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Pension reform and demographic uncertainty: the case of Germany

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Abstract

The present paper compares the distributional and risk-sharing consequences of two pension reform options in Germany, which both aim to improve the sustainability of the current system by introducing demographic variables to the benefit calculation. While the first reform proposes a so-called 'sustainability factor', which measures the changes in the dependency ratio, the second reform proposes a so-called 'demographic factor', which takes into account the changes in life expectancy. Our simulations indicate that both reforms imply a double burden for currently middle-aged generations and a double relief for future living generations. On the one side, resources are redistributed from currently towards future living generations. In addition, part of the risk from demographic uncertainty is shifted from future living towards currently living middle-aged generations. The reforms differ, however, with respect to the magnitude of the resource distribution and risk implications. Therefore, future generations are much better off with the 'sustainability factor', while it is not clear whether middle-aged generations are better off with the 'demographic factor' or the 'sustainability factor'.

1 Introduction

Just like most other industrialized countries, Germany is currently facing an unprecedented demographic transition. Due to the low fertility rates (the so called 'baby bust') starting in the 1970s and the retirement of the baby boom generations of the sixties, the proportion of elderly in the population will increase significantly. At the same time, the working-age population will shrink or grow only very slowly due to the low fertility rates of the past decades. Since the elderly depend on the young to finance their pension and health care benefits, population aging will lead to a dramatic fiscal crisis in the future. According to some recent projections, payroll taxes to the pension, health care and long-term care system will increase from 36%

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to 56% in the medium run, see Bonin (2002) or Fetzer, Moog, and Raffelhüschen (2003).

Of course, since they depend on various assumptions on future demographic and economic trends, such tax hikes are uncertain. But since they threaten the sustainability of the whole social security system, politicians have started to cut down pension and health care benefits. Partly, this reduction in benefits takes into account the future demographic uncertainty. For example, already the former conservative government introduced a so called 'demographic factor' (DF-reform) which was supposed to reduce future benefits in accordance with the increase in future life expectancy. This reform was suspended soon after the government change in 1998 and substituted in 2001 by a new benefit scheme which reduces pension levels independent of future demographic trends. However, soon it turned out that the so-called 'Riester Reform' would hardly suffice to keep the pension contribution rates below the envisaged 23% in the medium run. Consequently, the government has introduced in 2004 the so-called 'sustainability factor' (SF-reform) which reduces future benefits in accordance with the increase in the dependency ratio – the ratio of retirees to workers.[1]

The present paper compares the economic effects of these conflicting pension reform options in Germany. From the preceding discussion it should be quite clear that a complete assessment has to cover the (traditional) intergenerational welfare effects, as well as the risk-sharing properties of the alternative schemes. Consequently, our analysis has to take into account the uncertainty of the population and economic projections, how this uncertainty affects the different generations and how the uncertainty is altered by the considered policy reforms. In order to achieve this, our study combines stochastic population forecasts and the overlapping-generation approach pioneered by Auerbach and Kotlikoff (1987).

Previous contributions such as Fehr (2000), Hirte (2002) and Börsch-Supan *et al.* (2003) have already applied the latter model to German pension reform issues. However, these studies are typically based on a specific ('deterministic') population forecast with certain values for future fertility, mortality and immigration rates. Börsch-Supan *et al.* (2003) as well as Beetsma, Bettendorf, and Broer (2003) take into account the uncertainty of the population forecast by comparing the results of various projections which are based on rather 'optimistic' or 'pessimistic' assumptions about future demographic variables. This so-called scenario-based approach to forecasting has at least three important shortcomings. First, typically these scenarios assume a perfect (positive or negative) correlation between the processes of fertility, mortality, and migration as well as a perfect correlation across age and time for each vital process. Second, the pairing of assumptions might not make sense since the method could combine scenarios for different processes which correspond to completely different levels of uncertainty. Finally, it is not possible to assign a probability to a specific projection which allows the user to assess the likelihood of the underlying assumptions. Consequently, scenario-based

[1] Börsch-Supan, Reil-Held, and Wilke (2003) discuss the reform objectives and compare alternative indexation formulas with respect to their impact on contribution rates and pension levels.

projections are not able to provide a probability distribution of future population structures.[2]

During the past two decades, demographers have developed stochastic population forecasts. Such probabilistic models derive the realizations of future fertility, mortality, and immigration rates from a stochastic process. Once the parameters of these processes are specified, sample paths of the future population are generated by starting with the last-known population vector and applying the randomly simulated vital rates over time. Since the population is simulated many times, it is possible to derive an entire distribution for the demographic variables at any future date. These stochastic population projections are then used as a basis for an assessment of the uncertainty of government budget projections, see for example Congressional Budget Office (2001). While the CBO projections do not account for behavioral reactions, the present paper follows Lassila and Valkonen (2001) as well as Alho *et al*. (2005) by using the stochastic population projections as a basis for a general equilibrium model of the Auerbach and Kotlikoff (1987) type. By combining a deterministic overlapping generations model with stochastic demographic projections, the present approach does not account appropriately for the uncertainty in the agents decision processes. Agents and firms in the model do have perfect foresight of the future population in each simulation run of the model. Of course, the omission of uncertainty in the economic model is a theoretical drawback, but it reduces the computational problems considerably.[3] We extend previous studies and apply this framework in order to quantify the uncertainty of implicit debt levels and the intergenerational risk-sharing implications of different pension reforms.

Our analysis reveals that there was only a 3 (11.3) % probability that the contribution rate will be less than 22 (23) % in 2030 under the previous pension system. Consequently, a reform was necessary, since the government aimed to stabilize future contribution rates. The reformed current pension scheme which includes the 'sustainability factor' increases the respective probability up to 19 (65.4) %. The introduction of a 'demographic factor' would have reduced future contribution rates much less. The probability that the contribution rate in 2030 will be less than 22 (23) % would have only slightly changed from 3 (11.3) to 0 (15.6) %. Therefore, while both reforms shift resources from the currently elderly towards younger and future living generations, the intergenerational welfare redistribution is stronger under the SF-reform. In addition, both reforms shift part of the risk from demographic uncertainty from future living generations towards currently living middle-aged generations. However, the magnitude of the risk redistribution is different between the two reforms. Consequently, our simulations indicate a double burden for currently middle-aged generations and a double relief for future generations. While future generations are much better off with the SF-reform, it is not clear whether middle-aged generations are now better off with the SF-reform compared with the

[2] A more detailed discussion of scenario-based projections and the stochastic forecasting approach is provided by Schieber and Hewitt (2000), Lee and Tuljapurkar (2001) or Lee and Edwards (2002).

[3] See Ríos-Rull (2001) who employs recursive methods in order to deal with overlapping generations and stochastic populations.

DF-reform. They would have experienced lower reductions in expected welfare under the DF-reform, but at the same time they would have born more risk than under the SF-reform.

In the following, we first describe the structure of the stochastic population model and the simulation model of the German economy. Then we discuss the modelling of alternative pension reform options and report the simulation results.

