The Impact of Demographic Developments on the German Statutory Pension System

François Peglow*and Robert Fenge†

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Abstract

The paper analyzes the impact of demographic developments on the German pension system until the year 2060. As a central innovation we decompose the isolated impact of mortality, fertility and migration developments on the dynamics of the German pension system. We propose a decomposition approach that combines demographic projection methods and a pension simulation model. The model will be presented in detail. We are able to show that the past population structure and future mortality improvements will be the most important factors shaping the development of the German pension system. Furthermore, we present calculations for the potential capability of higher fertility rates for stabilizing the pension system.

*Max Planck Institute for Demographic Research - Laboratory Survival and Longevity; University of Rostock; Email: peglow@demogr.mpg.de.

†University of Rostock, Chair of Public Economics

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1 Introduction

In the coming decades Germany will face a significant process of population aging. The changes in the population structure with a prominent increase in the share of elderly people raise concerns on the future viability of social transfer systems. In particular the sustainability of the German Statutory Pension System ("*Gesetzliche Rentenversicherung*", GRV) is endangered as its primary pay-as-you-go (PAYG) financing scheme puts the main burden on the working population. The increase of the share of older people in Germany – caused by the diminution of the size of the working population and a growing number of older people – undermines the revenue side of the GRV while expenditures for pension benefits rise simultaneously.

Important questions arise. How will contribution and replacement rates of the German pension system change? What will be the main demographic driver for these developments? What kind of policies can ensure the future sustainability of the pension system and what are the most promising policy options?

An identification of adequate reform strategies requires a detailed analysis of the factors that affect the budget of the GRV. Interestingly, when analyzing pension systems, population aging is predominantly regarded as a change of the population structure without a further analysis of the underlying demographic mechanisms that determine that change. An aging population results from the interplay of fertility, migration and the development of life expectancy. Also past changes of these demographic factors influence population aging as they shaped the population structure of today.

Adding to the understanding of the impact of population aging on pension systems we provide estimations of the separate influences of demographic developments on the GRV. We therefore develop a newly decomposition approach to disentangle the independent effects of fertility, mortality and migration on central characteristics of the German pension system.

Our paper comprises seven sections. In Section 2 we first give a brief overview of the history of the German Statutory Pension System. A description of the underlying simulation model as well as a detailed characterization of incorporated economic and demographic development scenarios are given in Section 3. Section 4 introduces our decomposition approach. Results for development of the German pension system and an analysis of the influence of varying economic and demographic development scenarios are shown in Section 5. The decomposition results of the impact of single demographic factors are presented in Section 6, followed by a conclusion.

2 German Pension System: From Bismarck to nowadays

The German Statutory Pension System has a long history of over 120 years. In 1889 chancellor Bismarck layed the foundation of social security with the 'law concerning disability and old-age security' (*"Gesetz, betreffend die Invaliditäts- und Alterssicherung"*, IAVG).[1] The IAVG introduced a disability and an old-age pension for blue collar workers and lower civil servants. Also medical rehabilitation was provided.[2] The main focus of the system was put on disability (Eichenhofer et al., 2012, Rn. 27-28, p. 12.). The pension benefits have been low and provided rather a 'subsidy' to old age income than an old age income (Eichenhofer et al., 2012, Rn. 42-43, p. 19.). The system was organized as a funded social security system. In the following years the system emerged and provided medical rehabilitation, old-age, disability and survivor benefits.

In 1957 – after several shocks due to World War I, a hyperinflation in the beginning 1920's and World War II – a major pension reform established the principles of the actual German Statutory Pension System.[3] The funding of the GRV was gradually converted to a PAYG scheme and the remaining capital stock of the former funded system was spend by 1967 (Börsch-Supan, 2000, p. F25.). Benefits of already existing pensions had been raised and the development of future pensions was indexed to gross wages (Eichenhofer et al., 2012, Rn. 22-25, pp. 32.). The reform of the GRV was "designed to extend the standard of living that was achieved during work life also to the time after retirement" (Börsch-Supan, 2000, p. F25.). Especially in the 1970s the pension benefits had been increased and flexible rules for early retirement were introduced with a reform in 1972.

The predicted acceleration of costs and increasing contributions lead to a further important reform in 1992. The legal age of retirement was gradually raised and an deduction factor for early retirement was introduced, so that early retirement causes lower future pensions. Furthermore, pension benefit indexation was changed to net wages (Rürup, 2002, pp. 143.).[4] In 2001 a major reform gradually changed the paradigm of the GRV. An additional state-subsidized private old age pension was introduced to compensate for declining replacement rates in the public pension. In contrast to the pay-as-you-go system of the first pension pillar, private pensions are financed by a funded scheme. Also the pension-benefit indexation was changed to 'modified gross wages' – considering the development of gross

[1] See Deutsches Reichsgesetzblatt volume 1889, No. 13, pp. 97 - 144.

[2] See § 12 (4) IAVG.

[3] We focus on an overview of the pension system of West Germany as after the German reunification the western system was extended to East Germany.

[4] High unemployment in the 1990s and demographic aging lead to the 1999 pension reform. Here, the introduction of a 'demographic factor' that includes the change in life expectancy at age 65 when indexing pensions can be seen as the major change (Rürup, 2002, p. 148.). After federal elections in 1998, the new government abolished the demographic factor(Rürup, 2002, p. 150.).

wages, contribution rates to the public pension and the evolving burden of private pension saving. As a further response to demographic aging, in 2004 a 'sustainability factor' was added in the pension indexation formula that additionally links the adjustment of pension benefits to the ratio of pensioners to contributors. A further reform in 2007 enacted the gradual raise of the legal retirement age to 67.

Today the GRV provides old-age pensions, survivor pensions and disability pensions for almost all workers. Furthermore, medical rehabilitation and about half of the health care costs of pensioners are paid by the GRV. The benefits relate with a point system to the individual life time earnings[5] and are indexed to the development of 'modified gross wages' and the relation between pensioners and contributors – the sustainability factor.[6] The financing is organized as a pay-as-you-go scheme with a reserve fund of 0.2 to 1.5 monthly expenditures of the GRV.[7] Contributions are related to gross wages of insured persons. The contribution rate changes systematically to balance the budget of the GRV. Additionally to contributions, the budget of the GRV includes federal subsidies of approximately 25 percent.[8] Although the pension benefits and the contributions rate arise from exogenous factors and the current pension legislation, the government defined lower bounds for the replacement rate and an upper bound for the contribution rate. Up to the year 2030 the contribution rate shall not exceed 20 percent and the net replacement rate of a standardized pension shall not be less than 43 percent of the average disposable income.[9] The legal retirement age is 67 with a transition phase between 2012 and 2030.

3 The Pension Simulation Model

The focus of our simulation model is put on the impact of population aging on the first pillar of the German Statutory Pension System as it is financed by a pay-as-you-go funding scheme that strongly reacts on changes of the population structure. Furthermore, the first pillar of the GRV provides the main income source in old age for a majority of the German population. Aspects of (funded) private and occupational pension plans are not considered.

The simulation model provides a flexible framework for the analysis of the coming developments of the pension system. It combines several different demographic and economic development scenarios. Within the scenario approach potential feedback effects between

[5]See § 70 SGB VI.
[6]See § 68 SGB VI.
[7]See § 158 SGB VI.
[8]See § 213 SGB VI.
[9]See § 154 SGB VI. A standardized pension refers to a standardized working career of 45 working years with average gross earnings. It equals a monthly pension payment of 45 times the actual pension value.

economic conditions and individual behavior are not modeled. We treat all scenarios utilized in the simulation model as independent from each other.[10]

The first part of the simulation procedure introduces the modeling of future population developments. We therefore describe assumptions on fertility, mortality and migration. The second part of the simulation model description introduces the projection method of labor force participation rates and further assumptions on the labor market, wages and the determination of the number of pensioners. The third part of the simulation procedure explains the modeling of revenues and expenditures of the German Statutory Pension System.

3.1 Modeling Demographic Development

The future population development – explained by future fertility rates, life expectancy developments and migration numbers – is essential to our analysis. A population projection serves as the key instrument for quantifying the impact of mortality, fertility and migration on the future pension system development. It provides the basis for the decomposition of demographic effects.[11] Our calculations make use of demographic scenarios provided by the "12th coordinated population projection for Germany" (Federal Statistical Office, 2009). Additionally we utilize comparative benchmark projections to isolate the impact of each demographic factor. Therefore mortality rates, fertility rates and migration numbers are held constant at the level of 2010, successively. For example, the impact of mortality improvements on the future developments is based on a projection with constant fertility rates and without net migration.[12]

3.1.1 Fertility

In our model we use period data on age-specific fertility rates that can be summarized by the total fertility rate (TFR). The total fertility rate measures the average number of children per woman.

Our *'reference fertility scenario'* refers to a total fertility rate reaching 1.6 children per woman in 2025 and staying at that level until 2060. This characterizes the fertility scenario 'G2' of the official projections (Federal Statistical Office, 2013b; Pötzsch, 2010). It is assumed that the share of women having their first child above age 30 stagnates

[10]Neither systematic individual behavioral responses to different pension system parameters nor effects of the population size on employment rates and wages are modeled. Also interaction effects between demographic variables are not considered.

[11]See Section 4.

[12]For a detailed description of the projection model and underlying methods see Peglow (2013).

and fertility above age 30 will rise. Consequently, the total fertility rate advances to 1.6 children per woman in the year 2025 (Federal Statistical Office, 2009, p.27.). In contrast, the Federal Statistical Office (2009) assumes 1.4 children per woman in their base scenario. We do not follow this assumption as actual trends indicate increasing fertility rates so that fertility decisions are rather postponed than lowered. A period TFR of 1.6 appears more realistic than lower rates (Goldstein and Kreyenfeld, 2011).

In our sensitivity analysis we also employ a *'low fertility scenario'* that assumes a almost constant TFR approaching 1.4 children per woman in 2020 (Federal Statistical Office, 2009, p.27.).

For a comparison of the potential impact of fertility we also utilize a hypothetical *'high fertility scenario'*. Here, we assume that fertility in Germany reaches in 2025 with a TFR of 2.01 the same level as observed in France in the year 2010 (HFD, 2012). This setup allows us to discuss more distinct fertility changes than actual trends are indicating.

For the decomposition approach we apply constant fertility rates of the year 2010 – a TFR of 1.35 children per woman – in all comparative benchmark projections.

3.1.2 Life Expectancy

We use the underlying period rates of age- and sex-specific mortality that refer to the life expectancy scenarios provided by the Federal Statistical Office (Federal Statistical Office, 2013c). Our *'reference mortality scenario'* assumes an increase of life expectancy at birth by 6.3 years for women and 7.3 years for men between 2010 and 2060. In 2060 a newborn girl is expected to live 89.2 years and a newborn boy 85.0 years.

A *'high life expectancy scenario'* assumes that life expectancy at birth reaches 91.2 years for girls and 87.7 years for boys in 2060.

For the projection of the comparative benchmark populations we use constant mortality rates referring to a life expectancy at birth of 82.9 years for women and 77.6 years for men.

3.1.3 Migration

Three different assumptions on yearly net migration numbers are included in the model. Age-specific migration data for women and men was provided by the Federal Statistical Office (Federal Statistical Office, 2012). The *'reference scenario'* includes an increasing net migration from 10.000 to 100.00 people per year between 2010 and 2014. Until 2060 migration numbers remain constant.

Our *'high migration scenario'* is assigned to yearly migration number of 200.000 people from 2020 onwards with a previous linear increase starting from the level of 10.000 people per year in 2010.

The projection of benchmark populations apply balanced net migration over the complete analyzed period.

3.2 Labor Market Development and Pensioners

3.2.1 Participation Rate Projection

In addition to demographic variations of the population in working ages, the development of the labor force participation rates will determine the future size of the labor force. The active working population results from applying the participation rates to the underlying population. Therefore, the simulation of the labor force requires a projection of future labor force participation rates. For our model we apply a dynamic cohort approach developed by the OECD and further extended by the European Working Group on Aging to project future participation rates (European Commission, 2005; Carone, 2005; Burniaux et al., 2004).

