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The Impact of Population Aging on Savings, Investment and Growth in the OECD Area

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Abstract

Goal of this paper is an assessment of the relevance of the various channels through which population aging affects saving and investment. In a first part, I collect evidence on age-saving, age-consumption, and age-income profiles in order to project the supply of and the demand for funds, given no behavioral changes. However, due to many feedbacks that may change individual behavior and due to the rapid globalization of world capital markets, major capital market disequilibria are unlikely to evolve. The second part of the paper is therefore concerned with an equilibrium analysis in which a global rate of return equilibrates the demand for, and the supply of, funds.

In the short run, until about the year 2010, demographic effects are more likely to increase rather than to decrease the supply of funds. This result, in contrast to earlier studies, rests on the fact that a relatively rich baby boom generation is now entering the high saving and high income years. This increase in demand will meet an essentially unchanged demand for funds. In the longer run, however, a rising capital labor ratio due to population aging is likely to depress the return to capital in the aging OECD countries, reducing savings at the same time as governments are tempted to increase their demand for funds to finance social expenditures.

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1. Introduction

The expected change in the age structure of the OECD countries is dramatic and will lead to a substantially higher proportion of older people. Within little more than one generation, the ratio of older people to working-age people will about double in the OECD. Germany and Switzerland stand out as countries whose share of older people is projected to attain the highest levels among OECD members by the year 2030. Japan is notable as a country in which the proportion of elderly, starting from a low level, will increase particularly rapidly. A demographic change of such a magnitudes and speed is unprecedented since the industrial revolution, and the industrialized countries will have to learn how to cope with this change.

This paper is concerned with the question in how far the dramatic change in the age structure will affect saving and investment in the OECD countries. There are many mechanisms that link saving and investment with the demographic structure of a country. From a microeconomic point of view, saving rates vary by age, productivity varies by age, consumption varies by age -- hence, a shift in the demographic composition of a country alters the corresponding aggregates even if the economic behavior of each individual remains unaffected by population aging. Moreover, from a macroeconomic point of view, population aging changes the current balance between output and labor such that there will be less workers per consumer than today. This will drive wages up relative to the remuneration of other factors of production, such as capital, reducing the incentive to save if the interest-elasticity of saving were positive. In addition, some capital may become obsolete due to the shrinkage of the labor force and diminishing returns to scale which worsens the declining attractiveness of accumulating capital.

While there is little debate about the validity of these basic mechanisms per se, their quantification is highly controversial. Microeconomic evidence on life cycle saving, productivity and consumption yields a wide variety of age-saving, age-productivity, and age-consumption profiles. There is no agreement on the sign, let alone the quantity of the elasticity of saving with respect to the after-tax interest rate. And it is less than clear whether the demographically-induced change in the capital-labor ratio in one country is relevant for domestic savings if there are other countries that grow and offer worthwhile investment possibilities.

Goal of this paper is an assessment of the relevance of the various channels through which population aging affects saving and investment. I collect evidence on age-saving and age-consumption profiles that permit a rough projection of the demand for, and the supply of, funds,

given no behavioral changes, and I present a rather coarse model shedding light on potential feedbacks that might change individual behavior. I stress „rough“ and „coarse“ because the many feedbacks escaping a precise quantification and the many uncertainties render any forecast of saving and investment volumes during the next generation a highly speculative exercise. The volume of funds supplied and demanded in OECD capital markets depends on all markets in each country and on interdependencies among markets as well as among countries. Hence, modelling a global capital market requires a general equilibrium model of all OECD countries impossible to calibrate with reasonable accuracy. I therefore pursue two parallel strategies which complement each other - a set of detailed partial analyses that ignore feedbacks, and a general equilibrium analysis that abstracts from details.

Accordingly, the paper has two parts. In the first part, I filter microeconomic age-saving and age-consumption profiles through the population aging process in order to estimate demand for, and supply of, funds under the condition that individual behavior remains as it is today. To this end, section 2 investigates the microeconomic evidence on the relation between age and saving. Section 3 employs these data to project the supply of funds in the OECD area. Section 4 uses well-known projections of social expenditures, in particular social security benefits, in order to forecast public demand for funds. Section 5 adds private investment demand. Finally, section 6 contrasts these components of capital supply and demand in an attempt to show where potential capital market pressures will originate. However, given the many feedbacks alluded to above and the rapid globalization of world capital markets, major capital market disequilibria are unlikely to evolve. The second part of the paper is therefore concerned with an equilibrium analysis in which a global rate of return equilibrates the demand for, and the supply of, funds. Section 7 describes the evolution of equilibrium saving and investment, and section 8 sketches the capital flows that emerge within the OECD countries as well as between the OECD and the less industrialized world. Section 9 concludes.

Part I: Partial Analyses

2. Age and Cohort Effects in Saving and Income

Households are the primary savers in an economy. And since a household's propensity to save depends on the age of the household members, the national saving rate is affected when the population ages. This section investigates how the household's propensity to save relates to age and is based on recent survey data evidence rather than on life cycle theory.

Standard assumption in economic theory, based on Modigliani's work, is to postulate a hump-shaped life-cycle saving profile. In its simplest form, the life-cycle hypothesis supposes that households save until retirement and then dissave (Modigliani and Brumberg, 1954; Modigliani and Ando, 1957). Earlier analyses on the effect of population aging on saving conducted by the IMF and the OECD used these hypothesized life-cycle patterns and concluded that national saving rates will decline in response to population aging because the dissaving elderly households become a larger proportion of the population (Heller, 1989; Auerbach and Kotlikoff, 1987; Auerbach et al., 1990).

A growing body of evidence has put doubt on the validity of this simple form of the life-cycle hypothesis. Household survey evidence yields a much more complex relation between the age and the saving rate of a household. It is particularly helpful to investigate the cross national evidence. A recent study on six of the G7-countries provides a set of comparable age-saving profiles, summarized in Figure 1 (Poterba, 1994). Three observations stand out. First, saving of the elderly is almost everywhere positive. Except for some age-groups in the U.S., the elderly do not dissave. Second, even more striking, in five out of six countries, the saving rate for those 65 and over is higher than for those aged 25-64. Both observations are in contradiction to the life cycle hypothesis. Third, the U.S. is an outlier not only by having the lowest saving rate but also by featuring relatively high saving of adults in the second half of their working lives (ages 45-64) in comparison to both the saving rate of the elderly and the saving rate of younger adults (Weil, 1994). The last observation is significant because the baby boom generation will „filter" through the age group of 45-64 during the coming 15 years.