2 The population model

Our stochastic population forecast is derived with the program PEP (Program for Error Propagation).[4] The starting point of our projection is the population structure for the year 2000 in Germany which is provided by the Federal Statistical Office of Germany. Our point forecast for age-specific fertility rates assumes that their current level of fertility would also prevail in the future. This means that on average German woman will have 1.4 children in the future. Similarly, our point forecast for immigration assumes that the current age and sex-specific immigration rates will be stable in the long run. This implies an annual net-immigration of 200,000 on average. Finally, with respect to mortality, our point forecast assumes an increase in future life expectancy. The applied sex, age, and time specific mortality rates are taken from Bomsdorf (2003). According to his estimates, life expectancy in Germany will increase from 80.5 to 85 years for female persons and from 74.5 to 78.7 for male persons until 2050.

These point estimates for fertility, immigration, and mortality serve as the median of the predictive distribution of these variables. The program PEP then simulates these vital rates randomly, such that future fluctuations are of similar magnitude as past fluctuations.

The general structure of a specific population forecast can be described with three basic equations. In each year $t \geqslant 2000$ the existing total population $[Pop(t)]$ is distinguished according to their age a and their sex $[N^i(a, t), i \in \{m, f\}]$. Assume that $d^i(a, t)$ and $M^i(a, t)$ denote the stochastic sex-specific realizations of mortality and immigration rates at age a in year t. The number of male and female persons in year t is then equal to the survivors of last year's natives and present net immigrants

$$N^i(a, t) = (1 - d^i(a, t))N^i(a-1, t-1) + M^i(a, t) \quad i = m, f \quad a > 0. \tag{1}$$

Next, the number of male and female newborn are simply computed from the stochastic realization of fertility rates $f(a, t)$ of female persons between age 15 and 45 in year t, i.e.

$$N^i(0, t) = \omega^i \times \sum_{a=15}^{45} N^f(a, t) \times f(a, t) \quad \text{with} \quad \omega^m = 0.512 \text{ and } \omega^f = 0.488 \tag{2}$$

defines the birth shares of male and female newborn.

[4] A detailed description of PEP is available at http://www.joensuu.fi/statistics/juha.html/. The basic ideas underlying PEP are discussed in Alho and Spencer (1997) as well as in Ahlo *et al.* (2005).

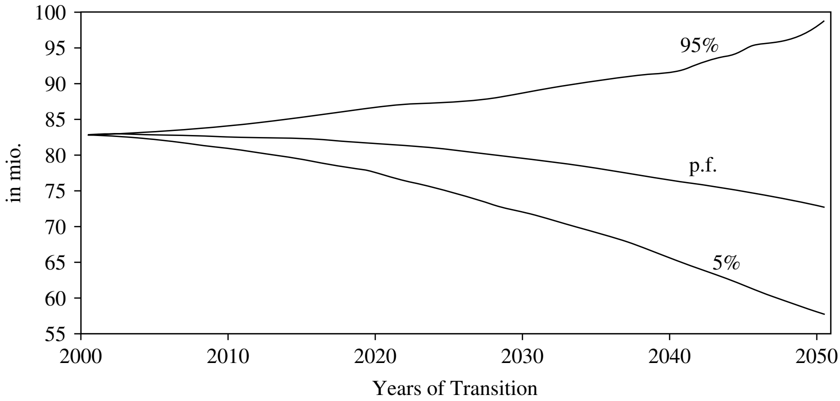

Figure 1. Total population

For convenience, we have restricted the maximum age to 100 years. Consequently, the total population number in t is computed from

$$Pop(t) = \sum_{a=0}^{100} N(a,t) = \sum_{a=0}^{100} [N^m(a,t) + N^f(a,t)]. \tag{3}$$

For our economic model it is important to reach a stable population structure in the future. Therefore, the vital parameters are simulated randomly only between 2001 and 2050. After 2050 we keep mortality and immigration at their point forecast and compute a constant fertility rate from the average realizations during the years 2001 and 2050. Consequently, the model arrives at a constant population structure in 2150. We simulate 300 population forecasts with different randomly selected rates for fertility, immigration and mortality.[5] Consequently, for any population statistic at each future date there is an entire distribution of 300 outcomes. Given such a distribution it is possible to estimate the forecast interval.

Figure 1 plots our forecast of the total population in Germany with a 90 % probability interval between years 2001 and 2050. As discussed above, this projection is based on our point forecasts (p.f.) which are also shown in Figure 1. Note that our point forecast is close to the medium variant forecast of the Federal Statistical Office of Germany (2003), which predicts a decline of the total population from currently 82.4 million to 75.1 million in 2050. However, since the fertility rates are not normally distributed around 1.4, the median projection of the predictive distribution is not identical with the point forecasts. Although it is more likely that the total population will fall in the future, the likelihood that it will be higher than currently is 24.3 %. According to our estimates there is a 90 % probability that in 2050 the total population in Germany is between 57 and 97 million people.

Similarly, Figure 2 plots the point forecast and the probability interval for the future old-age dependency ratio. Until 2030 the dependency ratio in Germany will

[5] This number was mainly chosen due to time constraints. However, increasing the number of simulations did not change the distribution significantly.

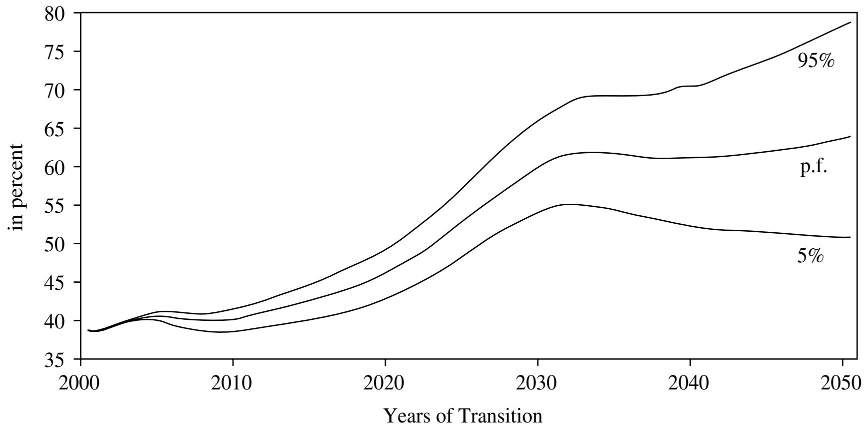

Figure 2. Old-age dependency ratio (62+ pop./20–61 pop.)