The dynamic approach explicitly considers systematical differences in labor force participation between cohorts. Our projection reflects changes in labor participation among different age and gender groups and systematically projects cohort-specific trends into the future. This is the main advantage of the dynamic cohort-component methodology compared to a static projection, where future developments are based on cross-sectional trends and cohort-specific developments are not taken into account (European Commission, 2005; Burniaux et al., 2004). Implicitly, the approach considers notable development trends of labor force participation for the young, women and the elderly. These trends can be ascribed to changes of 'social factors' (e. g. longer schooling), 'demographic factors' (e. g. lower fertility), 'institutional factors' (e. g. reforms of early retirement laws) and 'economic factors' (e. g. household income, part-time employment) in recent years (Carone, 2005, p. 9.).

In Germany, particularly the labor participation of younger women in their reproductive ages has undergone substantial changes and increased over the last years compared to previous cohorts. An explanation could be a higher share of childless women or a better compatibility of family and work. Also the effects of longer schooling can be observed in younger age groups, while labor force participation in older ages show an increasing trend presumably initiated by a raise of legal retirement ages (Werding and Hofmann, 2008, pp. 22.).

In a first step of the projection, gender-specific labor force entry and exit rates are calculated for single ages. We utilize micro data provided by the German Microcensus of the German Federal Statistical Office for the latest years 2005 to 2010 (Federal Statistical Office, 2013a). In line with the European Commission (2005) and Werding and Hofmann (2008), the rate of entry into the labor market Ren_{x+1} describes the share of persons of cohort t+1 who were still inactive at age x and enter the labor market at age x+1. Assuming identical entry behavior of successive cohorts t and t+1, entry rates can be calculated based on the underlying participation rates Pr using Equation 1.

$$Ren_{x+1} = 1 - \frac{Pr_{max} - Pr_{x+1,\,t+1}}{Pr_{max} - Pr_{x,\,t}} \geq 0 \tag{1}$$

We assume an upper limit of the labor force participation rate Pr_{max} of 0.99 for men and women.[13] The calculation of exit rates follows an identical strategy. Equation 2 characterizes the share of persons of cohort t+1 who where active at age x and will have left the labor force at age x+1 under the assumption of identical exit behaviors of successive cohorts t and t+1.

$$Rex_{x+1} = 1 - \frac{Pr_{x+1,\,t+1}}{Pr_{x,\,t}} \tag{2}$$

Depending on whether the labor force participation of a cohort is increasing or decreasing, the estimated entry or exit rates are used to project labor force participation rates according to Equation 3 or respectively Equation 4.

$$Pr_{x+1,\,t+1} = Ren_{x+1} \cdot (Pr_{max} - Pr_{x,\,t}) + Pr_{x,\,t} \tag{3}$$

$$Pr_{x+1,\,t+1} = (1 - Rex_{x+1}) \cdot Pr_{x,\,t} \tag{4}$$

The first projection step of future participation rates can be characterized as a "rather mechanical calculation" (Werding and Hofmann, 2008, p. 25). While cohort-specific trends are reproduced, the unconditional projection of these trends will bias the calculation of future labor force participation rates.

Therefore, in a second step these 'raw' participation rates have to be adjusted regarding three aspects. First, extended duration of schooling and higher education explain a drop in labor force participation in younger ages. But, higher education only postpones the entry of younger cohorts into labor force. To avoid an extrapolation of low labor participation of younger cohorts within the 'mechanical' projection, we define a lower floor for participa-

[13] European Commission (2005) and Werding and Hofmann (2008) also use an upper limit of the participation rate of 0.99. In contrast, Burniaux et al. (2004) assume an upper limit of 0.95.

tion rates below age 20.[14] Participation rates for the ages 15 to 19 are allowed to increase if this is the result of the cohort projection model. Otherwise, the rates remain constant at the level of 2010 (European Commission, 2005, pp. 50). Second, micro data for previous years show clear effects of the legal retirement age on labor force participation at older ages - especially around the 'early' and 'legal' retirement age. These observable trends are mitigated by the cohort projection and have to be restored (Werding and Hofmann, 2008, p. 25). Third, information on labor force participation differs between German Microcensus data and German national accounts. This divergence can be explained by an under-reporting of marginally employed persons. We proportionally correct the bias using estimates of the statistical differences between Microcensus date and data of national accounts on labor participation provided by the Institute for Employment Research IAB (Fuchs and Söhnlein, 2003). Furthermore, the calculated rates are scaled to fit the national account macro data.

Altogether, the cohort projection approach of labor force participation rates combined with the corrections described provide information on future labor force participation rates for Germany. The results base on already implemented laws and refer to the legal retirement age of 65.

In the third step of the participation rate projection the raise the legal retirement age from 65 to 67 is modeled. The previously described methodology reflects observable development trends caused by already implemented laws. The raise of retirement ages[15] gradually phases in between 2012 and 2029.[16] A precise estimation of the impact of increasing legal retirement ages on the effective changes of individual labor market behavior is not possible yet as experience on the long term impact of such reforms is still missing in Germany (Fuchs, 2006, p. 2). In order to produce reliable participation rate projections accounting for these future changes further assumptions are necessary. We follow Werding (2011) and Werding (2013b) and assume that the raise of legal retirement ages by 2 years will (further) increase the effective retirement age by 1.5 years.[17] This assumption accounts for the fact that not all individuals are able or willing to fully adapt to the raise of the legal retirement age. Technically, we calculate the average effective age of retirement by applying the concept of the average exit age from the labor force utilizing our projected participation rates that are based on a legal retirement age of 65 (European Commission,

[14] An extrapolation of a lower labor force participation in younger ages would negatively bias the overall labor force participation in later ages. The applied correction mechanism avoids negative effects of schooling on the labor force development.

[15] See RV-Altersgrenzenanpassungsgesetz (RVAGAnpG), § 235 SGB VI.

[16] Between 2012 and 2013 the legal retirement age increases by 1 month a year, between 2024 and 2029 by 2 months a year. Cohorts born 1964 (and later) can claim a full old-age pension without any deductions at the age of 67 from 2031 onwards (Werding and Hofmann, 2008, p. 50).

[17] Past reforms already cause labor market trends that lead to an increase of effective retirement ages. The further raise of the legal retirement age will cause a supplementary postponement of retirement.

2005, Annex 5). Afterwards, we proportionally rescale the participation rates starting at the age with the highest labor force participation rate ($Pr_{\bar{x}}$), so that our assumption of an increase of effective retirement ages by 1.5 years is fulfilled. Within the rescaling procedure we assure non-increasing participation rates:

$$Pr_{\bar{x}} \geq Pr_{\bar{x}+1}.$$

3.2.2 Labor Force, Employment and Wages

The future labor force results from applying the labor force participation rates with the population numbers. To derive the number of employed persons from the labor force we additionally need assumptions on coming unemployment rates. In our model future developments of the labor market are reflected by three different unemployment scenarios. The *'reference unemployment variant'* assumes a constant unemployment rate of 7.7 percent – the level of 2010 (Bundesagentur für Arbeit, 2011). In a *'low unemployment variant'* unemployment rates decrease from 7.7 percent in 2010 to a "natural lowest level of 4.0 percent" (Börsch-Supan and Wilke, 2009, p. 35) in 2060. We also consider increasing unemployment rates from 7.7 percent in 2010 to 10 percent in 2060 in a *'high unemployment variant'*. Together, the three scenarios cover a broad range of probable unemployment scenarios and allow to evaluate the impact of uncertain employment developments.

In our pension simulation model we further require the number of employees subject to social insurance contributions. First, we identify the number of self-employed persons and civil servants – both groups are not insured by the German pension system – by applying age-specific rates calculated from Microcensus data (Federal Statistical Office, 2013a). We assume that the shares of self-employed persons and civil servants in the labor market develop linearly to the change of legal retirement ages of the GRV.[18]

Afterwards, we use the yearly averages of the quarterly data on employees subject to social insurance contributions provided by the Federal Employment Agency to approximate the share of employees subject to social insurance contributions on the overall employed persons (Bundesagentur für Arbeit, 2013). Starting in 2011 this proportion remains constant at the median of the previously observed rates.

Data on average earnings subject to social insurance contributions of the contributors are provided by the German statutory pension insurance (Deutsche Rentenversicherung,

[18]We use the averages of the latest observed rates for each group as the baseline for a linear rescaling. Our model retains an age-specific structure of employment that is linked to the development of the legal retirement age over the whole projection period. Other studies e. g. Holthausen et al. (2012) use constant rates as a simplified modeling approach.

2012, p. 262). From 2010 onwards, three different scenarios of linear wage growth characterize future developments: (i) 1.5% growth per year, (ii) 2.5% growth per year and (iii) 3.5% growth per year. Based on the average gross wages, we derive earning profiles from age-specific income data (Federal Statistical Office, 2013d).

3.2.3 The Number of Pensioners

Our pension simulation model comprises disability pensions, old-age pensions and widow's or respectively widower's pensions. Thereby, disability and old-age pensions result from individually acquired pension entitlements, while widow's and widower's pensions result from pension entitlements of spouses. We derive the number of disability pensioners and old-age pensioners as the number of non-working individuals eligible for a pension using labor force participation rates and population numbers. In a second step we estimate the number of disability pensioners based on observed shares of disability pensioners in the group of persons eligible for a pension. The number of old-age pensioners can be calculated after a correction for self-employed individuals and civil servants.

To calculate the number of non-working individuals eligible for a pension the youngest age for receiving a pension is set to age 50. At first, we calculate the number of non-working persons for all age groups. For any given age x ($x \geq 50$) the number of non-working persons (${}^{nw}N_x$) results from the labor force participation rate (Pr) and the cohort size ($N_{x,\,t}$):

$$ {}^{nw}N_{x,\,t} = N_{x,\,t} \cdot (1 - Pr_{x,\,t}) \quad . $$

Second, we have to identify the number of already retired self-employed persons and civil servants within the group of non-working persons. We model the share of retired self-employed persons and retired civil servants proportionally to their share in the labor force.[19] The number of retired self-employed persons and retired civil servants (${}^{ret}N^{se,cs}_{x,\,t}$) is calculated with the age-specific rates of self-employed persons ($Pr^{se}_{x,t}$) and civil servants ($Pr^{cs}_{x,t}$):

$$ {}^{ret}N^{se,\,cs}_{x,\,t} = {}^{nw}N_{x,\,t} \cdot \left(Pr^{se}_{x,t} + Pr^{cs}_{x,t} \right) \quad . $$

Third, we approximate the number of persons who never contributed to the pension system (${}^{not}N_{x,\,t}$) based on the cohort-specific maximum labor force participation rates ($Pr^{max}_{c,\,t}$):

$$ {}^{not}N_{x,\,t} = \left({}^{nw}N_{x,\,t} - {}^{ret}N^{se,\,cs}_{x,\,t} \right) \cdot \left(1 - Pr^{max}_{c,\,t} \right) \quad . $$

[19] That expands the assumptions on the labor force structure to the structure of pension claims (see Section 3.2.2).

Finally, the number of pensioners ($N^{pp}_{x,\,t}$) – non-working individuals eligible for a public pension – results from subtracting the non-working individuals without pension claims from the non-working individuals:

$$N^{pp}_{x,\,t} = {}^{nw}N_{x,\,t} - {}^{ret}N^{se,\,cs}_{x,\,t} - {}^{not}N_{x,\,t} \quad .$$

With the number of pensioners $N^{pp}_{x,\,t}$ as the basis we use the observed age-specific disability pension numbers to calculate age-specific rates of receiving a disability pension $d_{x,t}$ (Deutsche Rentenversicherung, 2013):

$${}^{dis}N^{pp}_{x,\,t} = N^{pp}_{x,\,t} \cdot d_{x,t} \quad . \tag{5}$$

From 2012 onwards, we assume that age-specific disability rates develop linearly to the increase of legal retirement ages. The number of old-age pensioners results as an 'analytical residual' in the group of pensioners. In our model old-age pensions are included starting at age 60. This early retirement age x_{min} is shifted between 2012 and 2029 by 2 years according to the raise of legal retirement ages:

$${}^{old}N^{pp}_{x,\,t} = N^{pp}_{x,\,t} - {}^{dis}N^{pp}_{x,\,t} \quad , \forall x \geq x_{min} \quad . \tag{6}$$

With this modeling approach we build a flexible framework for the calculation of pensioners that arise from population developments and labor force participation. An increasing labor force participation automatically reduces the number of pensioners and vice versa.