FIGURE 1: Cross National Comparison of Survey-Based Age-Saving Profiles

The empirical age-saving profiles in figure 1 are based on cross sections of the household survey data and are therefore confounded by cohort differences. Different age groups in a given cross section differ not only by their age but also by their birth cohort. Different birth cohorts experienced different earnings histories and different investment opportunities. These different experiences may contribute more to the shape of the saving profiles in figure 1 than differences in age. The contamination with cohorts is significant because the second and third of the above observations may not hold up once we look at cohort-specific age-saving profiles. In addition, the impact of population aging on saving depends on the age effect alone, not on accompanying cohort effects. Using descriptive age-saving profiles such as those in figure 1 may therefore yield biased projections of future saving behavior.

Because the United States, Japan and Germany hold the largest portions (40.5, 25.2, and 7.7 percent, resp.) and account for almost two thirds of total wealth in OECD member countries, we give saving behavior in those three countries a closer look. Specifically, we combine survey data from several cross sections which enables us to separate age from cohort effects. Survey data in the U.S. comes from the Consumer Expenditure Surveys (CEX), 1980-1990, and is benchmarked against the National Income and Product Accounts (Attanasio, 1994). The Japanese saving data is compiled from the National Survey of Family Income and Expenditure (NSFIE), 1979, 1984, and 1989 (Takayama and Kitamura, 1994). The German data base are the Income and Expenditure Surveys (EVS), 1978, 1983 and 1988, benchmarked against the national household saving rate provided by the Bundesbank (Börsch-Supan, 1994).

FIGURE 2: Cohort-Specific Age-Saving Profiles in Germany, Japan, and the U.S.

Figure 2 depicts the changes in the saving rates as each observed cohort ages.[1] While we have 11 observations for each cohort in the American data, we can follow each German and Japanese cohort only through three years. Because of the many overlaps in the American cohort data, we present a smoothed plot in addition to the raw data. Following each cohort shows that individual saving rates increase with age until about 45, then decline. In very old age, saving appears

to increase again. In Germany, the turning point is earlier, in Japan, there is no appreciable turning point. Comparing the levels of each cohort from right to left in these graphs, i.e., from earlier to later cohorts, shows that recently later cohorts have a higher saving rate than earlier cohorts in all three countries.

These observations can be extracted more formally by a regression of saving rates on age and cohort. Assuming that year effects influence all cohorts equally, we can interprete this regression as a separation of the data in figure 2 into a pure age effect and a pure cohort effect.[2] Figure 3 shows the respective profiles, based on a fifth order polynomial in age, augmented by a set of cohort indicators. The upper charts show the age effects, the bottom charts depict the cohort effects in the three countries.

FIGURE 3: Age and Cohort Effects in Saving Rates (Germany, Japan, U.S.)

For the purpose of projecting future savings, the high saving rates among households aged 45-64 is significant because the baby boom generation will enter these ages soon, and because income is highest during those ages. The decline after age 65, which is stronger in the cohort-corrected data than in the raw data, is less significant because the population weights decrease with age due to mortality and because retirement income is lower than income at age 45-64. Most importantly, even though saving rates decline with age, there is very little dissaving observable in the data.[3] The cohort-effect corrected profiles are thus different in several crucial dimensions from those derived using the life-cycle hypothesis and employed in the earlier IMF and OECD studies.

Weil (1994), in his review of the studies in Poterba (1994), provides two explanations for this difference that also fit the cross national evidence in figure 1. First, he observes that countries in which the saving rate in old age is high relative to the saving rate of younger households have also the highest relative incomes in old age. This observation supports the notion that generous public pensions create high savings among the elderly because consumption decreases faster with age than

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[1] The graphs for Germany and Japan report mean, the U.S. graph median saving rates.

[2] This assumption is not uncontroversial. See Heckman and Robb (1987).

[3] The studies in Poterba (1994) show more statistics underlining this point.

income, as opposed to predictions of the simple life cycle hypothesis (Börsch-Supan, 1992). Hence, aggregate saving rates are sensitive to the income support of the elderly in a much more direct way than through the so-called Feldstein-effect, according to which saving of the younger is crowded out in anticipation of pension benefits.

Second, Weil observes that countries with a large share of elderly tend to have a low overall saving rate.[4] This observation, in combination with the high saving rates in old age, supports the notion that younger adults save less in anticipation of intergenerational transfers, mainly sequests left by a relatively large number of elderly savers. Hence, aggregate saving rates are responsive to the conventions and habits that govern transfer behavior between generations, such as bequests and inter vivos gifts.

Both observations emphasize that projections of saving on the basis of a current description of behavior is strongly subject to the Lucas-critique about feedbacks of public policy on behavior. Specifically, I want to emphasize that the stability of the age-saving profiles throughout the aging process is a strong assumption because pension provisions and transfer habits may be adapted in the wake of population aging when relative cohort sizes change.

The cohort changes depicted in the bottom charts of figure 3 may reflect such feedbacks.[5] They are important because they concern the baby boom generation. It is exacly this numerous generation for which saving rates increase compared to cohorts born one generation earlier. While it is haph_____ to project the observed cohort differences to yet unborn cohorts, the baby boomers' increased propensity to save at all ages is an important ingredient for a projection of the supply of capital in the next 15-20 years that must be distinguished from the age composition effect characterized by the age-saving profiles in the top charts of figure 3.

Saving is the product of saving rate and income. I analyze saving rates and income separately because saving rates are behavioral parameters that may change independently from changes in income. In order to project saving, I multiply age-specific saving rates by age-specific income. For the reasons discussed, age-income profiles are also exhibiting age and cohort effects that must be

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[4] Ironically, just this cross national evidence is cited by Modigliani and others as evidence for the life cycle hypothesis, based on the (false) premise that saving rates become negative with age.

[5] Note that cohort changes are much more precisely captured in the American data because the larger number of observations for each cohort.

separated before the impact of population aging can be measured. I use the same methodology and employ the same data as for the saving rates. Figure 4 shows - as an example - the h.s. disposabel in here profile (Attanasio, 1994). The separation into pure age and pure cohort effects relies again on the (strong) assumption that year effects influence all cohorts equally. As is clearly visible in figure 4, cohort effects have shifted income up quite strongly during the last 20 years. Cohort effects will shift not only saving rates but also income up for the baby boom generation. Con___, age at cohort effects for saving rates of ___ yields rather strong cohort in figure 5 (Attanasio, 1994), of the age- . The age effect yields an increase in saving ? until about age 57, the a decline. There is no dis____ on average, rather saving rates increase slightly at very old age.