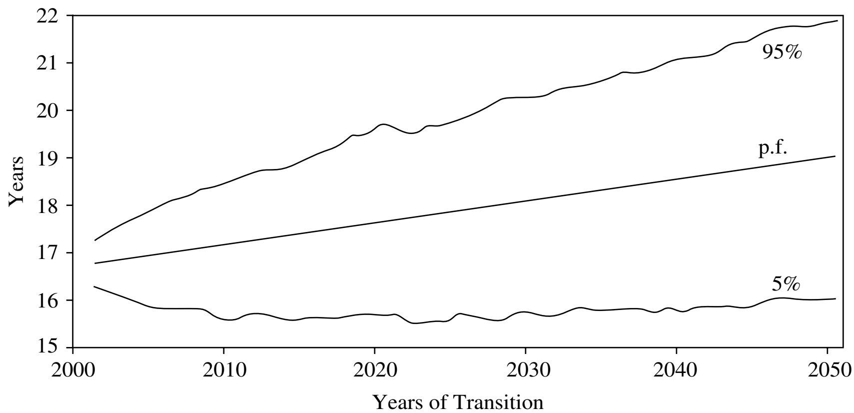

Figure 3. Life expectancy at age 65

increase with certainty. However, the magnitude of the increase is quite unclear and the uncertainty is growing over the years. After 2030 there is also a slight chance that the dependency ratio will fall again, while it stays almost constant in our point forecast.

Finally, Figure 3 shows the probability distribution for the future life expectancy at age 65. Since life expectancy is uncertain at present, there exists also a probability interval in year 2001. In the future, this interval will increase; there is even a small probability that life expectancy will fall again. On the other hand, our point forecast shows a steady increase of the life expectancy.

Since our economic model does not distinguish between sexes, we have to compute age-specific 'average mortality rates' which are applied to the economic model. The latter are computed by simply subtracting the immigrants of both sexes from the number of persons of a specific age and year

$$d(a, t) = 1 - [N(a, t) - M(a, t)]/N(a-1, t-1), \tag{4}$$

where $M(a, t) = M^m(a, t) + M^f(a, t)$ denotes the total number of net immigrants in year t.

3 The economic model

This section describes the economic model which is used to compute the baseline path of the economy and evaluate the policy reforms. We first explain the decision problems of households and firms, then we discuss the tax and transfer system of the economy, and, finally, we present the equilibrium conditions.

The household sector

Although the model includes immigrants from abroad, we do not distinguish between natives and immigrants on the household side. When immigrant households arrive in Germany, they are endowed with the same assets as their native counterparts of the same age.[6] The representative household is completely annuitized and, consequently, leaves no bequests at date of death. All agents start to make their own economic decisions at age 21.

As usual in the Auerbach and Kotlikoff (1987) tradition, our model assumes a preference structure that is represented by a time-separable, nested CES utility function. Remaining lifetime utility $U(j, t)$ of a generation of age j at time t takes on the form

$$U(j, t) = \frac{1}{1-\frac{1}{\gamma}} \sum_{a=j}^{100} \left(\frac{1}{1+\theta}\right)^{a-j} P(a, i) \left[c(a, i)^{1-1/\rho} + \alpha(a)\ell(a, i)^{1-1/\rho}\right]^{\frac{1-1/\gamma}{1-1/\rho}}, \tag{5}$$

where $c(a, i)$ and $\ell(a, i)$ denote consumption and leisure, respectively, and i is defined as $i = t + a - j$.

Since lifespan is uncertain, the utility of consumption in future periods is weighted with the survival probability of reaching age a in year i

$$P(a, i) = \prod_{u=j}^{a} [1 - d(u, u-a+i)], \tag{6}$$

which is determined by multiplying the conditional survival probabilities from year t (when the agents age is j) up to year i. The parameters θ, ρ, and γ represent the 'pure' rate of time preference, and the intratemporal elasticity of substitution between consumption and leisure at each age a and the intertemporal elasticity of substitution between consumption and leisure in different years, respectively. The leisure preference parameter $\alpha(a)$ increases with age through the life cycle in order to get a realistic intertemporal labor supply pattern.

[6] It is debatable whether this assumption is realistic, but it is necessary to keep the structure of the model simple, see also Fehr, Jokisch, and Kotlikoff (2005).

Given the asset endowment $a(j, t)$ of the agent in year t, maximization of (5) is subject to a lifetime budget constraint defined by the sequence

$$a(j+1, t+1) = a(j, t)\left[\frac{1+r(t)}{1-d(j, t)}\right] + W(j, t) - T(j, t) - c(j, t), \tag{7}$$

where $r(t)$ measures the pre-tax return on savings and $W(j, t) = w(t)E(j)[\bar{h} - \ell(j, t)]$ denotes the gross labor income of the age-j agent in year t which is derived as the product of her/his labor supply and her/his wage rate. Given the time endowment $\bar{h}$, the individual wage is the product of the gross wage rate $w(t)$ in period t and the age-specific earnings ability

$$E(j) = e^{4.47 + 0.033(j-20) - 0.00067(j-20)^2}, \tag{8}$$

which is taken from Auerbach and Kotlikoff (1987: 52).

The net-taxes $T(j, t)$ of an agent age j in year t consist of consumption, capital income, and wage taxes, as well as social security contributions net of pensions (Pen), i.e.

$$T(j, t) = \tau^c(t)c(j, t) + \tau^r \tilde{r}(j, t)\mathrm{a}(j, t) + [\tau^w(t) + \tau^{ss}(t)/2]W(j, t) - [1 - \tau^h(t)/2]Pen(j, t), \tag{9}$$

where τ^c, τ^r, and τ^w denote the consumption, capital income, and wage tax rates, respectively. The tax base for the capital income tax $\tilde{r}(j, t) = (1 + r(t))/(1 - d(j, t)) - 1$ also covers the return due to annuization. In Germany, the social security contributions $\tau^{ss}(t) = \tau^p(t) + \tau^h(t)$ for pension (τ^p) and health care[7] (τ^h) are split between the employer and the employee. Pension benefits are age and period specific, but retired persons have to pay half of their health care contributions, while the other half is financed by the pension system (see below).

Given individual consumption, leisure, and asset levels of all agents, we can compute the aggregate variables. Aggregate assets of period t are computed from the savings of natives who live in period $t-1$ and from the assets of those who immigrate in period t

$$A(t) = \sum_{a=21}^{100} \mathrm{a}(a, t)N(a-1, t-1) \quad \text{and} \quad \mathscr{A}(t) = \sum_{a=21}^{100} \mathrm{a}(a, t)\frac{M(a, t)}{1 - d(a, t)}. \tag{10}$$

Arriving immigrants in t are endowed with the same assets as the native population. Since all assets in the model are annuitized (see equation (7)) we have to apply the respective domestic survival probabilities to the immigrant cohorts in order to get their cohort size in the year before immigration. Consequently, the aggregation also includes the assets of (potential) immigrants who died upon immigration.

Aggregate labor supply and consumption in year t, $L(t)$ and $C(t)$ is computed from the individual labor supplies and consumption demand, i.e.

$$L(t) = \sum_{a=21}^{100} E(a)\left[\bar{h} - \ell(a, t)\right]N(a, t) \quad \text{and} \quad C(t) = \sum_{a=21}^{100} c(a, t)N(a, t). \tag{11}$$

[7] In our model, health care contributions and outlays also include long-term care contributions and outlays.