Our simulation of widow's and widower's pensioners follows a simplified approach. As survivor's pensions refer to pension claims of spouses, we approximate the future number of widow's and widower's pensioners (${}^{wf}N^{pp}_{x,\,t}$ and ${}^{wm}N^{pp}_{x,\,t}$) based on the female and male population age 60 and older ($N_{x\geq 60,\,t}$). We therefore calculate the number of widow's pensioners as the (cumulative) share of observed widow's pensioners (wf_t) in relation to the female population age 60 and older:

$${}^{wf}N^{pp}_{t} = wf_t \cdot \sum_{x\geq 60}^{100} {}_{fem}N^{f}_{x,\,t} \quad .$$

Identically, the number of widower's pensioners is calculated as the (cumulative) share of observed widower's pensioners (wm_t) in relation to the male population age 60 and older:

$${}^{wm}N^{pp}_{t} = wm_t \cdot \sum_{x\geq 60}^{100} {}_{male}N_{x,\,t} \quad .$$

From 2010 onwards both rates wf_t and wm_t are kept constant (Deutsche Rentenversicherung, 2013).

3.3 Revenues and Expenditures of the German Pension System

The simulation of the German Statutory Pension System follows a detailed accounting approach of revenues and expenditures within the pay-as-you-go funding scheme. We model the detailed pension legislation to be able to project reliable future developments. The focus of our model is set on long-run developments in Germany. Differences in demographic developments, in labor force developments and differences in the specific pension legislation between Eastern Germany and Western Germany are not considered. Implicitly, we assume a uniform pension system and comparative developments in both parts of Germany in the long run.

3.3.1 Revenues

The main revenues of the German pension system consist of contributions paid by employees subject to social insurance contributions (${}^{w}N^{SV}_{x,\,t}$)[20] and supplementary federal subsidies. Altogether, in 2010 contributions accounted for approximately 75 percent of all revenues of the GRV (Deutsche Rentenversicherung, 2012).

We distinguish between contributions made by employed and unemployed people. Employed people pay full contributions according to their gross income ($BE_{t,\,x}$) and the actual contribution rate (RVB_t) of the German Statutory Pension System. Considering age-specific income profiles, Equation 7 describes the contributions of employed people at age x in year t ($CR^{wp}_{t,\,x}$).

$$CR^{wp}_{t,\,x} = RVB_t \cdot BE_{t,\,x} \cdot {}^{w}N^{SV}_{x,\,t} \tag{7}$$

Additionally, contributions of unemployed people (${}^{w}N^{uep}_{x,\,t}$) are paid by the Federal Employment Agency. The Federal Employment Agency pays contributions based on 80 percent of the average unemployment benefits – equal to 60 percent of the gross income.[21] On average, contributions of unemployed people equal about 48 percent of corresponding full contributions. Equation 8 describes the contributions of unemployed people at age x in year t ($CR^{uep}_{t,\,x}$).

$$CR^{uep}_{t,\,x} = RVB_t \cdot 0.48 \cdot BE_{t,\,x} \cdot {}^{w}N^{ue}_{x,\,t} \tag{8}$$

[20]See 3.2.2.
[21]See § 166 (1) No. 2 SGB III and § 149 No. 2 SGB III.

Supplementary to contributions, federal subsidies are an important revenue source. The tax-financed federal subsidies contain a general subsidy ABZ ("Allgemeiner Bundeszuschuss"), the additional federal subsidy ZBZ ("Zusätzlicher Bundeszuschuss").

The general federal subsidy[22] develops in line with the ratio of the gross wages of the previous years. Additionally, changes in the contribution rate of the GRV are considered in the alteration. Therefore, the general federal subsidy is multiplied by the change of the ratio of 'virtual' contribution rates – the contribution rates that would occur in the absence of federal subsidies:

$$ABZ_t = ABZ_{t-1} \cdot \frac{BE_{t-2}}{BE_{t-3}} \cdot \frac{RVB_t^{vir}}{RVB_{t-1}^{vir}} \quad .$$

In our model we use a simplified updating mechanism and tie the development of the general subsidy to the change in the ratios of previous gross wages and ('effective') contribution rates:

$$ABZ_t = ABZ_{t-1} \cdot \frac{BE_{t-1}}{BE_{t-2}} \cdot \frac{RVB_{t-1}}{RVB_{t-2}} \quad . \tag{9}$$

The additional federal subsidy[23] develops proportionally to sales tax revenues. The enhancement allowance[24] ("Erhöhungsbetrag") EB is adjusted to the change of gross wages and is further raised by revenues of ecological taxes. In our model we update both parts of the additional federal subsidy according to the gross wage development. The changes over time are represented in Equation 10.

$$ZBZ_t = (ZBZ_{t-1} + EB_{t-1}) \cdot \frac{BE_{t-1}}{BE_{t-2}} \tag{10}$$

Further income sources (${}^{add}CR_t$) – e. g. income from assets and refunds – play a minor role in the total budget. Between 2005 and 2010 other sources accounted for approximately 0.4 to 0.7 percent of the total revenues of the GRV (Deutsche Rentenversicherung, 2012). We include other income sources as a constant amount in our model.[25]

3.3.2 Expenditures

The pension simulation model comprises the expenditures for old-age pensions, disability pensions and survivor's pensions. Additionally, costs for health insurance, rehabilitation

[22] See § 213 (2) SGB VI.
[23] See § 213 (3) SGB VI.
[24] See § 213 (4) SGB VI.
[25] The observed amount of other income sources accumulates from distinct sources and varied over the years. We therefore abstain from modeling a systematical development of future values.

costs and administrative costs are modeled. Further expenditures are summarized as other costs.

In the German Statutory Pension System the individual pension reflects the income history of a working life. Based on the relation of individual earnings and average gross wages individuals obtain personal earning points for each working year. An earning point corresponds to an individual wage equal to average gross wages in a given year. A higher or lower wage will change the obtained earning points proportionally. Thus, if a persons earns half of the average gross wage also only 0.5 personal earning points are received for that year. The individual monthly pension arises from multiplying the sum of personal earning points with the 'actual pension value' – the monetary value of an earning point – that is updated in line with structural and economical developments.[26]

We abstract from the individual perspective and estimate average cohort-specific earning points in our model. Therefore, based on the given cohort employment history – resulting from cohort-specific labor force participation rates[27] and age-specific earning profiles[28] – average cohort-specific earning points ($EP_{t-c,\,c}$) are calculated for all cohorts c at age x ($x = t - c$) in year t. The youngest age for receiving a pension is assumed to be 50.[29] The sum of pension payments (${}^{sum}P_t$) in year t is calculated based on the number of pensioners of a cohort $N^{pp}_{c,\,t}$, the average cohort-specific earning points ($EP_{t-c,\,c}$) and the actual pension value (aRW_t):

$$ {}^{sum}P_t = aRW_t \cdot \sum_{c\,=\,t-50}^{c\,=\,t-100} \left(N^{pp}_{c,\,t} \cdot EP_{t-c,\,c} \right) \quad . \tag{11} $$

Thereby the sum of all pension payments consists of payments for disability pensions (${}^{dis}P_t$), old-age pensions (${}^{old}P_t$) and survivors pensions for women and men (${}^{wf}P_t$ and ${}^{wm}P_t$).

Starting at the age of 50 disability pensions are included in our model.[30] The German pension legislation differentiates between a 'full' disability pension and a 'partial' disability pension.[31] We only consider full disability pensions without any reductions. When disability pensioners reach the legal retirement age (LRA_t), disability pensions are converted into

[26]See Sectio 3.3.3.
[27]See Section 3.2.1.
[28]See Section 3.2.2.
[29]See Section 3.2.3.
[30]In Germany disability pensions can be claimed at any age, given the required entitlements. Thereby disability pensions can be paid temporarily if e. g. improved health obviates a disability pension in later years. We account for these intermittent disability pensions and add a fixed number of disability pensions according to the observed number of disability pensions below age 50 (Deutsche Rentenversicherung, 2013). Starting in 2011, the number of disability pensioners below age 50 remain constant.
[31]See §33 (3) SGB VI and §67 SGB VI.

old-age pensions. Disability pension payments are calculated as:

$$ {}^{dis}P_t = aRW_t \cdot \sum_{c=t-50}^{c=t-LRA_t-1} \left({}^{dis}N^{pp}_{c,t} \cdot EP_{t-c,c} \right) \quad . $$

In our model old-age pensions are included starting at an early retirement age $x_{min} = 60$. This early retirement age x_{min} is shifted by 2 years according to the raise of the legal retirement age. For the calculation of old-age pension payments, the sum of earning points is additionally multiplied with an adjustment factor RZF for early retirement. When retirement occurs before the legal retirement age the adjustment factor is reduced by 3.6 percent per year of early retirement up to a maximum of 10.8 percent:[32]

$$ {}^{old}P_t = aRW_t \cdot \sum_{c=t-x_{min}}^{c=t-100} \left({}^{old}N^{pp}_{c,t} \cdot RZF_{c,t} \cdot EP_{t-c,c} \right) \quad . $$

Our modeling approach simplifies the complex German pension legislation. In the German pension system different kinds of old-age pensions can be claimed and different minimal ages of possible retirement apply.[33] The differentiation between the types of pensions depends on the year of birth, the kind of former occupation and special characteristics of the employment history (e. g. unemployment, number of working years). Generally, early retirement will cause reductions of the sum of earning points by 0.3 percent per each month of early retirement. On the other hand, retirement past the legal retirement age is rewarded by a 0.5 percent increase of the sum of earning points for every month of later retirement.[34]

We also include survivors pensions in our model. The German pension legislation differentiates between a temporary ‘small widow’s pension’ that entitles to 25 percent of the underlying regular pension and a ‘large widow’s pension’ with benefits corresponding to 55 percent of a regular pension.[35] In both cases for the first 3 months survivors pensions equal 100 percent of the underlying regular pension of the deceased. The respective entitlements depend on the age of the survivors, on the disability status of survivors and on the existence of underage children.[36] As a simplification we assume that all widow’s and widower’s pensioners are entitled for a ‘large widow’s pension’ or respectively a ‘large widower’s pension’. Furthermore, we specify survivors pensions in relation to the average

[32] The adjustment factor is 1.0 when retirement occurs at the legal retirement age. Early retirement for one year would reduce the adjustment factor by 3.6 percent to 0.964 (= 1 − 0.036). An increase of the sum of earning points for ‘late retirement’ – retirement beyond the legal retirement age – is not considered in the model.

[33] See § 33 SGB VI.

[34] See § 77 SGB VI.

[35] The same applies for widower’s pensions.

[36] See § 67 (5,6) SGB VI and § 46 SGB VI.

earning points of old-age pensioners. Thus, survivor pension payments refer to 55 percent of the pension of an average old-age pensioner. Using average male earning points, widow's pension payments (${}^{wf}P_t$) are calculated as:

$$ {}^{wf}P_t = {}^{wf}N_t^{pp} \cdot \frac{\sum_{c=t-x_{min}}^{c=t-100} {}_{male}EP_{t-c,\,c}}{\sum_{c=t-x_{min}}^{c=t-100} {}_{male}^{old}N_{c,\,t}^{pp}} \cdot aRW_t $$

and widower's pension as:

$$ {}^{wm}P_t = {}^{wm}N_t^{pp} \cdot \frac{\sum_{c=t-x_{min}}^{c=t-100} {}_{fem}EP_{t-c,\,c}}{\sum_{c=t-x_{min}}^{c=t-100} {}_{fem}^{old}N_{c,\,t}^{pp}} \cdot aRW_t \quad . $$

In addition to pension payments, we also consider further expenditures of the German Statutory Pension System. We model expenditures for contributions to the health insurance of pensioners, administrative costs and expenditures for medical rehabilitation. Expenditures for health insurance contributions of pensioners CE_t^{health} add up to half of the by 0.9 percent diminished contribution rate for the statutory health insurance (GKV_t)[37] and are paid on the base of the total pension expenditures ${}^{total}P_t$:

$$ CE_t^{health} = {}^{total}P_t \cdot \frac{GKV_t - 0.009}{2} \quad . $$

Data on the contribution rate for health insurance for the years 2000 to 2010 was provided by Deutsche Rentenversicherung (2012). Starting in 2011 we assume a constant rate of 15.5 percent.