FIGURE 4: Cohort-Specific Age-Income Profile in Germany, Japan, and the U.S.

Cohort effects are ____ strong for the cohort just at before the age. As we will see in the section, these cohort effects will a strong increase in the supply of funds in the near future.

FIGURE 5: Age and Cohort Effects in Income (Germany, Japan, U.S.)

3. Projected supply of funds in the OECD area

Having assembled the building blocks, I project the supply of funds by a shift-share analysis presuming the stability of age-saving and age-income profiles during the short- and medium-run future, 1990-2010. We distinguish between age-composition effects and cohort effects. Both effects work through three channels: changes in the aggregate household saving rate, changes in household income, and changes in the household composition that are relevant when we translate population projections into household figures.

First, as seen in the previous subsection, saving rates vary with age. The left chart in figure 6 shows an estimate of the OECD-wide age-saving profile.[6] Population aging puts fewer households in the low saving age categories and more households in the high saving age categories, resulting in higher saving on an aggregate level. This effect differs across countries, as we have seen in the previous section. In the United States, population aging during the next 15 years shifts more weight to the high saving ages 45-64. After 2010, the numerous baby boom generation enters the low saving ages 65+. In Japan, saving rates increase almost monotonously with age, such that the effect of population aging is similarly monotonous. In Germany, the overall effect is ambiguous. Population aging reduces the relative proportion of households below age 37, but it also increases the number of households in the „saving trough" after retirement. The increase in saving rates after age 75 is of smaller relevance because the number of households of very old age is relatively small even after taking account of the projected decline in mortality.

FIGURE 6: Estimated OECD Age-Composition Effect.

Second, the age-composition effect of saving rates is amplified by the shape of the age-income distribution. Because not only saving rates but also income is highest in the age category 45-64, a shift of the population weight into this age category raises the annual flow of saving more than in proportion to the saving rate. The result of this combined age-composition effect is visible in the right chart of figure 6. Total OECD saving increases from $$ ... in 1990 to $$ .... in 2010, and then begins to decline.[7] The increase due to the age composition effect is not large. The main point is that there will be no decrease in saving due to population aging until about the year 2010.

Third, we describe HH-saving. Hence, we have to translate available population projections into household projections using age-specific household rates.[8] Population aging lowers average household size because household size typically declines as households age. For the oldest

[6] Weighted average of Germany, Japan and the United States, capturing 73.4% of total OECD wealth.

[7] Calibrated to the National Income Accounts in 1990 (OECD, 1993).

[8] OECD Demographic Data File, medium fertility variant projection. Household rates are taken from Mikrozensus (Germany), Statistical Abstract (U.S.), and Kanemoto (1993), Japan.

households, household composition complicates the picture particularly in Japan where multigenerational households are still frequent (Takayama, 1994). In the United States and in Germany, there is no appreciable reduction in the household rate at very old ages because the percentage of children taking in their aging parents is rather low (Börsch-Supan, 1983; Ellwood and Kane, 1983). Population aging may therefore have additional effects working through these channels, and it may exhibit cohort effects. Household composition has changed considerably in the recent past, and a closer look at these changes and its relation to income and saving behavior requires more research.

Because the baby boom generation has a higher saving rate and higher income than the generation before, saving would increase even if the age-composition would not change. While „figure 6“ yields the pure effect of population aging in ____, it ignores the cohort changes that we ____ in the ____ section. However, we can trace cohort differences only to the extent that we already have accumulated knowledge about cohort-specific saving and income. We know cohort-specific saving and income of the generations just until the baby boom (figures 3, 4 and 5). We do not know how cohorts born after 1960 fared. Hence, we can trace cohort effects only during the immediate future. After 2010, the weight of the baby bust generation in total population is so large that their yet unknown cohort-specific saving and income level will determine aggregate saving. While the age-composition effect can projected further into the future with reasonable reliability, it is more speculative to predict cohort-specific saving rates of the cohorts born 1965 and after. Assuming no further cohort changes, i.e., fixing cohort-specific saving rates for cohorts born in 1960 or later at the 1955 level, ...?????

Actually, that we will see the cohort effect is to be considerably larger than the age-composition effect between 1990 and 2000.

The combination of age and cohort effects channeled through age- and cohort specific household rates, saving rates, and disposable household incomes, yields a mildly increasing aggregate saving rates in Japan, a mildly falling aggregate saving rate in Germany, but a strong increase in the U.S. aggregate household saving rate from 4.7 percent in 1990 to 5.2 percent in 2000 and 6.2 percent in 2010. The latter result is in sharp contrast to the projections by Heller (1989), Auerbach and Kotlikoff (1987), and Auerbach et al. (1990). The result rests on the combination of high saving rates and high incomes of the baby boom generation in the year 2010. In 1990, the leading edge of the U.S. baby boom generation was age 44, while the youngest baby boomers were

27 years old. In 2010, the baby boomers are between age 47 and 64, exactly in their peak saving and peak income ages.

Projecting the (stock) supply of funds requires a few more steps than projecting (flow) saving rates. First, we add capital gains and redistribute bequests according to a study conducted by the McKinsey Global Institute (MGI, 1994). This study applies a stochastic simulation model of capital accumulation in which saving follows the above saving rates, capital gains are based on their historical mean and variance since 1946, and a simple bequest mechanism in which 80 percent of the after-tax estate goes to the children and 20 percent to the grand children, based on the empirical mortality rates and age differences between generations. 30 percent estate tax is assumed to be consumed by the government, thus lost in the capital accumulation process. Second, we project the cohort changes (measured in the bottom charts of figure 3) into the future, fixing the cohort-specific saving rates for cohorts born in 1960 or later at the 1955 level. Since cohort-specific saving rates increased from the 1940 to the 1955 cohort in Germany, Japan and the U.S., this probably underestimates future savings.

Figure 7 shows the components of changes in the supply of funds in the U.S., and a rough estimate for the total change in supply of funds for all OECD countries for the near future, drawn from MGI (1994). OECD member countries other than Germany, Japan and the U.S have been added in proportion to their 1992 wealth levels.