The production side

The economy is populated by a large number of competitive firms, the sum of which we normalize to unity. The competitive labor market equalizes the labor supply of households and demand of firms.[8] Aggregate output $Y(t)$ is produced using a Cobb–Douglas production technology, i.e.

$$Y(t) = \phi K(t)^{\varepsilon} L(t)^{1-\varepsilon}, \tag{12}$$

where $K(t)$ is aggregate capital in period t, ε is capital's share in production, and ϕ is a technology parameter.

Firms have to pay corporate taxes $T^k(t)$ which are computed from

$$T^k(t) = \tau^k(t)[Y(t) - (1 + \tau^{ss}(t)/2)w(t)L(t) - \delta K(t)], \tag{13}$$

where the corporate tax rate $\tau^k(t)$ is applied to the output net of labor costs and depreciation. Note that the labor costs of the firm include a share of social security contributions. Capital is assumed to depreciate at rate δ and depreciation is subtracted from the tax base.

Firms will employ labor up to the point where the marginal product of labor equals labor costs (which include the employers social security contributions). Similarly they will employ capital up to the point where the net marginal product of capital is equal to the interest rate

$$(1 + \tau^{ss}(t)/2)w(t) = (1 - \varepsilon)\phi[K(t)/L(t)]^{\varepsilon} \tag{14}$$

$$r(t) = (1 - \tau^k(t))\{\varepsilon\phi[L(t)/K(t)]^{1-\varepsilon} - \delta\}. \tag{15}$$

The government sector

The consolidated government issues new debt $\Delta B(t)$ and collects net taxes and social security contributions from households and firms in order to finance general government expenditures $G(t)$ as well as interest payments on its debt

$$\Delta B(t) + \sum_{a=21}^{100} T(a,t)N(a,t) + \tau^{ss}(t)w(t)L(t)/2 + T^k(t) = G(t) + r(t)B(t). \tag{16}$$

With respect to public debt, we assume that the government maintains an exogenously fixed ratio of debt to output. General government expenditures $G(t)$ consist of government purchases of goods and services, educational expenditures, and health outlays. Over the transition, government purchases of goods and services g are held fixed per capita, similar to the age-specific outlays for education $edu(a)$ (which are only spent for children) and health $hc(a)$. Consequently we have

$$G(t) = Pop(t)g + \sum_{a=0}^{20} edu(a)N(a,t) + \sum_{a=0}^{100} hc(a)N(a,t). \tag{17}$$

[8] As Hirte (2002) has shown, it would be possible to consider imperfect labor markets in such a model but it would not fundamentally change the results.

Pension benefits in Germany are computed from the product of three elements: (1) the so-called 'adjustment factor' (AF) for pension type and retirement age, (2) the sum of 'individual earning points' (EP), which mainly reflect the retiree's relative earning position during working time, and (3) the 'actual pension value' (APV), which defines the value of one earning point in €. The pension of a pensioner who is age a in year t and who retired at age $\bar{a} \leqslant a$ in year $z \leqslant t$ is then

$$Pen(a, t) = AF(z) \times EP(z) \times APV(t). \tag{18}$$

Our model does not distinguish between different types of pensions. Consequently, the adjustment factor only deviates from one, if the individual retirement age deviates from the 'normal retirement age' of 65, which was introduced by the pension reform in 1992. When the complete reform is fully phased in, benefits will be reduced by 3.6% for each year of earlier retirement (in addition to the effect of fewer earning points). Our model assumes a constant average retirement age of $\bar{a} = 62$ during the transition and an increase in the 'normal retirement age' from 62 to 65 in 2006. Consequently, the individual adjustment factor $AF(z)$ depends on the year of retirement, while it is one for those who retired before 2002, its value reduces to 0.892 for those who retire in and after 2006. The earning points of an employee are computed from the ratio of his/her individual insured gross earnings to average gross earnings in each year of service. Consequently, the sum of the earning points during working years $EP(z)$ are also indexed by the year of retirement z. While the first two factors in (18) are kept constant in the years t after retirement, the actual pension value is adjusted according to

$$APV(t) = APV(t-1) \times \frac{Y(t) \times (1 - \tau^{pp}(t) - \tau^{p}(t))}{Y(t-1) \times (1 - \tau^{pp}(t-1) - \tau^{p}(t-1))} \times RF(t). \tag{19}$$

Equation (19) reflects the central elements of the adjustment formula which was introduced by the Riester Reform in 2001.[9] Since then, changes in the actual pension value are related to lagged changes of an artificial income concept which is computed from the gross income Y net of contributions to public pensions and fictitious contributions τ^{pp} to newly introduced private pension accounts.[10] Until 2010 the fictitious contribution rates to the private accounts increase from currently 0.5% to 4% which dampens the growth of the actual pension value. The reform factor $RF(t)$ is just a general placeholder for the sustainability and the demographic factor. Both factors will be specified in Section 5; in the basic setting the value of $RF(t)$ is one for all years.

The outlays of the pension system also include half of the health care contributions of pensioners. Since the budget of the pension system must be balanced in each period, the contribution rate $\tau^{p}(t)$ is computed from

$$\tau^{p}(t)w(t)L(t) = [1 + \tau^{h}(t)/2] \sum_{a=\bar{a}(t)}^{100} Pen(a, t)N(a, t) = [1 + \tau^{h}(t)/2]PB(t), \tag{20}$$

[9] For a detailed description and an economic evaluation of this reform, see Bonin (2002). Börsch-Supan, Reil-Held, and Wilke (2003) quantify the intergenerational welfare consequences of the reform.

[10] Mainly for simplicity, we have lagged the variables in (19) by one period, while in reality they are lagged by two periods.

Table 1. *Parameter values of the model*

	Symbol	Value
Utility function		
time preference rate	θ	0.02
intertemporal elasticity of substitution	γ	0.25
intratemporal elasticity of substitution	ρ	0.8
leisure preference parameter	$\alpha(a)$	1.0–1.8
Production function		
technology level	ϕ	1.08
capital share in production	ε	0.25
economic depreciation	δ	0.05
Policy parameters		
wage tax rate	τ^w	10.0
capital income tax rate	τ^r	14.0
corporate tax rate	τ^k	15.0
debt (in % of GDP)	B/Y	60.0
age of retirement	$\bar{a}$	62
replacement rate (pension/gross income)	Pen/W	0.5

where $PB(t)$ denote the total pension benefits in year t. Similarly, the health care contribution rate is computed from the budget of the health care system

$$\tau^h(t)[w(t)L(t)+PB(t)]=\sum_{a=0}^{100} hc(a)N(a,t). \tag{21}$$

Aggregation and equilibrium conditions

In general, equilibrium supply has to equal demand in all markets. If we aggregate the (individual) budget constraints (7) as well as the government budget constraints (16), (20), and (21) and substitute the capital market equilibrium condition

$$A(t)+\mathscr{A}(t)=K(t)+B(t) \tag{22}$$

we finally arrive at the national goods market equilibrium

$$Y(t)+\mathscr{A}(t+1)=C(t)+I(t)+G(t) \tag{23}$$

which states that the domestic production plus the assets of the arriving immigrants in the next period are equal to domestic demand. This completes the description of the model.