Administrative costs (CE_t^{admin}) are updated in relation to the evolution of gross wages (BE) and the number of pensioners (N_t^{pp}). We follow Wilke (2004) and include an attenuation factor $\phi = 0.1$ so that the change of the number of pensioners does not cause a one-to-one change of the administration costs:

$$ CE_t^{admin} = CE_{t-1}^{admin} \cdot \frac{BE_{t-1}}{BE_{t-2}} \cdot \left(1 + \phi \cdot \left(\frac{N_{t-1}^{pp}}{N_{t-2}^{pp}} - 1\right)\right) \quad . $$

Expenditures for medical rehabilitation (CE_t^{reha}) are updated according to the gross wage development:

$$ CE_t^{reha} = CE_{t-1}^{reha} \cdot \frac{BE_{t-1}}{BE_{t-2}} $$

[37] See § 249a SGB V.

Additional expenditures add up to less than one percent of the total expenditures and are summarized in a constant expenditure item to complete the model.[38]

3.3.3 Pension Adjustment and Contribution Rate Determination

The actual pension value (*aRW*) indexes pension payments to economic and demographic developments. Equation 12 characterizes the current indexation of pensions in the German pension system in detail.

$$aRW_t = aRW_{t-1} \cdot \underbrace{\frac{BE_{t-1}}{BE_{t-2} \cdot \left(\frac{\frac{BE_{t-2}}{BE_{t-3}}}{\frac{bBE_{t-2}}{bBE_{t-3}}} \right)}}_{\text{Gross Wage Factor}} \cdot \underbrace{\frac{100 - AVA_{t-1} - RVB_{t-1}}{100 - AVA_{t-2} - RVB_{t-2}}}_{\text{Old Age Provision Factor}} \cdot \underbrace{\left(\left(1 - \frac{RQ_{t-1}}{RQ_{t-2}} \right) \cdot \alpha + 1 \right)}_{\text{Sustainability Factor}} \tag{12}$$

The changes of average gross wages (*BE*), gross wages subjected to social insurance contributions (*bBE*), developments of the contribution rate for a subsidized private pension plan (*AVA*) and the contribution rate (*RVB*) as well as the pensioner ratio ("Rentnerquotient") *RQ* determine the pension value. The factor α is set to 0.25.[39] Summarizing, the evolution of the 'Gross Wage Factor' ("Bruttoentgeltfaktor"), the 'Old Age Provision Factor' ("Riesterfaktor") and the 'Sustainability Factor' ("Nachhaltigkeitsfaktor") determine the evolution of the actual pension value.

The Gross Wage Factor accounts for developments of the average gross wages over the previous years. Additionally, it also comprises the variation of average gross income subjected to social insurance contributions. We assume a constant share b for the difference between gross wages and wages subjected to social insurance. Thus, the Gross Wage Factor simplifies to $\frac{BE_{t-1}}{BE_{t-2}}$. Equation 13 describes the simplified pension indexation in our simulation model.[40]

$$aRW_t = aRW_{t-1} \cdot \frac{BE_{t-1}}{BE_{t-2}} \cdot \frac{100 - AVA_{t-1} - RVB_{t-1}}{100 - AVA_{t-2} - RVB_{t-2}} \cdot \left(\left(1 - \frac{RQ_{t-1}}{RQ_{t-2}} \right) \cdot \alpha + 1 \right) \tag{13}$$

The Old Age Provision Factor reflects the changing cost for pension contributions and

[38] Between 2005 and 2010 other expenditures accounted for 0.3 to 0.4 percent of the total expenditures of the GRV (Deutsche Rentenversicherung, 2012).

[39] Ssee § 68 (4) SGB VI.

[40] The modeling approach considers wages subjected to social insurance contributions as a fixed share b of gross wages. The term $\frac{\frac{BE_{t-2}}{BE_{t-3}}}{\frac{bBE_{t-2}}{bBE_{t-3}}}$ cancels out: $\frac{\frac{BE_{t-2}}{BE_{t-3}}}{\frac{bBE_{t-2}}{bBE_{t-3}}} = \frac{b}{b} \cdot \frac{\frac{BE_{t-2}}{BE_{t-3}}}{\frac{BE_{t-2}}{BE_{t-3}}} = 1$.

additional private pension plans. It therefore comprises the contribution rate of the GRV (RVB) and the required contribution rate for voluntary private pension plans (AVA) which are promoted by the federal government.[41]

The Sustainability Factor was introduced to insure a sustainable development of the GRV budget when the German population ages. Adjustments of the future actual pension values are diminished when the share of pensioners in relation to the number of contributors grows. The calculation is based on a standardization of the number of pensioners and contributors.[42] The standardized number of pensioners results from dividing the sum of pension payments by a normalized pension based on 45 earning points. The standardization of contributors is done by dividing the sum of contributions by the contributions based on the average gross income. The integration of the Sustainability Factor in the pension value indexation links the replacement rate to the population structure. Principally, the indexation formula for the actual pension value allows for positive and negative adjustments, dependent on the development of the described factors. But, the German Pension System comprises a 'protective clause' that prevents a decline of the actual pension value caused by the Old Age Provision Factor or the Sustainability Factor. In such a situation the actual pension value remains at the level of the previous year. This non-decrease of the pension value will be offset against future increases.[43] Our pension model accounts for that special feature of the GRV.

Overall, the total expenditures and the total revenues of the GRV have to compensate one another to achieve a balanced budget. If the budget of the GRV is unbalanced, the contribution rate of the GRV has to be adjusted to balance out differences. The budget constraint writes:

$$CR_t^{wp} + CR_t^{uep} + ABZ_t + ZBZ_t + {}^{add}CR_t = {}^{total}P_t + CE_t^{health} + CE_t^{admin} + CE_t^{reha} \quad . \tag{14}$$

Here, ${}^{total}P_t$ $(= {}^{dis}P_t + {}^{old}P_t + {}^{wf}P_t + {}^{um}P_t)$ describes the total pension expenditures for disability, old-age and survivor pensions. Rearranging Equation 14 together with Equation 7 and Equation 8 and solving for the contribution rate yields to:

$$RVB_t = \frac{{}^{total}P_t + CE_t^{health} + CE_t^{admin} + CE_t^{reha} - ABZ_t - ZBZ_t - {}^{add}CR_t}{BE_t \cdot ({}^{w}N_t^{SV} + 0.48 \cdot {}^{w}N_x^{ue})} \quad .$$

[41] A reform in 2002 introduced a voluntary third pension pillar eligible for state subsidies. Subsidized private pensions plans shall compensate future pensioners for an expected decline of the pension replacement rate caused by demographic aging.

[42] See § 68 (4) SGB VI.

[43] See § 68a SGB VI.

To allow for minor budget fluctuations over the year and to avoid permanent marginal contribution rate adjustments, the Statutory Pension System holds a reserve NRL_t of 0.2 to 1.5 monthly payments of own expenditures. Own expenditures of the GRV are the total expenditures diminished by the general federal subsidy, refunds and other compensations payments.[44] We model the own expenditures of the GRV as a share β_t of total expenditures (${}^{total}CE_t$) using data provided by Deutsche Rentenversicherung (2012). After 2010 the share β is assumed to be constant at the median level of observed rates ($\beta = 0.8$). When the reserve fund is expected to fall short of (or exceeds) the statutory bounds, the contribution rate is adjusted stepwise until equation 15 is fulfilled.

$$RVB_t = \frac{NRL_t + {}^{total}P_t + CE_t^{health} + CE_t^{admin} + CE_t^{reha} - ABZ_t - ZBZ_t - {}^{add}CR_t}{BE_t \cdot \left({}^{w}N_t^{SV} + 0.48 \cdot {}^{w}N_x^{ue}\right)}\,, \tag{15}$$

$$\text{with:} \quad 0.2 \geq \frac{NRL_t}{\beta_t \cdot {}^{total}CE_t} \leq 1.5$$

4 Decomposition Approach to Demographic Effects

We developed a decomposition approach to estimate the impact of different demographic factors on the development of central parameters of the German Statutory Pension System. Based on the pension simulation model and demographic benchmark projections single effects can be isolated. Our calculations refer to the reference year 2010, the starting point of our simulations. The decomposition results will allow for a detailed impact analysis on the effects of demographic developments on the pension system. In addition to a pension simulation model our decomposition gives deeper insights to the relevance of single demographic factors. The complex sets of assumptions and its interactions within the pension simulation are decomposed so that the potential influence and its comparative relevance can be evaluated. This information will be valuable for identifying and evaluating pension policy options.

We ascribe the absolute development of central pension system parameters (d_{total}) to the population structure in place in 2010 (*'structural effect'*), the development of fertility (*'fertility effect'*), the evolution of life expectancy (*'mortality effect'*), variations in net migration (*'migration effect'*) and a *'residual effect'* accounting for multiple interactions of the mentioned demographic effects.[45] For the calculation of all demographic effects identical economic assumptions apply.[46]

[44]See § 158 (1) SGB VI.

[45]Multiple interactions are characterized by the interaction of more than two variables – e. g. the population structure, mortality and fertility.

[46]Feedback effects of demographic assumptions on economic outcomes and vice versa are not considered.

In a first step the total development of the pension system is calculated as the outcome variable. Therefore, the progression of the pension system is simulated with a complete set of assumptions on future demographic and economic developments – the 'research scenario'. The yearly change of the pension parameters (d^{total}) can be observed as the difference between two successive years. Exemplary for the contribution rate, the total effect calculates as:[47]

$$d_t^{total} = RVB_{t+1} - RVB_t \quad .$$

In a second step, the *structural effect* (d^{struc}) is calculated. We project a benchmark simulation using the 'fixed demographic scenario'.[48] Thereby, mortality and fertility rates remain constant at the level of 2010 and there is no net migration. Changes of the pension parameters evolve from future economic developments and the demographic factors in 2010. Thus, developments of the pension parameters are mainly the result of the given population structure in the starting year of the simulation. The structural effect is immanent in all simulation results as the starting population structure remains the same. We therefore treat the structural component as the underlying basis for the estimation of all single demographic effects. The yearly structural effect is estimated as:[49]

$$d_t^{struc} = RVB_{t+1}^{struc} - RVB_t^{struc} \quad .$$

The *mortality effect* (Δ^{mort}) refers to a simulation based on a mortality scenario. Thereby, with constant fertility rates at the level of 2010 and in the absence of migration only mortality rates improve according to the assumptions of the research scenario. The mortality effect quantifies the impact of mortality developments in comparison to the mortality levels in 2010. Because of the immanent structural effect the yearly differences have to be corrected:

$$\Delta_t^{mort} = RVB_t^{mort} - RVB_{t-1}^{mort} - d_t^{struc} \quad .$$

Running the pension simulation with a fertility scenario – characterized by constant mortality and the absence of net migration – leads together with the correction for the structural effect to the *fertility effect* (Δ^{fert}). Here, the fertility effect characterizes the

[47]The decomposition of replacement rate changes and the decomposition of the development of the share of federal subsidies follows the same strategy. In the following we only refer to the contribution rate of the pension system.
[48]See Section 3.1.
[49]Here, RVB^{struc} characterizes the contribution rate in the fixed demographic scenario.

impact of fertility developments in comparison to fertility rates in 2010:

$$\Delta_t^{fert} = RVB_t^{fert} - RVB_{t-1}^{fert} - d_t^{struc} \quad .$$

Importantly, the described mortality and fertility effects involve 'first order' or 'direct' interactions. That means, that all demographic rates interact with the population structure. The larger the cohorts affected, the bigger the effect of varying rates.