FIGURE 7: Projected Supply of Funds, 1990-2000-2010

Two results are noteable. First, total OECD financial wealth supplied by households increases by US-$ 11.6 trillion from 1990 to 2000, measured in 1992 prices. This is about $ 5 trillion more than a simple trend-line projection from 1946 to 1990 would suggest.[9] About half of this extraordinary increase comes from the United States. Second, the extraordinary increase in the supply of funds in the U.S. is mainly a result of a population age composition effect and a cohort effect.

[9] It should be noted, that actual wealth in the United States was well described by this trend line.

4. Projected public demand for funds in the OECD area

Public demand for funds is likely to rise in the OECD countries. Even if all other government expenditures remain constant, social expenditures will rise roughly proportional to the dependency ratio unless severe policy changes will occur. This issue has already been discussed at length, see OECD (1988) or Hagemann and Nicoletti (1989). If old-age pension replacement rates are fixed at their current level, pay-as-you-go pension expenditures are exactly proportional to the old-age dependency ratio. The increase in public health expenditures depends on age-specific health costs. Microeconomic evidence in Japan (Takayama and Kitamura, 1994), and in the United States (Attanasio, 1994) shows that age-specific health expenditures increase almost exponentially with age, such that this part of social expenditures is likely to increase even faster than the old-age dependency ratio. On the other hand, population aging is accompanied by a decrease in the proportion of children, reducing social expenditures for schools and family transfers. However, this offsetting effect is relatively small (OECD, 1988) and probably exaggerate social expeditures past the year 2010 because they rest on rather high fertility assumptions.[10]

The rise in the dependency ratio translates into an increase in the public demand for funds as long as age-specific social expenditures and tax rates remain as they are now. This is a worst case scenario in terms of government deficits. A forecast of the demand for funds is of course conditional on public policy changes in reaction to population aging. Spending cuts in entitlement programs, either directly by reducing replacement rates or indirectly by reducing eligibility (e.g., by increasing the retirement age) and tax increases for the working population will decrease the demand for funds relative to the worst case scenario.

I model this worst case in a simple extrapolation exercise. The flow of public demand for funds -- the budget deficit -- is modelled as the excess of government expenditures over taxes. Government expenditures consist of public pensions (increasing at the rate of the dependency ratio), health insurance expenditures (increasing roughly exponentially with the mean age of the population), discretionary spending (fixed at the 1990 level), and interest payments on government debt. Taxes are fixed at the 1990 level according to our worst case assumption. I assume a favorable real interest rate of 3 percent for government borrowing. Government debt starts from the 1990 public debt levels as reported in the OECD National Accounts and accumulates with the budget deficits.

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[10] Fertility is supposed to return to replacement levels during the next 2 generations.

The actual figures for pension and health insurance outlays depend on the replacement rates. I use the numbers provided by MGI (1994) for five large OECD countries. I take the three largest economies, USA, Japan, and Germany, as in the previous sections, and add two countries with already very high debt levels, Canada and Italy.[11]

FIGURE 8: Projected Deficits, 1990-2000-2010

Results are summarized in figure 8. If taxes and benefits per capita stay as they are, all countries except for Japan will have rather large deficits evolving during the coming decades. In this worst case scenario, Italy and Germany, countries with very high dependency ratios, would have public deficits above 10% of GNP and a public debt above GNP in the year 2010. Italy, starting from a huge debt level,...$$$.. Relative to the European countries, Canada and the United States have a younger population and less generous entitlement programs, leading to lower deficit to GNP ratios. This helps Canada, even though she starts from a relatively high debt level in 1990, to have a lower debt to GNP ratio than Germany after the year 2010. Japan, in spite of a quick aging process, continues to have positive albeit small budget surpluses due to the low replacement rates in her retirement and health insurance systems.

These numbers are favorable with respect to the interest rate. Higher rates, for instance due to international competition for funds, raise budget deficits and speed up the accumulation of government debt. In turn and as already emphasized, the figures are a worst case scenario in terms of taxes and benefit levels. Increasing taxes and/or reducing benefits will stabilize the budget deficits and thus reduce the public demand for funds.

FIGURE 9: Projected Public Demand for Funds, 1990-2000-2010

Figure 9 accumulates the deficits into public debt, the demand for funds in the years 1990, 2000 and 2010, measured in 1990 prices. The U.S. debt amounts to $.... trillion, the German debt

[11] In Germany, this is a hypothetical exercise because the law prevents the social security system from borrowing.

...., not at all offset by the Japanese surplus of ..... Using the same weights as in section 3, total public demand for funds in the OECD is estimated to be .....

5. Projected private demand for funds in the OECD area

Private demand for funds -capital for investment in the OECD area - will also be affected by population aging, but in conflicting directions and in magnitudes difficult to quantify. The effects north the ____ several channels: population aging changes the capital intensity, the rate of technological change, and alters the composition of consumption goods that are demanded.

First, labor force growth rates will strongly decline in most OECD countries and be negative after 2010, see figure 10. Following the logic of a neoclassical growth model, this investment at the _____ for funds shrinkage of the labor force implies a decline in per worker capital accumulation. This is picked up in section 7. If labor force shrinkage would be faster than the sum of the rates of depreciation and labor augmenting technical progress, net investment could even be negative and capital could be converted into consumption if so possible.

FIGURE 10: Labor force growth rates in the OECD, 1990-2020

Second, population aging shifts not only the ratio between workers and retirees but also between young and old workers. The share of persons aged 45-64 in total working age population increases from 36.1 in 1990 to 46.5 in 2020, see figure 11. If old workers are less innovative than young workers, the rate of technical progress will slow during the population aging process.

FIGURE 11: Share of Young and Old Workers, OECD, 1990-2020

Third, this negative effect on technocal change is reinforced when the labor force shrinkage is sufficiently large to imply a total population decline. In this case, innovation which is typically characterized by large fixed costs becomes more expensive per capita at thurs less attractive because the fixed costs can be spread less on a shrinking population.

Fourth, and quite to the contrary, technological change may increase with population aging in order to offset the negative implications of labor scarcity. Put simply, scarcity is the mother of invention. This argument has been formalized by Romer (1990) and works through the channels of human capital accumulation that is hypothesized to speed up on a per capita basis in times of relatively slow population growth.