4 Calibration and simulation

In order to solve the model we have to specify the preference, technology, and policy parameters. Table 1 reports the most important parameter values. The preference and technology parameters are mostly taken from Auerbach and Kotlikoff (1987: 52f.) or Fehr (1999: 57). Note that we allow the leisure preference parameter α to rise

Table 2. *The initial year 2001*

	Model	Germany 2001
Expenditures of GDP (in % of GDP)		
private consumption	49.7	59.5
health care consumption	11.6	–
government purchases incl. education	18.3	19.0
aggregate education outlays	4.7	4.0
gross investment	20.4	19.5
exports-imports	0.0	2.0
Government indicators		
aggregate pension benefits	11.5	12.7
interest payment on public debt	1.8	3.2
pension contribution rate (in %)	19.4	19.5
health care contribution rate (in %)	15.4	15.4[1]
Tax revenues (in % of GDP)	19.9	21.5
wage income tax	6.4	6.8
interest income tax	2.2	1.5
consumption tax	9.8	10.9
corporation tax	1.6	0.0
consumption tax rate (in %)	19.7	–
interest rate (in %)	3.2	–
saving rate (in %)	9.5	10.2
capital-output ratio	3.0	3.5

Note: [1] In 2001 average health care rate was 13.7% and long-term care 1.7%.
Source: Institut der Deutschen Wirtschaft (2003).

linearly from 1.0 (at age 21) to 1.8 (at age 100). This procedure mainly effects the intertemporal labor supply, which is fairly high in early years and then is steadily reduced when approaching retirement.

On the fiscal side we specify the government per capita purchases of goods and services as well as education and health expenditures for different age groups, see (17). In order to finance the outlays, the wage tax rate, the capital income tax rate and the corporate tax rate are set exogenously. Since the deficit is endogenous (due to the fixed debt-output ratio), the consumption tax rate is used to balance the government budget. The retirement age $\bar{a}$ is set to age 62 in the starting year, since we expect that due to the pension reform of 1992 early retirement in the future years will be reduced significantly. Similarly, the current actual pension amount is specified to yield a replacement rate for gross income of 50%, which reflects the current situation for an average income earner.

Given the parameter values described above, Table 2 reports the initial equilibrium in year 2001 for our point forecast.[11] The initial year is not a long-run equilibrium. Consequently, we have to specify asset endowments for the households living in the

[11] Since households are forward looking and tax rates are different along each population path, the initial equilibrium is affected by the population forecast. However, the effects are not very significant.

Table 3. *Sustainability gap and necessary increase in tax revenues*

	Sustainability gap (in percent of GDP)			Tax increase (in percent)		
	5 %	P.f.	95 %	5 %	P.f.	95 %
Basic setting	88	151	219	6.4	11.8	17.6
Sustainability factor	75	133	197	5.6	10.5	15.9
Demographic factor	90	142	196	6.6	11.1	16.0

initial year. We follow Fehr (2000) and derive these asset endowments from a simulation of an artificial steady state.

While health care consumption is in reality a mixture of a private and public consumption good, it is a pure public consumption good in our model. Consequently, in our base year equilibrium private consumption expenditures are fairly low, but this difference is mainly due to health care outlays. The remaining government consumption expenditures then include purchases for goods and services as well as education outlays. Table 2 shows that our benchmark calibration yields quite realistic values for these expenditures. Our model also yields quite realistic tax and contribution rates, as well as tax structures in our base year equilibrium. Note that the endogenous consumption tax rate also includes excise taxes.

First we compute the sustainability gap and the increase in the revenues which is necessary to close this gap. In order to do that, the wage and interest rate and all contribution rates are fixed to their values in the initial year 2001. Also all individual consumption and leisure values are kept constant, only the population is changing in future years. Since contribution rates and consumption tax rate are not adjusted, the budgets of the government, the pension, and the health care system are not balanced. The present value of the annual gaps between revenues and outlays is the implicit debt, and, by adding the explicit debt, we get the sustainability gap. Of course, the sustainability gap depends on the population projection. Table 3 reports our point forecast for the sustainability gap of 151 % of GDP with a 90 % interval from 88 % to 219 %. It is also possible to compute the necessary increase in tax revenues which would close the sustainability gap. Given the initial equilibrium from Table 2, tax revenues would have to increase by 11.8 %, with an 90 % interval from 6.4 % to 17.6 %.

Next, we consider the baseline path of our economy. Since the future is uncertain, Figure 4 shows the point forecast and the 90 % confidence interval of the endogenous pension contribution rate. Not surprisingly, the contribution rates in Figures 4 will increase in the future quite substantially due to ageing.

Note that the confidence interval for the pension contribution rate in Figure 4 has a very similar shape to the confidence interval for the dependency ratio in Figure 2. While the contribution rate will almost stay constant up to year 2010, it will steadily increase afterwards until 2030. After 2030 it might increase further or even fall again. In our point forecast it reaches a maximum after year 2030 at about 25 %. While the objective of the Riester reform was to keep contribution rates below 22 % until 2030,

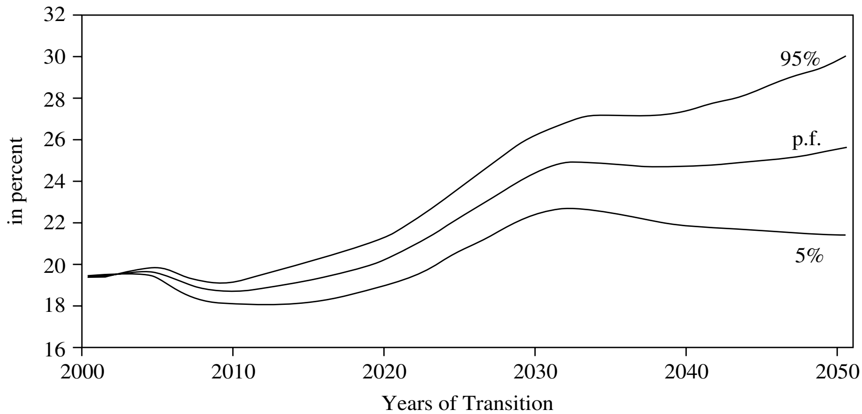

Figure 4. Pension contribution rate 2000–2050

our calculations indicate that there is only a likelihood of 3 (11.3) %, that the contribution rate will be below 22 (23) % in 2030. Of course, the uncertainty of the forecast increases over time as shown by the 90 % confidence interval.

The dynamics of health care contribution rates are slightly different compared with Figure 4, since health care outlays increase steadily with age and health care contributions are also paid on pension benefits. Finally, the consumption tax rates which balance the public budget in each year fall slightly until 2015 due to the rising average productivity of the ageing population. Afterwards they most likely increase again depending on the future population structure. If the dependency ratio increases faster, contribution rates rise stronger and labor supply is reduced. As a consequence, income taxes decrease and consumption taxes have to increase.

