosy. The main effect of demographic change is that the number of gainfully employed persons will fall sharply from 2010 onwards, whereas the number of consumers will largely remain constant until around 2040. This will put pressure on production capability and thus also on the overall growth of our economy: labor - at least in the highly skilled sector - will become increasingly scarce because it is not possible to compensate for this decline in employment per head of population by intensifying capital. For this, the change is too rapid and too extensive. Education and training will assume an increasingly important role to keep returns of productive capital high. Our future research will thus focus more on the role of human capital in the aging process

The paper shows that asset markets play an important role in an aging society. The logic of this is obvious because labor is becoming scarce. There are however two further reasons.

Firstly, capital investments are the only way of distributing resources over time and between the generations. More specifically, in the case of the demographic shift, capital investments are the vehicle that allows part of the earning power of baby-boomers to be used to finance their own pension instead of allowing the entire pension to be financed by those of the next generation, who will be completely overwhelmed because of their greatly reduced numbers. We therefore need the capital market so that the earning power of the younger generation is not overwhelmed by the excessive demands of the older generation.

The second reason lies in the international mobility of capital. As we know, mobility of the factor labor is not particularly good and we old countries cannot expect that younger countries will help to finance their pay-as-you-go systems, nor is it likely that a surge of migrants will pay their pension contributions. Capital, in contrast, can move around the global economy and bring in earnings from countries abroad where labor is more plentiful than it is here. For "old countries" such as Germany, Italy and Japan in particular, an open and globalized world can be of assistance during the aging process. Rich in consumers, poor in labor, these countries must have an intrinsic interest in boosting their imports. Free trading relations are therefore a substitute for inward migration. However, capital is required to extend production abroad. Not only that, it will also certainly be in the old countries' interest to retain a certain degree of control over companies which will be producing our consumer goods in the future by means of the mechanism offered by their foreign direct investments.

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