Finally, yet another mechanism that may change private investment in response to population aging is a change in the mix of consumption goods requiring the installation of a different production machinery. Again, there are conflicting tendencies. While an increase in the demand for health-care related equipment and the adaptation of homes and infrastructure to a higher share of elderly may generate an increase in fixed investment, an aging population is likely to shift consumption increasingly towards services, hence reducing the need for capital investment.

The evidence on the relation between the rate of technical progress and demographic factors such as labor force growth and the population age structure is very scant. The cross national analysis in Cutler et al. (1990) indicates a positive relation between labor scarcity and technological progress. Their analysis rests on a panel of 29 OECD countries 1960-1985 drawn from the Summers and Heston (1990) data. Cutler et al. find that a 1 percentage point decrease in the annual labor force growth rate raises productivity growth by about 0.5 percentage points per year. This effect is robust to several changes in the specification and sample selection. Most importantly, the effect is statistically significant while Cutler et al. were unable to ascertain a significant effect of the average age of the working population on productivity growth. The latter result corresponds to the inconclusive microeconometric evidence on the relation between individual productivity and age.[12]

Looking at gross fixed private capital formation, figure 12, private demand for funds in the three largest OECD economies was virtually constant during the last 15 years. Observing this, and realizing, that the above-mentioned mechanisms cannot sensibly be modelled in a partial equilibrium analysis, I use the current levels for the savings-investment balance of the ___ section. A general

[12] For a brief summary, see Börsch-Supan (19$$ EcPol).

equilibrium analysis follows in section 7. Measured in 1990 US-$ and abstracting from GNP growth, annual private demand for funds was $...in the U.S., $...in Japan, and $...in Germany. Using the weights of section 3, total annual private demand for funds in the OECD is estimated to sum up to .... $.

FIGURE 12: Gross Fixed Capital Formation, 1975-1990

6. Future evolution of saving-investment balance in the OECD area

Contrasting the supply of funds derived in section 3 with the public and private demand for funds estimated in sections 4 and 5 yields an indication of the pressures on OECD capital markets. This comparison ignores supply of, but in particular demand for, funds from non-OECD countries. The comparison also ignores all the feedbacks that are supposed to generate a capital market equilibrium, and all behavioral changes in response to population aging. It _____ gives an indication of the pressures that a ____ , to en in a OECD-wide capital market.

Figure 13 summarizes the results. In 2000.....

FIGURE 13: [short run OECD capital market pressures!]

In the longer run, the relative pressures on the demand and supply side of the global capital market may look quite different from figure 11. After about 2020, the baby boom generation retires and reduces its saving in absolute terms: saving rates decline, most strongly in the United States, and income levels decline when a large proportion of savers receives retirement income. At the same time, social expenditures keep rising with the increase in the dependency ratios. In 2035, when population aging is at its peak in most OECD countries, demand for government debt in the OECD peaks as well, while saving in the industrialized countries is relatively low. In addition to the demand for funds by governments of the developed countries, an increase for investment funds in the

developing countries is likely, adding further to demand pressures on a global capital market. Figure 14 gives a rough sketch of the demand for, and the supply of, capital if each component would evolve in isolation.

FIGURE 14: [MGI Summary 1, Exhibit 6]

large run, global capital market pressures

However, due to the many feedbacks that change individual behavior and due to the rapid globalization of the world capital market, major capital market disequilibria that may be suggested by the above figure are unlikely to evolve. The second part of the paper is therefore concerned with an equilibrium analysis in which a global rate of return equilibrates the demand for, and the supply of, funds.

Part II: Equilibrium Analyses

7. General Equilibrium Analysis of the Effect of Population Aging on Saving and Investment in the OECD

In times of population aging, capital becomes relatively more abundant while labor becomes relatively scarce. From a macroeconomic point of view, a society which maximizes consumption should decrease savings to accomodate a growth path that requires less capital to equip the shrinking labor force. In the language of the first part of this paper, this macroeconomic feedback of population aging on saving behavior could be identified as a prediction of future cohort effects.[13] This section provides „estimates" of the magnitude of this effect, based on a simple growth model.

The mechanism by which saving falls is the anticipation of a falling rate of return on capital. The empirical evidence on the question, whether age-specific saving rates vary indeed with the rate of return on capital, is highly controversial.[14] One may not be too irritated by the inconclusive time series evidence as none of the concepts is easy to measure, and fluctuations in savings and the rate of return have very different frequencies. However, it puts one in the uncomfortable position of not being able to relate the results of the growth model in this part of the paper directly to observed historical episodes.

In order to obtain an idea how an optimal saving rate will develop in the face of population aging, I employ the well-known Cass-Ramsey-Solow optimal growth model in a version popularized by Cutler, Poterba, Sheiner and Summers (1990) in an application to the aging problem in the United States. A major feature of this model is an aggregate savings rate that responds to the relative scarcity of labor and capital, hence demographic changes. Another important feature of a growth model, very different to the static projections of to___ expenditures in the previous sections, is the response of consumption to demographic changes.

An important consideration for most OECD countries is treade and foreign direct investment. Saving is increasingly determined in a world that has many countries competing for the most efficient use of capital with large capital flows among OECD countries but also between the OECD and non-member countries. I therefore extend the Cutler, Poterba, Sheiner and Summers model into a

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[13] Note that cohort and year effects are identical in a long-run growth model that abstracts from business cycles.

[14] See for instance Boskin (1978), Bosworth (1982), Bosworth, Burtless, and Sabelhouse (1991).

growth model that features many large countries and allows for a determination of a single rate of return on a global capital market.

The individual countries' growth paths are determined by two mechanisms. In each country, the saving rate is adjusted to maximize the present discounted utility from current and future consumption. The budget constraint is a function of labor supply and population size, the demographic inputs. The second mechanism is capital mobility. Capital flows will occur as long as the rate of return differs across countries. At each point of time, the equilibrium capital flows are therefore determined by a common interest rate on the global capital market. Uninhibited capital mobility is a critical assumption, discussed below.

I assume a common world production technology in terms of efficiency units of labor. Thus, after accounting for differential labor productivity, it does not matter in which country machines are located. This assumption is less strong than it may appear at first sight because we can account for productivity differences by rescaling the efficiency units of labor. Per worker world output at time t, $y(t)$, is produced from $k(t)$ units of capital per worker using a worldwide neoclassical technology $y(t) = f(k(t))$ that fulfills the Inada conditions. Per worker output $y(t)$ and capital intensity $k(t)$ are measured in a efficiency units, e.g., $k(t) = K(t)/(e^{gt} L(t))$, that reflect technical progress at a rate denoted by g as well as differences in labor productivity across countries. At the world level, wage rate $w(t)$ and interest rate $r(t)$ are determined by the familiar marginal productivity conditions. The world capital stock is the sum of the assets owned by each country, denoted by $a_i(t)$ for country ion a per worker basis.