This suffices to explain the baseline path. In the next section we turn to the considered policy reforms.

5 Options for pension reform and their impact on welfare and uncertainty

As already explained, the objective of the Riester reform in 2001 was to keep pension contribution rates below 22 % until 2030. In addition, the government also guaranteed that the net replacement rate would not fall below 67 %.[12] Already soon after 2001 it became clear that it would not be possible to reach both objectives simultaneously, since the calculations were based on too optimistic assumptions about future demography and employment. As a consequence, a new 'Commission for Sustainability in Financing the German Social Insurance System' (Rürup Commission) was established in November 2002.

In August 2003 the Rürup Commission published its reform proposal (Bundesministerium für Gesundheit und Soziale Sicherung, 2003) which mainly

[12] However, as noted by Bonin (2002) this net replacement rate is related to an artificial construct of net labor income. The replacement rate which is related to actual net income is much lower.

comprises two elements. The first is a gradual increase in the 'normal retirement age' which would further reduce the 'adjustment factor' in equation (18) if people would keep their current effective retirement ages. In the following analysis we will omit this measure and concentrate on the second element of the reform, the modification of the indexation rule. Here the commission proposed a so-called 'sustainability factor' which would relate the future changes in the benefit level to changes in the dependency ratio. In 2004 the German government has adopted this indexation rule in the new pension formula. Consequently, in our simulations we assume that the value of the reform factor $RF(t)$ in equation (19) changes for $t \geqslant 2005$ to

$$RF(t)=1+0.25\left(1-\frac{DR(t-2)}{DR(t-3)}\right), \tag{24}$$

where $DR(\cdot)$ measures the ratio of pensioners to contributors of a specific year. Of course, since the dependency ratio will increase with almost certainty, the new indexation rule will decrease future benefits compared with the status quo of the Riester reform. Note, however, that the impact of the rising dependency ratio on benefits is dampened by the weight 0.25.

Since it is unclear how strongly the future dependency ratio will increase, the sustainability factor could be also interpreted as an insurance device against demographic uncertainty. If population ageing is stronger than currently projected, the fall in future benefits would automatically be stronger than currently projected. If population ageing is less severe, future benefits would be higher. Since the fluctuation of the future contribution rate is dampened compared with the existing system, the proposed benefit indexation stabilizes the future contribution rates, while at the same time it increases the uncertainty of future benefits.

In our simulations we compare this indexation rule with an alternative reform where benefits are adjusted by taking into account the increase in life expectancy. A so-called 'demographic factor' was already proposed by the former conservative government in the late 1990s.[13] Since the expected rise in life expectancy would also reduce future pensions, such an indexation rule could also be interpreted as an insurance against demographic uncertainty. In our model, the demographic factor could be included by replacing the reform factor $RF(t)$ from equation (24) with

$$RF(t)=1+0.5\left(\frac{LE(t-3)}{LE(t-2)}-1\right), \tag{25}$$

where $LE(\,)$ measures the remaining life expectancy of a 65-year-old in a specific year. Note that the demographic factor applies a higher weight of 0.5 compared with the sustainability factor.[14] The different weights in the reform factors are due to different changes in the underlying demographic variables. Future life expectancy increases in the point forecast by about 12% until 2050, while the future dependency ratio will

[13] Rürup (2000) as well as Schmähl and Viebrok (2000) discuss the pros and cons of the reform proposal; Hirte (2002) presents an economic evaluation of the reform.

[14] The original proposal included a time lag of eight years for the changes in life expectancy. We reduced the time lag mainly for technical reasons and for a better comparison with the dependency factor.

increase by about 57%. The weights represent the share of the burden from these changes which is placed on retirees.[15]

Given the two reform alternatives we can again compute the sustainability gap. Table 3 shows the respective 90% intervals and the point forecast for the sustainability gaps and the corresponding necessary increase in tax revenues.

Both reforms reduce the sustainability gap and the uncertainty, but only very modestly. Of course, the same applies to the necessary tax increase which is slightly smaller after the reforms.

Under the present system, pension benefits are only linked to gross labor income. Consequently, contribution rates will rise if the dependency ratios increase. Both proposed indexation rules (24) and (25) link future replacement rates directly or indirectly to the future dependency ratios. Consequently, since rising dependency ratios reduce future benefits, their impact on future contribution rates will be much smaller than before the reforms. However, as shown in Figures 2 and 3, both indices will change quite differently in the future. While the dependency ratio stays almost constant until 2020 and then rises until 2030 in our point forecast, life expectancy is projected to increase steadily between 2000 and 2050. In addition, as shown by the narrow 90% confidence intervals, the dependency ratios are quite certain in the next twenty-five years, their fluctuation increases only after 2025. In contrast, the dispersion of the life expectancy is already fairly high in the near future and steadily increases. Consequently, the two indexation formulas will have different impacts on the macroeconomy as well as the intergenerational distribution and risk sharing. In order to assess the reforms, the next subsection compares the implied changes in contribution and replacement rates. Then we compare the welfare and risk implications.

Effects on contribution rates and replacement rates

Of course, both pension reforms aim to alter the path of replacement and contribution rates in the economy. Figures 5 and 6 compare the predictive distributions of the replacement and contribution rates before (dashed lines) and after (solid lines) the introduction of the 'sustainability factor' (SF-reform). In our base year, the replacement rate is 50% (see Table 1), afterwards it falls due to the increase in the fictitious contribution rate τ^{pp} until 2010 and the rising contribution rate (see Figure 4) afterwards. The higher the future contribution rate, the lower will be the future replacement rate. If contribution rates would fall again after 2030, the replacement rate could also increase slightly. After the SF-reform, replacement rates will fall much faster until 2030. Then they might increase again (if the dependency ratio falls, see Figure 2) or fall further (if the dependency ratio rises further). Since population uncertainty now directly affects future replacement rates, current middle-aged generations have to bear more risk.

While future replacement rates are more uncertain, future contribution rates become more certain. Figure 6 compares the predictive intervals for the contribution

[15] Some back of the envelope calculations indicate a reduction in the pension level due to the demographic factor by about 6% (i.e. $0.5\times(1/1.12-1)$) in 2050 and a respective reduction due to the sustainability factor by about 14% (i.e. $0.25\times(1-1.57)$).