The *migration effect* (Δ^{mig}) is calculated in a similar way and results from a simulation based on constant fertility and mortality rates and the correction for the structural effect:

$$\Delta_t^{mig} = RVB_t^{mig} - RVB_{t-1}^{mig} - d_t^{struc} \quad .$$

The underlying demographic scenario allows for varying migration numbers as used in the research scenario.

Finally, the emerging residuals define the *residual effect* (d^{res}):

$$d^{res} = d_t^{total} - d_t^{struc} - \Delta_t^{mort} - \Delta_t^{fert} - \Delta_t^{mig} \quad .$$

The residual effect comprises multiple interaction effects. For instance, higher net migration numbers will increase the affected cohort sizes. When mortality rates improve in affected ages, the effect of mortality changes will be larger compared to the situation without migration.

5 Projection Results of Central Pension System Variables

The projection of future developments of pension system parameters marks the starting point for the decomposition analysis. We therefore give a short overview of coming developments of the contribution rate, the net replacement rate and the share of federal subsidies in the budget of the GRV. All developments from 2010 onwards result from the simulation model. Data for the years 2000 to 2009 were provided by Deutsche Rentenversicherung (2012).

The illustrated simulation results are based on the wage growth scenario of 2.5 percent p.a. and the reference unemployment scenario of constant unemployment rates of 7.7 percent.[50] Demographic assumptions refer to the reference scenario where fertility increases to a TFR of 1.6, life expectancy at birth increases by 6.3 years for women and 7.3 years

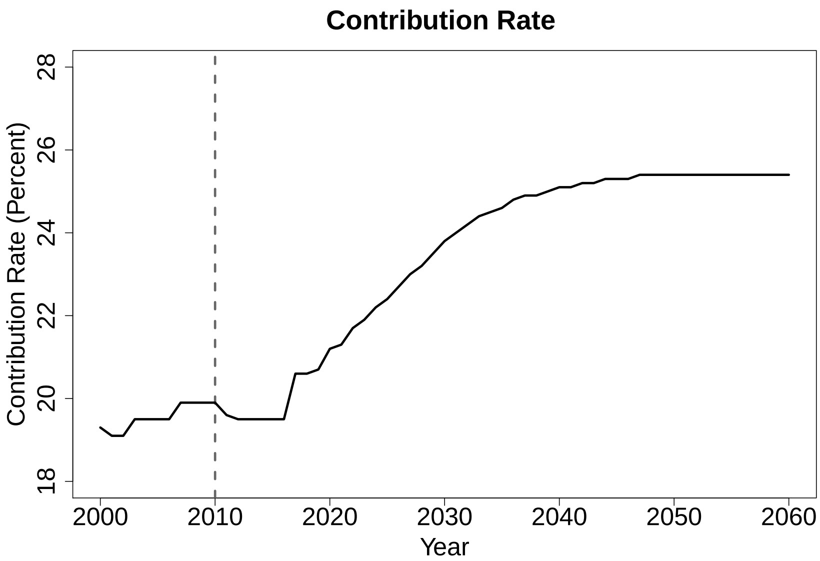
[50]See Section 3.2.2.

for men and a yearly net migration reaches 100.000 people.[51] The subsequent sensitivity analysis evaluates the impact of variations in economic and demographic assumptions on our simulation results.

5.1 Contribution Rate

Figure 1 illustrates the contribution rate development in the reference scenario from the year 2000 to 2060. Starting in 2010, the shown development refers to the results of the simulation model.

Figure 1: Development of the Contribution Rate



Source: Deutsche Rentenversicherung (2012) and own calculations.

In 2000 the contribution rate was 19.3 percent. After a small drop to 19.1 percent the contribution rate increased between 2003 and 2007 in two steps to 19.9 percent and remained constant until 2010. Starting in 2010, our pension simulation model projects a moderate downturn of the contribution rate to 19.5 percent until 2016.[52] Between 2017 and 2022 the contribution rate expands noticeably by 2.2 percentage points followed by a steady increase until a plateau of 25.4 percent is reached in 2047.

The simulation results show that the costs of the pension system will rise significantly.

[51] For details on fertility, mortality and migration see Section 3.1.1, 3.1.2 and 3.1.3.

[52] Observed contribution rates for the years 2011 to 2013 are not shown here. In 2010 and 2011 the observed contribution rate was 19.9 percent. In 2012 and 2013 this rate declined to 19.6 and 18.9 percent.

Without future reforms the political goal of a maximum contribution rate of 20 percentage until 2020 and 22 percentage until 2030 will be endangered.[53]

5.2 Net Replacement Rate

Despite contribution rates, the net replacement rate (NRR_t) is another central variable characterizing the pension system. The net replacement rate is measured as the ratio of a standardized pension – reduced by long-term care insurance and health care insurance contributions – and the average gross income corrected for social insurance contributions. Social insurance contributions include contribution rates for long-term care insurance (PKV_t), health care insurance (GKV_t), unemployment insurance (ALV_t) and statutory pension contributions (RVB_t).[54]

$$NRR_t = \frac{45 \cdot aRW_t \cdot 12 \cdot \left(100 - PKV_t - \left(\frac{GKV_t - 0.9}{2} + 0.9\right)\right)}{BE_t \cdot \left(100 - PKV_t - \left(\frac{GKV_t - 0.9}{2} + 0.9\right) - ALV_t - RVB_t\right)} \tag{16}$$

The net replacement rate describes the fraction of disposable standardized income provided by the pension system to the average disposable income of the working population. It reflects the relative generosity of the pension system and the relative income situation of pensioners in comparison to the working population. Equation 16 describes the calculation of the net replacement rate.

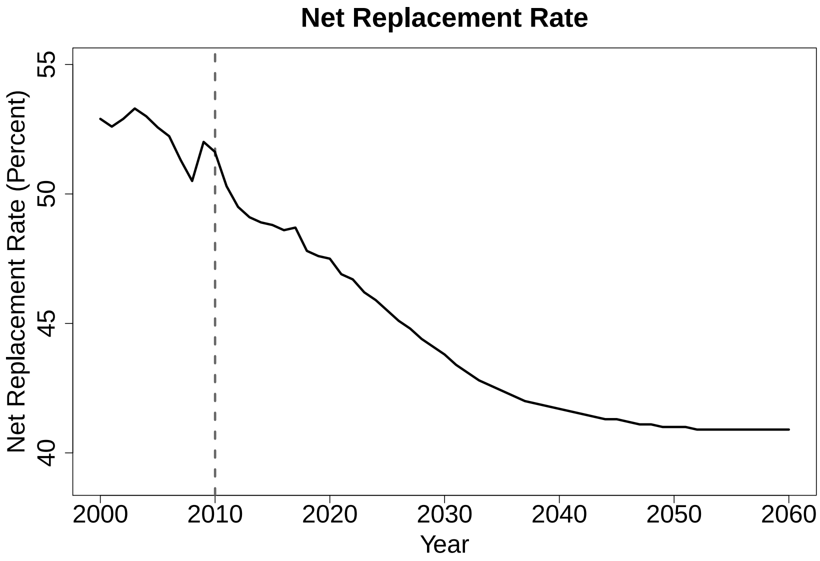
Figure 2 illustrates the development of the net replacement rate. With a break between 2007 and 2009, the net replacement rate decreases with an attenuating slope from 52.9 percent in 2000 to 40.9 percent in 2060. In addition to higher contributions to the GRV also the long-term development of net replacement rate shows that the pressure on the pension system will increase. Under our utilized assumptions the net replacement rate will not fall below 46 percentage until 2020 and 43 percentage in 2030 so that policy goals can be achieved.[55] But, these results elucidate that maintaining a high standard of living in retirement requires additional private pension plans for future pensioners as the replacement rates will further decline after 2030.

5.3 Share of Federal Subsidies

The share of federal subsidies – the ratio of federal subsidies to total expenditures – in the budget of the GRV indicates the average financial burden of the pension system to

[53]See § 154 SGB VI.
[54]See § 154 (3) No. 2 SGB VI.
[55]See § 154 SGB VI.

Figure 2: Development of the Net Replacement Rate



Source: Deutsche Rentenversicherung (2012) and own calculations.

public finances in Germany. We only consider the general subsidy and the additional federal subsidy including the enhancement allowance as direct federal payments in our calculation (Deutsche Rentenversicherung, 2012, p. 249.). Additional federal allowances paid for e.g. pension contributions during child-rearing or subsidies for the health insurance of pensioners are not included in the calculation of the share of federal subsidies.

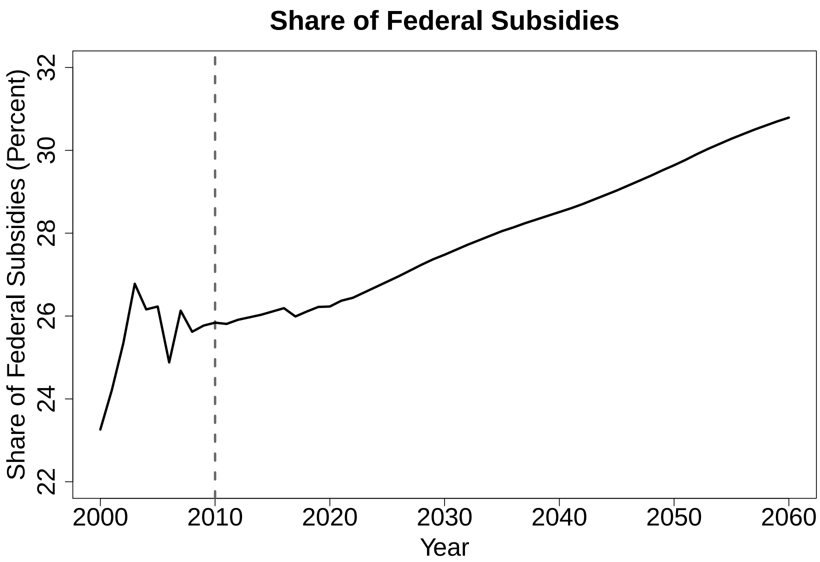
In 2000 about 23.3 percent of the total expenses were financed by federal subsidies. After a sharp increase to 26.4 percent in 2003, the share of federal subsidies reached 25.8 percentage in 2010. In the following years the share rises steadily up to 30.8 percent in 2060. These developments illustrate a growing financial burden for public finance in addition to increasing costs within the PAYG pension system.

5.4 Variations on Economic Assumptions

The previously presented simulation results refer to the reference scenarios for demographic and economic developments. In order to be able to evaluate the impact of central assumptions on future economic conditions we perform a sensitivity analysis. We analyze the effects of variations in wage growth and unemployment rates.[56]

[56]The results of the sensitivity analysis are illustrated in comparison to the economic and demographic reference scenarios.

Figure 3: Development of the Share of Federal Subsidies



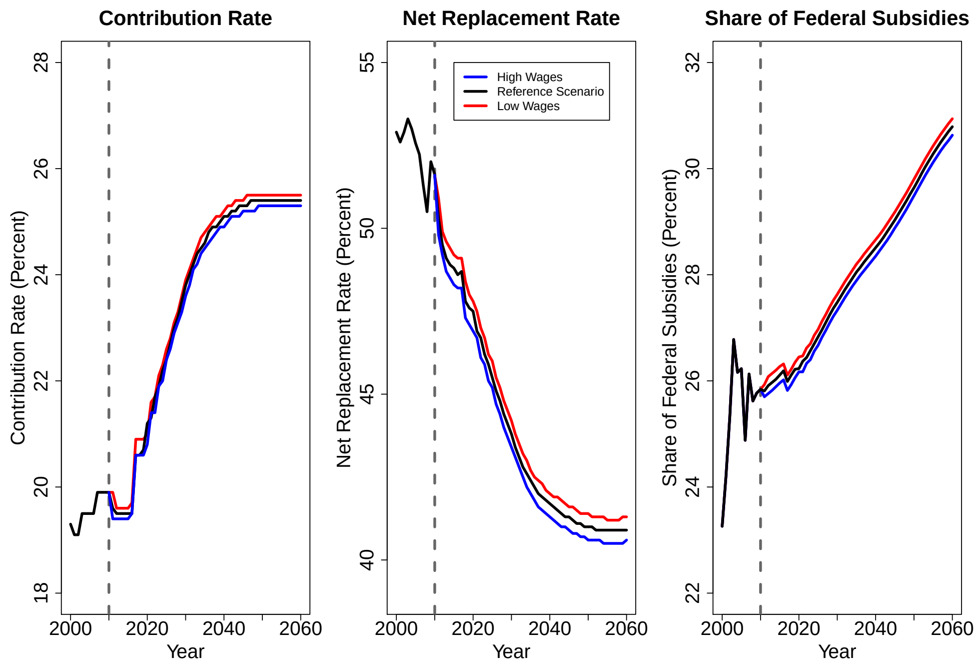
Source: Deutsche Rentenversicherung (2012) and own calculations.