The growth model is characterized by two equations of motion for each country. The first equation of motion is each country's asset accumulation equation or budget constraint:

$$(1) \qquad da_i(t)/dt = w(t) + r(t)\cdot a_i(t) - c_i(t)/a_i(t) - [n_i(t)+d+g]\cdot a_i(t).$$

Net additions to each country's assets, $da_i(t)/dt$, are financed from the difference between gross national income on the one hand, and the sum of consumption and replacement investment on the other hand. Gross national income in country i is the sum of wages and interest income obtained from the assets owned by this country. Consumption, $c_i(t)$, is converted from a per capita to a per worker basis by the ratio of workers to consumers, the support ratio, $a_i(t)$. This is the first demographic parameter entering the model. Finally, replacement investment consists of depreciation at a fixed rate d, and the endowment of new and more efficient labor with capital at a rate $n_i(t)+g$. The labor force growth rate $n_i(t)$ is the second demographic parameter entering the model.

Maximizing consumption of country *i* subject to this country's budget constraint yields the familiar Euler equation for the path of per capita consumption:[15]

$$(2) \qquad \frac{dc_i(t)/dt}{c_i(t)} = s \cdot (r(t) - (r + d + g/s)) .$$

The main mechanism in this second equation of motion is the tradeoff between consuming now and consuming later. This tradeoff is governed by the difference between the rate of return from capital, $r(t)$, and the gross rate of time preference, $r + d + g/s$, which consists of the net rate of time prefernce, r, the rate of depreciation, d, and a correction term due to the measurement in efficiency units, g/s. If the time preference rate is high relative to the interest rate, consumers prefer consumption right now, leading to an initially high and then decreasing consumption. In turn, consumption increases relative to the previous year if the market interest rate exceeds the gross rate of time preference. The factor of proportionality between the difference in interest and time preference rates and the relative change in consumption is the intertemporal elasticity of substitution, s. The larger s, the more sensitive is current consumption to changes in the rate of return from capital relative to the time preference rate.

Asymmetries between countries emerge when the demographic variables -- the support ratios $a_i(t)$ and the employment growth rates $n_i(t)$ in each country -- begin to differ. Starting from an equal position, flows of capital from country *i* to country *j* make $a_i(t)$ larger and $a_j(t)$ smaller than $k(t)$, the average capital endowment of a worker in the world (in efficiency units), such that the share of assets held in foreign capital amounts to

$$(3) \qquad f_i(t) = [a_i(t) - k(t)] / k(t) .$$

Thie model is described in appendix one and a very crude picture of a macroeconomy. It describes a highly aggregate level of the economy. It traces only long-run trends and those under very restrictive assumptions. The intertemporal utility maximization in equation presumes perfect foresight. Impatience is built in by allowing for a positive discount rate, but there is no uncertainty or disagreement about the path of demographic changes, and social preferences stay constant during a period of considerable social changes. It abstracts from many feedbacks. Labor supply is likely to react to population aging, through the market (increasing wages) as well as through pupblic policy (an

[15] Underlying is a constant-elasticity felicity function weighted by the size of population.

adjustment of the social security eligibility age). The rate of technical progress may change with population aging, see section 5. Fertility may change in the face of an aging society, see Becker and Barro, 1988. There is little empirical guidance to model these feedbacks. Some of the missing feedbacks are cushioned by the assumptions underlying the demographic and employment scenarios (OECD, 1988). Other feedbacks are more elusive.

Population aging has very different impacts on the evolution of savings depending on whether a country is considered a closed or an open economy. While the assumption of a closed economy is extreme for all OECD countries, maybe with the exception of the United States, the assumption of uninhibited capital flows across the world is the other extreme. I therefore proceed in three steps. In the remainder of this section, I investigate the impact of population aging on saving and investment in the OECD economy as a whole. Section 8 inspects the capital flows that emerge among OECD countries in order to establish an OECD capital market equilibrium. Because the developing countries are likely to contribute substantially more to the demand for funds in the future than they do now, I also look into the effect of trade and capital flows between the OECD and developing countries on saving and investment within the OECD. Detailed results of the last step are relegated to the appendix.

Figure 15 shows the two components of demographic inputs to the OECD growth model. The first component is the falling relative number of workers in the population, as described by a falling support ratio (or a rising dependency ratio). The support ratio falls steadily from now to the year 2040. The acceleration after the year 2010 is particularly noteworthy. The second component is labor force shrinkage. The OECD labor force growth rate is declining until 2025, then resumes, but remains negative from the year 2015 on.

Figure 15: Labor Force Growth and Support Ratio in the OECD

Figure 16 depicts how aggregate saving in the OECD reacts to these demographic changes, under the premise that we can abstract from trade with, and foreign direct investment in, countries outside the OECD. Saving of course equals investment in this closed, OECD-wide economy. The baseline path of saving follows closely the path of labor force growth, shown above. Because capital becomes partially obsolete when the labor force shrinks, saving and investment start declining. The

saving rate is 0.56 percent lower in 2000 and pretty much remains on this level until the year 2010. After 2010, the effect becomes much more dramatical. The saving rate declines by about 2 percentage points when population aging speeds up and reaches its miniumum in the year 2035, ten years after the greatest decline in the labor force, but before the OECD support ratio rebounds.

Figure 16: Equilibrium Net Saving Rate in the OECD (Autarky)

Figure 16 also depicts the sensitivity to alternative assumptions about the of rate technical progress. *„g(LFG)“* depicts the aggregate saving rate if the rate of technical progress is a negative function of labor force growth according to the the fourth mechanism mentioned in section 5 I use the coefficient implied by the estimates of Cutler et al. (1990). Because new investment is created due to the increasing speed of technical change in the face of labor scarcity, saving and investment fall much slower than in the base case. The path denoted by *„g(LFG,AGE)“* adds the second mechanism described in section 5: An older labor force may be less innovative than a younger labor force. Again, I employ the coefficient estimated by Cutler et al. (1990). The negative effect of an increasiv average age of the north force overcompensates the positive labor scarcity effect and leads to a decline of 3 percentage points in the aggregate OECD-wide saving rate between 1990 and 2035 as compared to a .... in the case. The general orders of magnitudes are very similar in all three cases. Hence, if one believes in Cutler et al. elasticities, reasonable changes in the rate of techniocal progress will not change the overall conclusion of a substantial decline in saving in the long run.