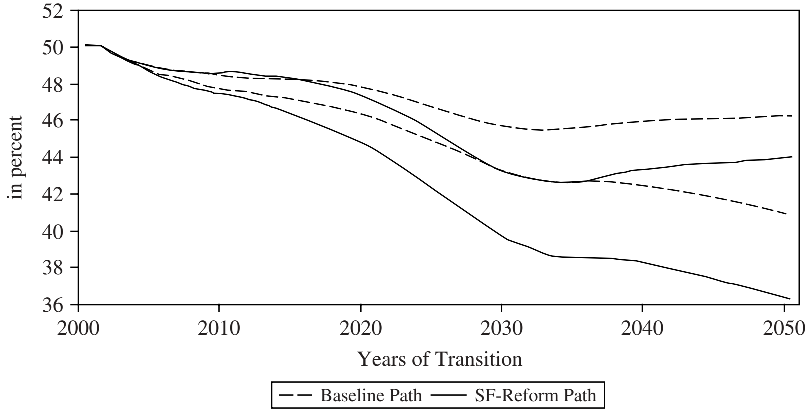

Figure 5. Replacement rates (90 % interval) with SF-reform

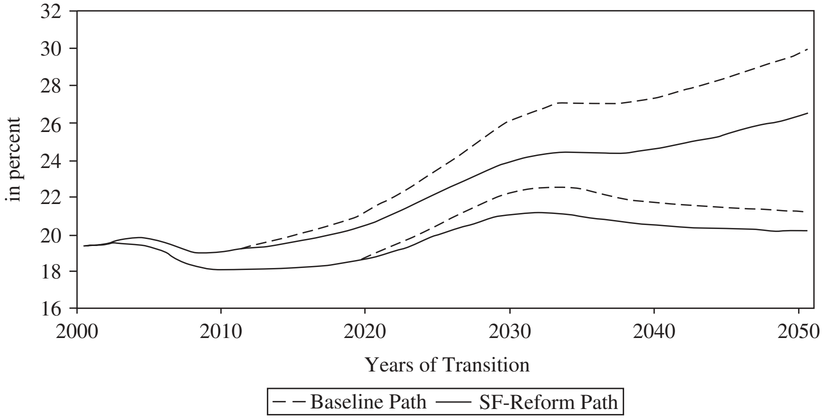

Figure 6. Contribution rates (90 % interval) with SF-reform

rates of the baseline scenario (dashed lines, which were already explained in Figure 4) and after the SF-reform. As one would expect, due to the lower replacement rates the SF-reform reduces future contribution rates. However, the fluctuation of the contribution rates is also dampened, which implies less risk for future generations.[16] After the reform, the probability of a contribution rate below 22 (23) % in 2030 rises to 19 (65.4) %.

Next we compare the replacement and contribution rates after the introduction of the 'demographic factor' (DF-reform). Remember that in contrast to the dependency ratio, life expectancy is already quite uncertain in the short run, see Figure 3. Consequently, adjusting the benefits to changes in life expectancy will increase the fluctuation of the replacement rates even in the short run and reduce the level in the

[16] Our policy reform, therefore, shows a similar trade-off as the reform discussed in Alho *et al.* (2005).

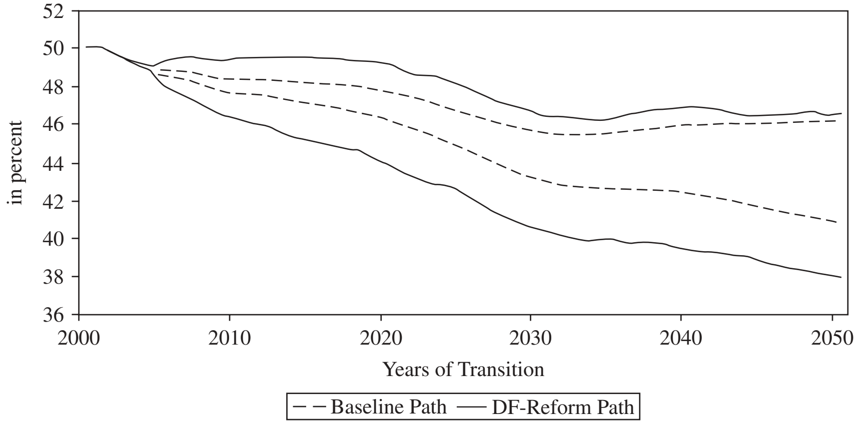

Figure 7. Replacement rates (90 % interval) with DF-reform

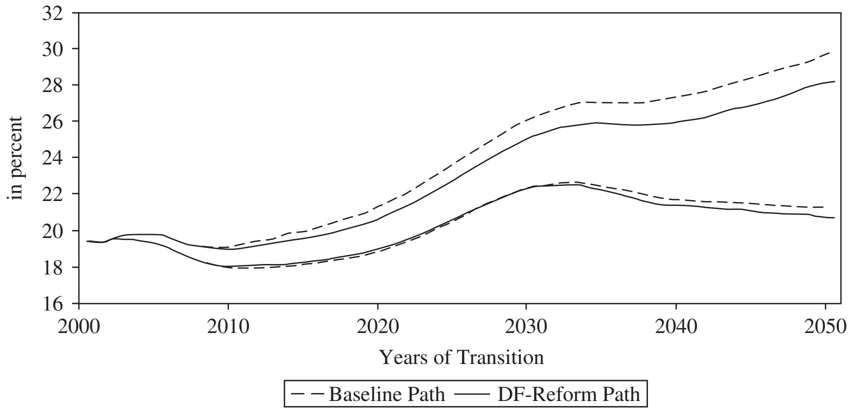

Figure 8. Contribution rates (90 % interval) with DF-reform

long run only slightly. This is exactly shown in Figure 7 where the dashed lines of the baseline path are the same as in Figure 5. The 90 % confidence interval of the replacement rates never crosses the respective interval of the baseline scenario. Consequently, uncertainty with respect to the replacement rates rises already after the implementation of the reform in 2005 and increases constantly afterwards. In the long run, the expected replacement level is also lower than before, but the reduction is only small compared to the SF-reform.

Next we compare in Figure 8 the predictive interval of the contribution rates before and after the DF-reform. Since this reform has only a minor impact on the replacement rate level, the reduction of future contribution rates is also small. Since the solid lines lie within the dashed lines, the DF-reform reduces the fluctuation of the contribution rates already in the short and medium run until 2030. Again we find the same trade-off between the variability of the replacement rates and the contribution

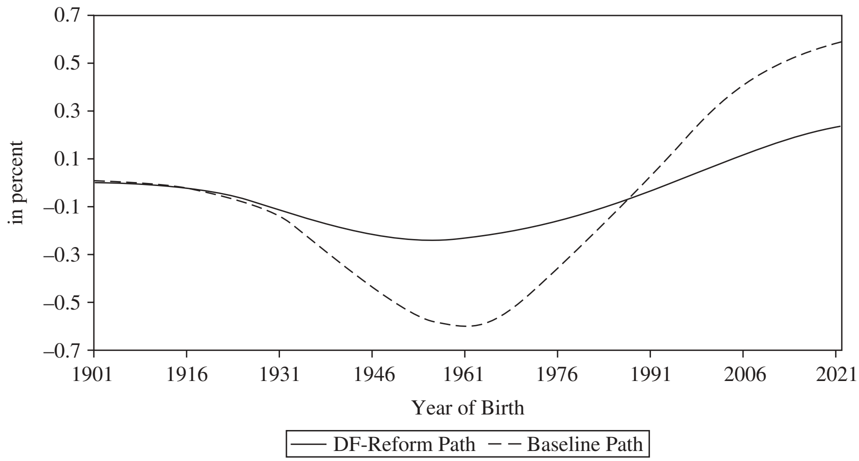

Figure 9. Expected welfare effects of the pension reforms (in percent of remaining lifetime resources)

rates as under the previous reform. However, under the DF-reform currently elderly have to bear a higher risk since their benefits become more uncertain already in the short run.