5.4.1 Wage Growth

In the long run a higher wage growth rate of 3.5 percent per year will slow down the increase of the contribution rate. Pictured in Figure 4, until 2045 the contribution rate will be 0.1 to 0.2 percentage points lower compared to the reference scenario. In the following observed years the contribution rate in the higher wage growth scenario will be 0.1 percentage points lower compared to the contribution rate in the reference scenario. Conversely, a lower wage growth rate of 1.5 percent per year will slightly advance the pace of increase of the contribution rate. Overall the contribution rate in the low wage scenario will be between 0.1 and 0.2 percentage points higher. Altogether, wage growth variations have a minor impact on the contribution rate development in our model as higher wages directly cause higher pension payments without a delay for adjustments. However, in reality pension payments adapt to growing wages with a time lag. This time lag can cause larger effects of wage growth variations on the contribution rate development as long as wage growth exceeds or falls behind the reference wage growth rate. Model calculations that include these effects can be found in e. g. Holthausen et al. (2012).

Focusing on the relative generosity of the pension system – characterized by the net replacement rate – wage growth variations develop a symmetrical effect on the replacement rate. An increase (decrease) of the wage growth rate by 1 percentage point will cause a reduction (rise) of the net replacement rate between 0.4 and 0.6 percentage points.

Figure 4: Sensitivity Analysis of Pension System Developments - Wage Growth



Source: Own calculations.

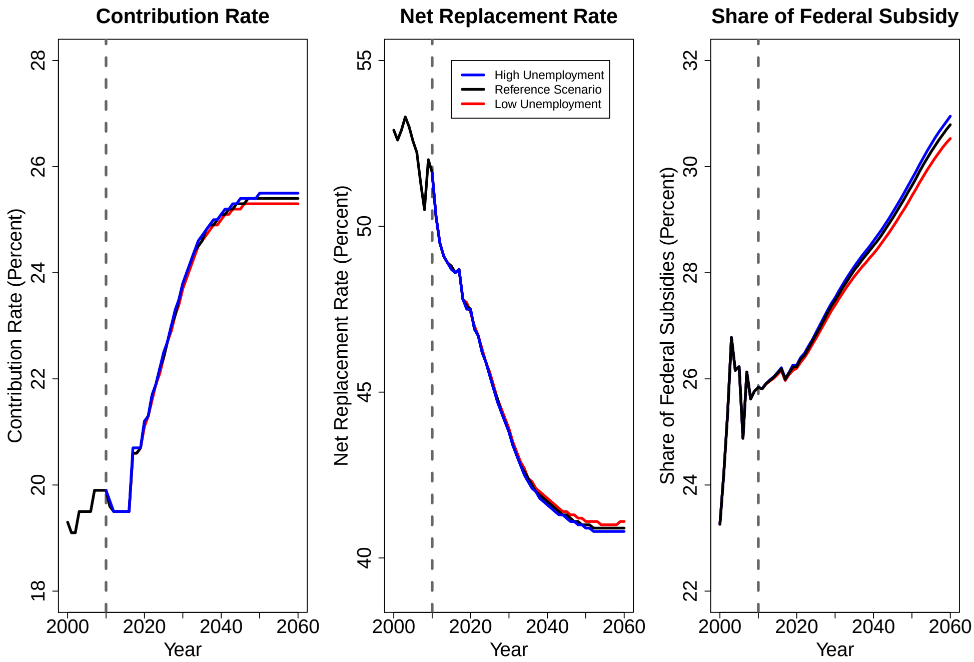
Also the share of federal subsidies shows a symmetrical impact of wage growth variations. Overall, the assumption of the higher wage growth rate will reduce the share of federal subsidies by 0.1 to 0.3 percentage points. Reversely, the assumption of the lower wage growth rate will increase the share of federal subsidies in the same way.

5.4.2 Unemployment

Figure 5 illustrates the effects of unemployment development changes. The development of the contribution rate shows only minor variations when unemployment assumptions change. With a higher unemployment rate the contribution rate further increases and reaches in 2060 a 0.1 percentage points higher level. Lower unemployment reduces the contribution rate by 0.1 percentage points in the long run.

A higher unemployment rate shows hardly any effect on the net replacement rate. Also lower unemployment rates will raise the replacement rate slightly between 0.1 and 0.2 percentage points. Similar effects are visible when analyzing the share of federal subsidies in the budget of the GRV. Higher unemployment will marginally increase the share of federal subsidies by approximately 0.1 to 0.2 percentage points. In the lower unemployment

Figure 5: Sensitivity Analysis - Unemployment



Source: Own calculations.

scenario the share of federal subsidies decreases by about 0.2 to 0.3 percentage points.

Summarizing, based on our model and on our considered development scenarios variations of the utilized economic assumptions have a minor impact on the central pension system variables. Thereby, differing wage growth rates affect our simulation results more than varying unemployment scenarios.

5.5 Variations on Demographic Assumptions

Besides an undetermined economic future also the development of demographic conditions includes uncertainty. We therefore discuss the impact of varying demographic assumptions for mortality, fertility and migration on our simulation results.[57]

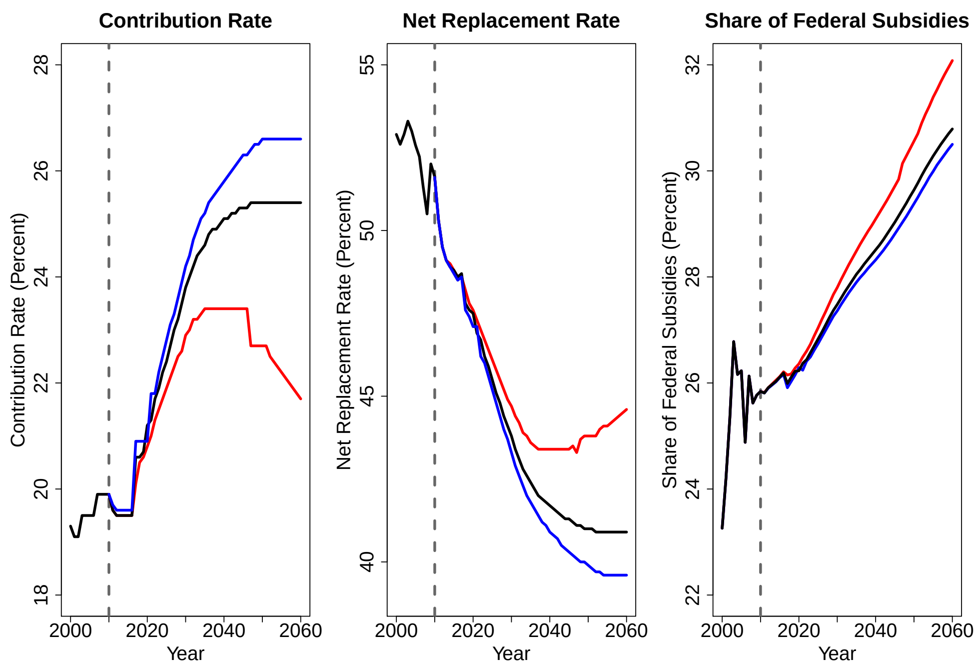
[57]The results of the sensitivity analysis are illustrated in comparison to the economic and demographic reference scenarios.

5.5.1 Mortality

In comparison to our reference mortality assumption Figure 6 shows the developments of central pension system variables when life expectancy stagnates at the level of 2010 or further advances to a life expectancy at birth of 91.2 years for girls and 87.7 years for boys in 2060. In both cases substantial changes occur.

With the unlikely assumption of stagnating life expectancy the contribution rate reaches the peak plateau of 23.4 percent between 2035 and 2046. Afterwards the contribution rate decreases with a larger step in 2047 and a continuous development afterwards to 21.7 percent in 2060. Compared to the reference scenario the contribution rate would be 3.7 percentage points lower in 2060. In the identical mortality scenario the decline of net replacement rate levels off at approximately 43.4 percent in 2037. Afterwards it regains 1.2 percentage points so that the net replacement approaches 44.6 percent in 2060. This is 3.7 percentage points higher than the results in the reference scenario reveal. The share of federal subsidies in the budget of the GRV reacts negatively on a life expectancy stagnation. Compared to the reference scenario the share increases more quickly to 32.1 percent in 2060 – a difference of 1.3 percentage points.

Figure 6: Sensitivity Analysis - Mortality



Source: Own calculations.

When mortality advances according to the high life expectancy scenario opposing effects arise. Compared to the reference scenario the contribution rate will rise by additional 1.2 percentage points more rapidly and reaches 26.6 percent in 2060. At the same time the net replacement rate further decreases by 1.3 percentage points to 39.6 percent. The share of federal subsides develops on a slightly lower path and decreases by 0.3 percentage points in comparison to the reference scenario.

The more optimistic mortality scenario utilized by the Federal Statistical Office shows that – compared to our reference simulation results– the costs of the pension system can even further increase. Thus, our results show not a potential upper level of possible financial burden in the future. When life expectancy increases more rapidly than proposed in our reference assumptions the financial sustainability of the pension system is further endangered and a reform of the German pension system will be inevitable. Given the stunning fact that life expectancy improved in a world wide context steadily by a quarter of a year per year, highlights the future challenges of the German pension system (Oeppen and Vaupel, 2002, p. 1031.). But, a stable trend of improving life expectancy has the advantage that future development trends are less uncertain – especially compared to a highly volatile development of migration and stagnating trend in fertility. In addition, longer lives offer the chance to redistribute gained life years (Vaupel and Loichinger, 2006).

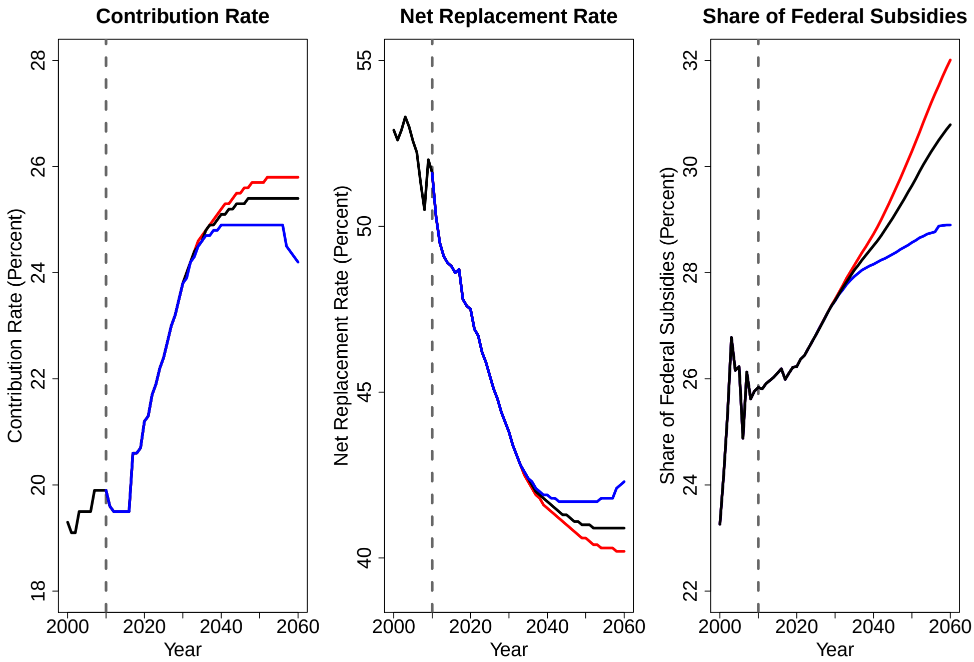
5.5.2 Fertility

The impact of different fertility developments is illustrated in Figure 7. In addition to the developments in the reference scenario the developments in a low fertility scenario with a TFR of 1.4 and the developments in a high fertility scenario with TFR of 2.01 – based on French fertility rates of 2010 – are presented.