The obsolescence of some of the capital stock will also reduce the interest rate. Figure 17 depicts this effect. The estimates are not very sensitive to the above-mentioned variations in the specifications about the rate of technical progress. They agree on a substantial decrease in the rate of return, from 6.7 percent in 1990 to below 3.5 percent in 2025, when labor shrinkage is largest.

Figure 17: Equilibrium Rate of Return (OECD, Autarky)

Not only saving but also consumption is endogenous and reacts to demographic changes. As the support ratio declines, the opportunity set for consumption shrinks. This is in stark contrast to the fixed age-specific consumption „needs“ underlying the shift-share analysis of social expenditures in section 4. On the other hand, obsolete capital can be converted to consumption, thereby increasing the opportunity set. This effect is emphasized in the Cutler et al. (1990) study for the United States. The rather smooth aging process in the aggregate OECD leads to a very small increase in consumption only in the first years after the society starts adapting to the demographic changes. After this brief episode of higher con____ per capita consumption falls steadily for the next two generations. Note that a closed OECD economy cannot borrow the funds required to finance the bulge of social expenditures sketched in figure 14. This is forces to reduce the OECD consumption.[16] Per Capita, consumption is of course sensitive to the rate of technical progress. The effects are straightforward and are depicted in figure 18.

Figure 18: Relative Consumption in the OECD (Autarky)

8. Aging and Capital Flows within the OECD

The preceding section treated the OECD as a homogeneous aggregate. However, as figure 19 shows, demographic changes are actually very different across OECD members. Germany has the one of the most pronounced aging processes in the OECD and will experience a much stronger decline in her aggregate saving rate than projected for the OECD as a whole (Börsch-Supan, 1985). In turn, Turkey will face virtually no population aging, even after the year 2030, when e.g. the South East Asian countries are projected to age quickly.

Figure 19: Support Ratios in Selected Regions

[16] The model does not specify the decline for workers and pensioners separately.

Differences in speed and extent of population aging open opportunities for trade and foreign direct investment. By exporting capital to less rapidly aging countries and producing there, a country like Germany can at least partially offset the reduction in the rate of return and, according to the logic of the neoclassical growth model, thus also in domestic saving. The issue is complicated in a system of many countries, some of them aging faster than others, some of them not aging at all. There will be competition across the aging countries for profitable foreign direct investment in countries that age slower or not at all.

In this section, I model the interaction among groups of OECD countries with different population, capital and production structures. To this end, I feed the above growth model of with data from all OECD countries, arranged in 12 regions. I disaggregate the European Union into the major single countries (Germany, France, Italy, and the United Kingdom), define a region of the small countries of the European core (Austria, Belgium, Luxembourg, the Netherlands, and Switzerland), Scandinavia (Denmark, Finland, Iceland, Norway, and Sweden), the Southern European Periphery (Greece, Portugal, Spain), and add the quickly growing countries of Turkey and Ireland as a ninth region. The United States, Canada, and Australia (combined with New Zealand) are treated separately. Although these 12 regions cover all OECD countries (as of 1988), this is state of a global capital market because some important regions are missing in this picture: the newly industrialized countries in South East Asia, the emerging Eastern European economies, and the developing countries.[17]

This disaggregate model is much harder to feed with data and to calibrate than the model in the previous section. American support ratios and labor force growth are taken from Cutler et al. (1990) who employ projections from the U.S. Social Security Administration. In order to describe the German demographic and employment evolution, I use the demographic and employment scenario lined out in B ... (1994). Projections for the other European countries and Japan are less detailed and were taken from Summers and Heston (1990) and OECD (1988).

The results of the emerging capital flows, the relative ownership of capital as defined in equation 3, is displayed in figure 20. Germany and the smaller European core countries, and to a lesser extent Japan, Italy, and Canada export capital throughout the period considered. Relative to today, Germany will own 18 percent more of the OECD capital than an average OECD country. This ownership share will increase further as population aging continues. Until 2005, Japan is second

to Germany as a capital exporter - at least, as it concerns capital flows precipitated by population aging. After 2010, when Japan's labor force increases again, Japan's share of OECD real wealth declines.

Capital exports flow into the Southern European Periphery, with the bulk going to Turkey. The inclusion of Turkey at the European periphery is particularly significant. Turkey has an extremely different demographic outlook than the European core countries. Since Turkey is also relatively big, reaching Japan in size about the year 2030, she can absorb a lot of capital in form of foreign direct investment.[18] The only other permanent recipients of capital are Australia and New Zealand.

France, Scandinavia, the United Kingdom, and the United States change during the aging process (around the year 2010) from being capital importers to becoming capital exporters. However, population aging-related capital flows play a relatively minor role for the UK and the US.

Figure 20: Result of Capital Flows within the OECD

I should not finish this section without a word of caution: The simulations in this section are illustrative rather than projections, aiming at rough orders of magnitudes. The simulation results are robust against variations in technology but the capital flows depend very sensitively on the demographic inputs and the relative sizes of the regions included. They of course very much depend on the absorption of capital in the receiving countries, in particular economic and political stability necessary to warrant high rates of return. The appendix also shows that the results change dramatically if large countries such as India or China start offering productive investments such that they absorb large amounts of capital.

9. Conclusions

As the public pay-as-you-go pension systems of the aging industrialized countries are likely to become seriously strained under the growing dependency burden, the question arises whether a society should rely on private savings to finance old-age consumption. This is an empirical question

[17] See the appendix for an inclusion of these regions.

[18] The odd combination of Ireland with Turkey results from the very similar demographic patterns in both countries.

about the magnitude and the flexibility of saving rates. The paper takes the German case as an example. A simple computation of the pension gap shows that saving rates must increase in an unprecedented fashion in order to compensate for the dependency effect. However, the analysis of German age and cohort patterns shows that this is unlikely. First, the life cycle structure structure of German saving rates will not generate a lot of „excess“ savings. If one believes the (weak) evidence generated by the separation of age and cohort effects, the opposite is the case. Second, if cohort effects are governed by the rationale underlying a neoclassical growth model, i.e., if an aggregate saving rate emerges that maximizes the long-run welfare of a country, then saving will strongly decline, only somewhat moderated in the case of heavy investment in less aging countries.