Expected welfare changes and intergenerational risk sharing

The analysis of the changes in replacement and contribution rates in the previous subsection already gave an idea about the direction of the intergenerational welfare effects and risk sharing implications of the two considered reform packages. Since replacement rates as well as contribution rates fall after both reforms, the intergenerational redistribution effects of the reform will be in favor of younger and future generations at the expense of currently elderly. Since replacement and contribution rates fall further under the SF-reform, we would also expect a stronger intergenerational redistribution under the SF-reform. In order to quantify the intergenerational welfare effects of the two reforms, we compute for each population path the generation-specific utility levels before and after the specific reform and derive the respective Hick'sian equivalent variations (HEV) relative to remaining lifetime resources. Next we compute from the 300 HEV-realizations the *expected* welfare change for each generation. Figure 9 compares the expected welfare changes of the two reform variants for generations who are born between 1901 (oldest generation still alive in 2001) and 2021. It confirms the prediction that the intergenerational redistribution is stronger under the SF-reform.

Under the SF-reform, currently middle-aged generation are much worse of than under the DF-reform. The generations born in the early 60ies are hurt the most, since they retire after 2020 when the replacement rate starts falling due to the SF-reform. Older generations are hurt less, since they retire earlier while younger generations benefit from the reduction in the contribution rates. The welfare of already retired generations in 2005 remains almost constant. The replacement rates will also fall after

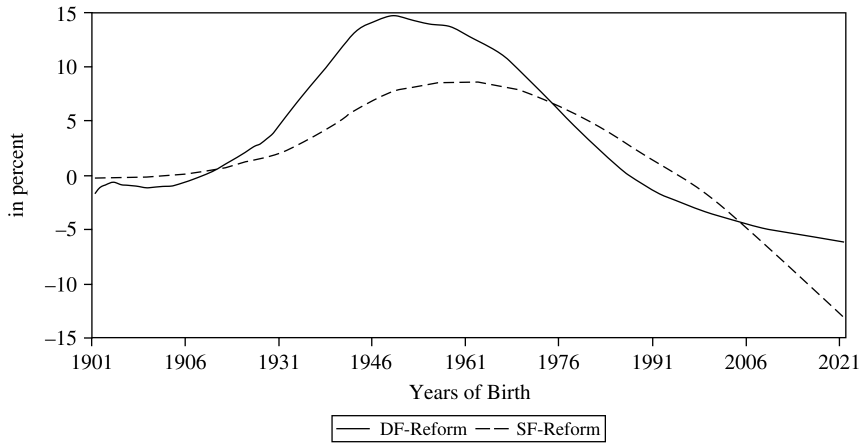

Figure 10. Intergenerational risk-sharing implications of the pension reforms (normalized ratio of standard deviation)

2020 under the DF-reform. However, the reduction is much smaller and, consequently, middle-aged generations lose much less. Similarly, younger and future generations can expect a lower welfare gain under the DF-reform, since the contribution rates fall much less.

Next we compare the impact of the two reforms of the generational-specific uncertainty. In order to measure the risk effects, we compute for each generation the standard deviation of the 300 utility levels (one for each path) under the baseline (σ^B) and the reform scenario (σ^R). Then we normalize the ratio of the two standard deviations to receive $\sigma^R/\sigma^B - 1$ as an index of the generational-specific risk effects. If the index is greater than zero, generational-specific risk has increased and vice versa.

Figure 10 shows that the SF-reform does not alter risk for currently elderly, increases risk for the middle-aged generations and reduces risk for younger and future generations. Of course, the risk-sharing implications of the SF-reform are on the one side due to the stronger fluctuation of the replacement rates after 2030 (which increases the risk of the middle-aged) and the reduced fluctuation of the future contribution rates (which reduces risk of the younger and future generations).

The general pattern is similar under the DF-reform, but currently elderly and middle-aged generations experience a much higher risk increase than before while cohorts who are currently around 30 or younger bear a lower risk compared to the SF-reform. Future generations are better off under the SF-reform. The risk increase for currently elderly is mainly due to the immediate rise in the fluctuation of the replacement rates after the DF-reform. Since the DF-reform on the other hand reduces the dispersion of the contribution rates already in the short and medium run, cohorts who are currently younger than age 30 bear a lower risk than under the SF-reform. In the long run, however, the predictive interval of the contribution rate is tighter under the SF-reform. Consequently, future generations bear a lower risk under the latter reform.

6 Conclusion

The present study aims to improve our understanding of the risk-sharing implications of alternative pension reforms. Traditional studies exclude such problems since they are based on models which exclude uncertainty. Our approach explicitly takes into account the uncertainty arising from future population dynamics. This allows to quantify and compare not only the macroeconomic and distributional consequences of alternative reform packages, but also their intergenerational risk-sharing implications.

The approach is applied to the recent pension debate in Germany where the government has recently linked future changes in the replacement rate to changes in the dependency ratio (SF-reform). We compare this reform with a proposal of the previous government which aimed to link future changes in the replacement rate to changes in future life expectancy (DF-reform). Therefore, both reforms intend to stabilize the future contribution rates by taking into account future demographic uncertainty. Whereas the SF-reform concentrates on the changes of the future dependency ratio, the DF-reform integrates the changes in future life expectancy into the pension indexation formula. Our calculations indicate that both reform packages redistribute resources from currently living middle-aged generations to younger and future living generations. However, the redistribution is much stronger under the SF-reform than under the DF-reform. Similarly, both reforms increase the risk exposure of currently middle-aged and reduce the risk for younger and future generations. However, under the SF-reform the middle-aged and the future living generations bear a much lower additional risk than under the DF-reform.

Consequently, taking into account both the distributional as well as the risk-sharing implications of the considered reform packages changes their evaluation considerably compared to the traditional approach which excludes uncertainty. Compared to the DF-reform, the SF-reform is much less dramatic for currently middle-aged as suggested by the pure welfare effects. At the same time, the DF-reform is much worse for the currently elderly as suggested by the pure welfare changes. In the long run the SF-reform improves not only the welfare position of future generations, it also reduces their risk exposure more significantly than the DF-reform.

Since both reforms reduce (increase) the welfare and increase (reduce) the risk for middle-aged (future) generations, it is not possible to select preferred package without referring to a social welfare function. The question is whether it is possible to design a reform package, which has exactly opposite intergenerational distribution and risk-sharing properties. A reform which redistributes welfare from currently elderly towards future generations would be better accepted if the losers are compensated by a risk reduction while the winners have to bear more risk. How to design and implement such a reform will be the agenda for future research efforts.

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