When fertility rates would increase substantially and reach the French rates of 2010 the contribution rate of the GRV could be decreased by 1.2 percentage points and would reach 24.2 percentage in 2060 compared to the reference assumptions. At the same time the net replacement rate would gain 1.4 percentage points and reach 42.3 percentage. Also the share of federal subsidies would be reduced by 1.9 percentage points to 28.9 percentage when fertility increases to a TFR of 2.01.

A lower fertility rate with a TFR of 1.4 has opposing effects. The contribution rate would reach with 25.8 percent in 2060 a 0.4 percentage point higher level compared to the reference scenario. The difference emerge from a steeper rise of the contribution rate starting in 2035. The net replacement rate is negatively effected by lower fertility rates. After a uniformly development in line with the reference fertility scenario the net replacement rate drops faster after 2035. The replacement rate is in 2060 with 40.2 percentage approximately 0.7 percentage points lower compared to the reference simulation. The share of

Figure 7: Sensitivity Analysis - Fertility



Source: Own calculations.

federal subsidies in the budget of the GRV increases to 32.0 percent in 2060, a difference of 1.2 percentage points in relation the benchmark.

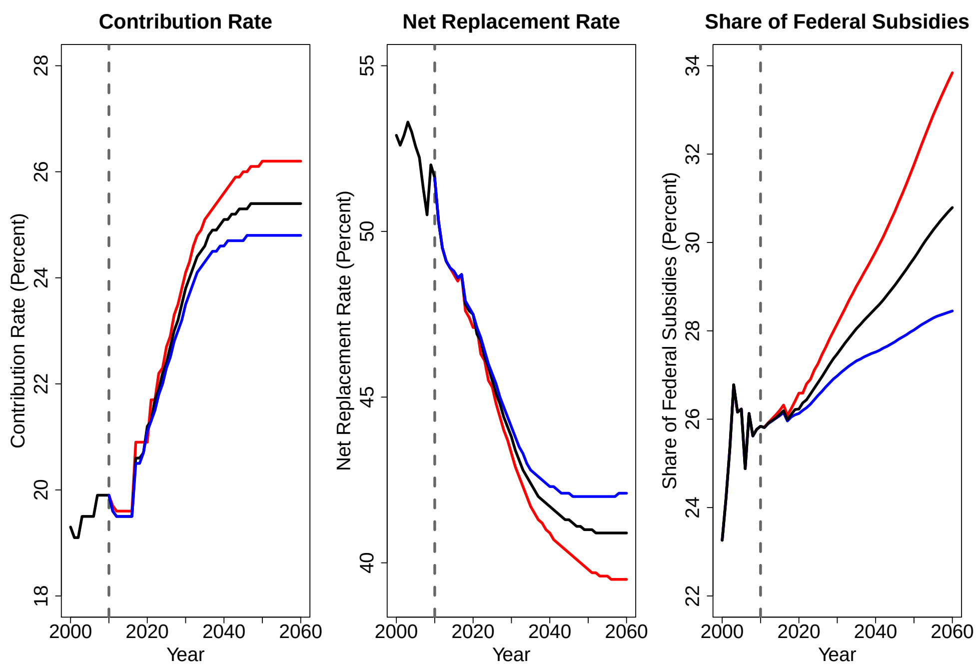
In summary, a variation of assumptions on fertility rate developments will gradually affect the German pension system. A higher number of births – or respectively a higher TFR – alters the pension system variables with a lag of time as the newborns have to enter the labor market first, before the pension system is affected. Thus, higher fertility rates start to impact the pension system between the years 2030 and 2035. However, a stable enhancement of fertility rates could reduce the financial burden in the future.

5.5.3 Migration

The impact of different migration scenarios is illustrated in Figure 8. Besides the reference scenario of a net migration approaching 100,000 people per year a low migration scenario without net migration and a high migration scenario with net migration of 200,000 people per year is presented.

A variation of assumptions on net migration has immediate effects on the pension system. Without net migration the contribution rate is higher and reaches 26.2 percent in 2060. Compared to the reference assumptions the difference sums up to 0.8 percentage points. Simultaneously, until 2060 the net replacement rate drops by 1.4 percentage points to 39.5 percent and the share of federal subsidies rises by approximately 3.0 percentage points to 33.8 percent.

Figure 8: Sensitivity Analysis - Migration



Source: Own calculations.

Vice versa, higher migration numbers reduce the contribution rate by 0.6 percentage points to 24.8 percentage in 2060 while the net replacement rate gains 1.2 percentage points and reaches 42.1 percentage. Also the share of federal subsidies decreases by 2.4 percentage points to 28.4 percent.

Summarizing, in our model different assumptions on migration numbers will have a notable impact on the pension system. As migration occurs often in working ages a variation in net migration has immediate effects on the contribution side of the pension system. In the long run migration can reduce the financial burden of the pension system when net migration is positive. But, with positive net migration future pension payments will also increase as former migrants receive pension entitlements when they contribute to the system. Thus, the practical potential of stabilizing a pensions system with migration policies is limited.

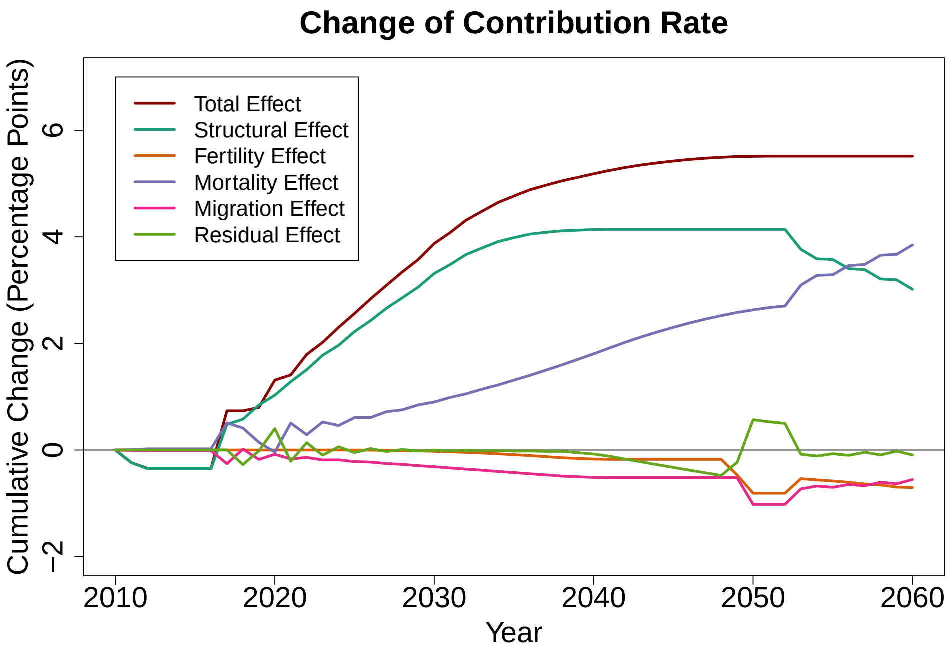
6 Results of Demographic Decomposition

As a central innovation, the decomposition of demographic effects allows for identifying the impact of each demographic factor on the simulated future developments of the German Statutory Pension System separately. We present the decomposition results based on our utilized reference scenarios for the period 2010 to 2060. The cumulative yearly change is divided into the impact of the structural effect of the baseline population in 2010, the fertility effect, the mortality effect, the migration effect and the residual effect of further demographic interactions.[58] Our presented results refer to the demographic and economic reference scenarios.[59]

6.1 Contribution Rate Changes

Figure 9 illustrates the cumulative demographic effects on the contribution rate. Depict

Figure 9: Effect of Demographic Factors on the Contribution Rate



Source: Own calculations.

is the total increase of the contribution rate – characterized by the total effect – and the

[58]See Section 4 for further details.
[59]See Section 3.1, Section 3.2.2 and Section 5.

cumulative impact of the underlying demographic factors. Overall, the contribution rate of the GRV will increase by about 5.5 percent between 2010 and 2060.

Within the first 6 years the structural effect is the single driver for a decline in the contribution rate by 0.3 percentage points. Afterwards, until 2052 it is the main factor for the enlargement of the contribution rate as about 4.1 percentage points of contribution rate increase is attributed to the structural effect. In the following years the impact of the population structure on the contribution rate development declines. However, in 2060 approximately 3.0 percentage points of the total contribution rate increase are caused by the structural effect. The present population structure of the reference year 2010 is one of the main drivers of contribution rate developments.

The second main driver of contribution rate developments is characterized by the mortality effect. Moreover, starting around 2052 it replaces the structural effect as the main influence factor. Before, the mortality effect develops with some fluctuations between 2010 and 2025 linearly and increases the contribution rate by about 2.7 percentage points in 2052. In the last years of the analyzed period the mortality effect shows a steeper growth and represents with 3.8 percentage points the most important driver of the total contribution rate increase in the analyzed period. Most prominent, the mortality effect and the structural effect raise the contribution rate. Without other interactions both effects would cause an increase by 3.8 or respectively 3.2 percentage points. While the mortality effect causes a steady increase of the contribution rate with a step between 2052 and 2053, the rise of the contribution rate determined by the structural effect becomes less important over the years.

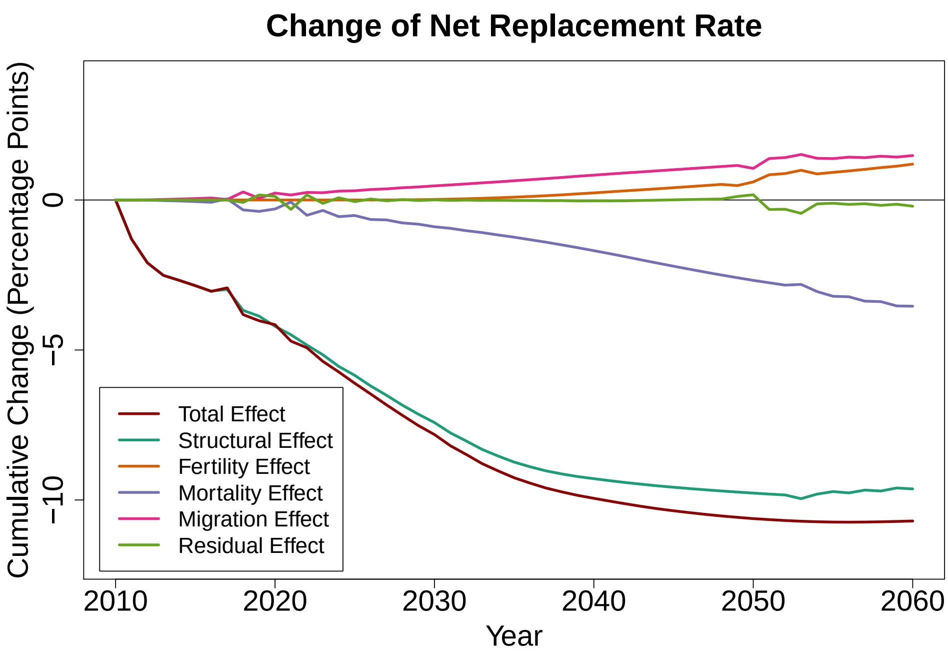
On the other hand, the fertility effect reduces the contribution rate by approximately 0.7 percentage points while the migration effects lowers the contribution rate by further 0.6 percentage points between 2010 and 2060. Thereby, the fertility effect firstly becomes operative in 2033 as newborns first have to enter the labor market before they affect the pension system. The migration effect has an influence on the pension system from 2017 onwards. In the reference scenario the diminishing impact of migration and fertility on the contribution rate can not counteract contribution rate growth caused by the population structure and mortality improvements.