The paper illustrates a well-known theoretical point. In an economy with a shrinking labor force, funding a pension system cannot work as an escape route from a rising burden of dependency. Faltering rates of return prohibit this mechanism. Section 3 of the paper shows that under moderately realistic assumptions, foreign direct investment helps -- it actually helps considerably in terms of consumption possibilities -- but the magnitude of the problem is too large to be offset. Because all industrialized countries are aging, a full offset would require a very large emerging market for investment.

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Appendix 1: Demographic Assumptions and Calibration, Germany.

- **Fertility**: Fertility will experience a slight upturn once the awareness of population aging becomes more widespread and in reaction to changes in social security policy. This is a crude attempt to „endogenize" fertility in response to population aging. It is unlikely that fertility will rebound to full replacement values. Departing from the OECD (1988) estimate, I assume a more gradual increase, starting from the current net replacemente rate of 1.39 and reaching the OECD rate of 1.60 only in the year 2050.
- **Mortality**: I assume that German life expectancy will trace the development of other countries that already experience a higher life expectancy such as Sweden, Switzerland, or Japan. Specifically, I assume that the German life expectancy will reach the current Japanese life expectancy in the year 2010; that it keeps increasing at the same speed until 2030; and that the progress in life expectancy will only then start to slow down. Accordingly, life expectancy at birth in Germany is projected to be 78.1 years in 2000, 78.9 in 2010, 81.0 in 2030, and 83.2 in 2050.
- **Immigration**: In response to the changes in the German asylum policy immigration will be lower than the IAB forecast but substantially higher than the Census prediction. I assume that in the long run immigration will be 80 percent of the IAB figures, i.e., about 115,000 immigrants in 2000 and about 100,000 after 2010.
- **Female Labor Force Participation:** I first employ the projections of the Research Institute of the German Employers Association (IW, Institut der Deutschen Wirtschaft, Köln), namely an increase in female labor force participation from 34.7 percent in 1990 to 38.2 percent in 2000. I assume a continuation of this increase to 39.3 percent until 2010, remaining at this level thereafter.
- **Retirement Age:** In another crude attempt to „endogenize" responses to population aging, I assume an increase in the average retirement age by one year until 2010 and by two years from 2030 on. Pensioners in the simulation model are defined as all persons as all persons who become non-workers past the peak of labor force participation at about the age of 48. This includes persons making use of the various early retirement schemes in Germany as well as persons claiming disability insurance.
- **Sensitivity**: I may finally note that different assumptions about fertility and mortality change the projections from now through the year 2030 only marginally because both the generation of future retirees and the generation of future workers are already in place. Different demographic projections begin to diverge significantly only after the year 2030. However, different

assumptions about the labor force, in particular immigration, do produce significant changes from the scenario depicted above.

- **Calibration**: In order to achieve realistic orders of magnitudes, I fit the growth model to actual national accounting data for Germany from 1978 through 1989, the year before unification.[19] Estimates of a CES production function yield a share of capital in total income of 40.99 percent, a ratio of capital to output of 2.70, and an essentially unitary elasticity of substitution in production, in combination with a rate of technical progress of 1.40 percent p.a., and a depreciation rate of 5.28 percent p.a.. Assuming a steady state in 1989, the gross rate of time preference is computed using the steady state equation for capital. This results in $r + g/s = 0.099$. The most problematic parameter in the model is the elasticity s because it cannot be obtained easily from national accounting data. I calibrate the model by a grid search over σ, fitting the predicted path of consumption to actual consumption data 1965-1989. This results in an elasticity of intertemporal substitution in consumption $s = 0.6749$, and implies a net discount rate $r = 7.8$ percent. This large discount rate indicates a high degree of impatience and is in line with the estimated low intertemporal elasticity of substitution in consumption.
- **Sensitivity**: The model is rather insensitive to variations in the two elasticities and reasonable variations in the parameters of the CES production technology. The most crucial parameter is the gross discount rate because it governs one of the Euler equation (2). Reducing the discount rate leads to a smoother path of consumption as impatience decreases, making intertemporal substitution more important.[20]

[19] The data is provided by the DIW, Berlin.

[20] A higher degree of intertemporal substitution does not appear to be warranted by the empirical evidence. One may wonder, however, whether such an assumption would change the following results in their substance. This is not the case.

Appendix 2: The OECD, Emerging Markets, and Developing Countries

Section 7 and 8 treated saving and investment in the OECD countries as if there were no other countries to invest in. In fact, „emerging market funds“ capture already now a significant portion of OECD savings. This section uses the model of section 7 to illustrate how saving and investment change when the OECD is able to exports capital to the non-OECD world. We first add the newly industrialized countries (NICs) in South East Asia (consisting of Hong Kong, Indonesia, South Korea, Malaysia, the Philippines, Singapore, and Taiwan).

The newly industrialized countries' labor force is still growing at rather high rates until the end if this century. It keeps growing until 2015, but then also declines. At the same time, the support ratio is improving until 2005, and declines after the year 2010. The demographic development of the NICs region is therefore similar to the U.S., but the level of the support ratio remains considerably higher than in the United States. However, the speed of the aging process projected for the NICs is considerable once they age.

Data for the newly industrialized countries is harder to obtain than for the OECD countries. I start with the 1990 support ratios published by the OECD Labor Force Statistics for each of the NICs, and then take Taiwan’s projected changes in the support ratio and her labor force growth, published by the World Bank, as representative for the entire NICs region.

I also add a third region which I dubb India. It is actually a hypothetical country of the size of India that grows at the same rate as the NICs between now and 2015, but then continues to grow at the 2015 rate when the NICs start aging. Also the support ratio is frozen at the 2015 level.

Figure A1: Saving Rate in a World Consisting of the OECD, the NICs, and India

Figures A1 and A2 show the result of this sensitivity analysis. The demand for capital in the quickly growing economies keeps the rates of saving and interest up. Trade with, and foreign direct investment in, the NICs alone stabilizes saving and interest until after the year 2005. If a country as large as India „takes off“, the decline in saving is postponed to after the year 2020, and the demand

for capital from the developing countries drives interest rates up. Because the model features a forward looking, perfect foresight equilibrium, all these effects are anticipated well in advance.

Figure A2: Interest Rate in a World Consisting of the OECD, the NICs, and India