The residual effect has a minor impact on the contribution rate development but shows erratic developments between 2045 and 2053.

6.2 Net Replacement Rate Changes

The analysis of the net replacement rate – illustrated in Figure 10 – shows a comparable, but reverse picture. As seen by the contribution rate development, the structural effect and mortality effect are the main factors for the total decline of the net replacement rates by 10.7 percentage points. Thereby, after a sharp decline of the net replacement rate within the first years of observation, between 2015 and 2035 the pace of the reduction decreases until 2040. In the following years the replacement rate change levels off.

Figure 10: Cumulative Effects on the Net Replacement Rate



Source: Own calculations.

The structural effect remarkably lowers the net replacement rate by about 10.0 percentage points at the maximum in 2053. Afterwards its impact slightly decreases to 9.6 percentage points in 2060.

Until 2060 a further reduction of the replacement rate by 3.5 percentage points is caused by the mortality effect. Thereby starting in 2016, the mortality effect linearly reduces the replacement rate.

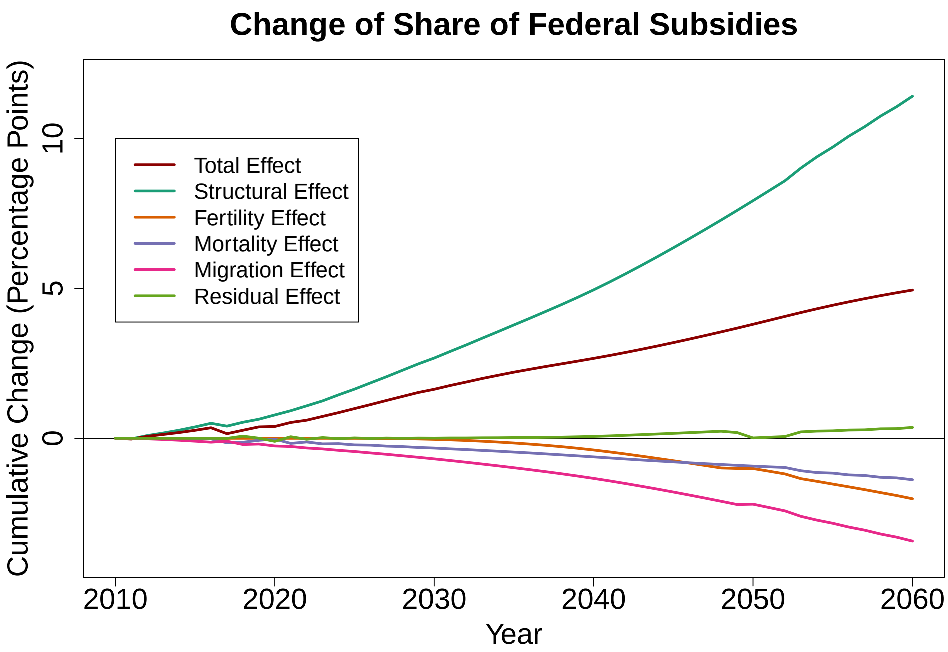
The migration and fertility effect stabilize the net replacement rate by 1.5 or respectively 1.2 percentage points. Both demographic factors have a continuous impact on the replacement rate. Despite the similarities, the stabilizing impact of migration will already start in 2016, while the fertility effect starts to influence the replacement rate from 2033 onwards.

The residual effect only has a negligible impact on the development of the net replacement rate. In 2060 its impact cumulates to a decrease in the replacement rate by 0.2

percentage points

6.3 Share of Federal Subsidies

Figure 11: Cumulative Effects on the Share of Federal Subsidies



Source: Own calculations.

The impact of demographic factors on the share of federal subsidies reveals different dynamics compared to the contribution rate or net replacement rate development. Overall, the share of federal subsidies rises by 5.0 percentage points. Figure 11 illustrates the composition of demographic effects. Remarkably, solely the structural effect would enlarge the share of federal subsidies in the budged of the GRV by 11.4 percentage points between 2010 and 2060. Thereby, the structural effect increases progressively. At the same time the migration, fertility and mortality effects counteract the impact of the structural effect. Fertility lowers the share of federal subsidies by 2.0 percentage points and the migration effect further lowers the share of federal subsidies by 3.4 percentage points. Both effects develop progressively. Also the mortality effect diminishes the share of federal subsidies linearly up to 1.4 percentage points.

Comparable to the evolution of the replacement rate and contribution rate, the residual effect has a minor impact on the increase of the share of federal subsidies in the budget of the GRV.

7 Conclusion

As a central innovation, we developed a decomposition approach that allows for an estimation of the impact of single demographic factors on the evolution of the German pension system separately. Our paper gives detailed insights in the composition and comparative relevance of demographic effects that explain the changes of central parameters of the pension system. We therefore presented the underlying simulation model for the pay-as-you-go (PAYG) financed scheme of the German Statutory Pension System in detail. Based on the model we simulate potential future development paths of the contribution rate, net replacement rate and the development of the share of federal subsidies in the budget of the GRV. To evaluate the impact of utilized economic and demographic assumptions we also provide a sensitivity analysis. Thus, we are able to discuss our simulation results in a broader context and consider the uncertainty involved in the used simulation approach.

Our model combines older approaches described in the literature and recent further developed concepts (Wilke, 2004; Werding and Hofmann, 2008; Werding, 2011; Holthausen et al., 2012; Werding, 2013b). The composed simulation framework rests upon actual official demographic projections (Federal Statistical Office, 2009). Developments of labor force participation rates refer to a cohort projection method (Burniaux et al., 2004; European Commission, 2005; Carone, 2005). The quoted simulation models share several similarities in the general modeling frame work but differ in specific aspects. In this way our pension simulation model shall extend the pension simulation approaches for Germany.

In the reference scenario – utilizing from our point of view the most probable economic and demographic development paths – our simulated contribution rate development is lower compared to the projections prepared by Werding (2013a) and Holthausen et al. (2012). Thereby, the overall development follows similar paths. Compared to our result of a contribution rate reaching 25.4 percent in 2060 a higher level of 27.2 percent (Werding, 2013a, p. 21.) and a medium level of 25.7 percent (Holthausen et al., 2012, p. 30.) can be found in the cited literature. The same similarities can be observed for the development of replacement rates.[60] according to our model, until 2060 the net replacement rate decreases to 40.9 percent – that corresponds to a gross replacement rate of 36.7 percent. Almost identically, the other studies project a net replacement rate of 41.1 percent (Werding, 2013a, p. 21.) and a gross replacement rate of 36.0 percent in 2060 (Holthausen et al., 2012, p. 30.).

Focusing on demographic variables, the observed differences in projected developments

[60]In contrast to Werding (2013b) and to our presentation of results in Section 5.2 Holthausen et al. (2012) only provide information for the gross replacement rate. For comparison the gross replacement rate of our model is illustrated in the Appendix (See 12.).

can be attributed to distinct utilized demographic assumptions.[61] Compared to our reference scenario Werding (2013b) considers no fertility increases and assumes a life expectancy at birth reaching 91.2 years for girls and 87.7 years for boys in 2060 as reference values. This is comparable to our 'high life expectancy' and 'low fertility' scenario. Holthausen et al. (2012) assume a total fertility rate of 1.4 and a life expectancy at birth of 92.3 years for girls and 89.2 years for boys in 2060. In relation to our reference scenario both studies apply higher net migration numbers of 150,000 people per year.

Summarizing, the presented developments of the contribution rate raise concerns on the feasibility of the political objectives formulated in the German pension legislation. The contribution rate shall not exceed 20 percentage until 2020 and 22 percentage until 2030. Also the net replacement rate shall not fall below 46 percentage until 2020 and 43 percentage in 2030.[62] Very likely reforms of the pension legislation will be inevitably in order to stabilize the contribution rate and the replacement rate. Also other studies – e. g. Müller and Raffelhüschen (2011) – come to a similar conclusion. However, the characteristics of a simulation model and the uncertainty involved in utilized assumptions complicate a clear assessment of long term variations in such a comparatively small range. The results of the sensitivity analysis confirm these difficulties.

Our newly developed decomposition approach allows for a cause and effect analysis of demographic variables on the German pension system. The integration of demographic projection techniques in a pension simulation model provides a tool for the decomposition of the effects of the process of demographic aging. More specific, the impact of life expectancy, fertility and migration can be evaluated independently. That gives new insights for a more purposeful development of reform options. Furthermore, it allows for focusing on the most important aspects of population aging and for the identification of the impact of the past progression on future developments.

The 'structural effect' marks a central aspect of our decomposition method. It describes the basic evolution of the pension system without any future demographic developments. It quantifies an inherent development that refers to the reference year – in our model the year 2010 – and characterizes the impact of previous economic and especially demographic changes. Overall, between 2010 and 2052 the structural effect mainly explains the developments of the pension system variables. However, afterwards the yearly influence on the developments shrinks as the large cohorts decease. This result shows that the status quo in the reference year and potential imbalances in the population structure are of central

[61] Besides differences in demographic assumptions also the specific wage and unemployment scenarios differ between the studies. We refrain from a discussion of these aspects as the sensitivity analysis revealed a minor impact of economic variations in our projection. Furthermore, the main focus of our paper is on demographic effects.

[62] See § 154 SGB VI.

importance.

Analyzing the impact of future demographic trends, mortality improvements significantly affect the development of contribution and replacement rates of the German pension system. This results holds even for our moderate assumptions on life expectancy increase. Our decomposition results elucidates the continuously growing influence of the mortality effect on the GRV. Starting in 2052, it is the main driver for the contribution rate development.

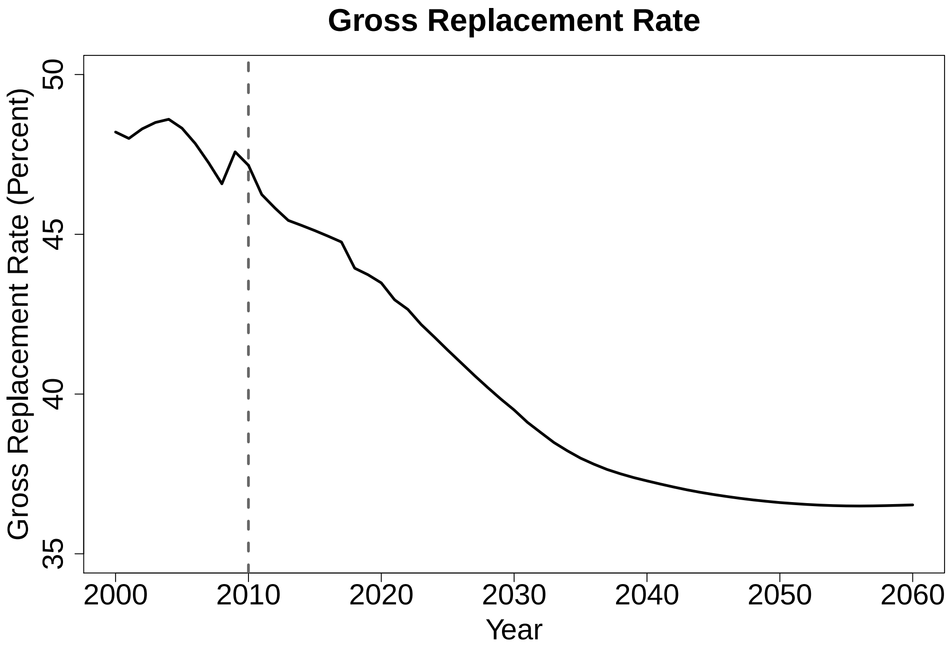
Fertility and migration affect the development of pension system parameters less prominent. Surprisingly, assuming a remarkable rise of fertility to a TFR of 2.01 until 2025 would have comparable effects on the pension system as a higher net migration of 200,000 people per year. But, migration will develop near-term effects while fertility impacts the pension system with a lag of time of approximately 15 years – the youngest age of labor force entry in our model.

In summary, our results reveal that the increase in life expectancy and the population structure present in the reference year 2010 develop the most prominent impact on the future pension system development. Both effects will put a higher burden on the sustainability of the German pension system. From the present point of view probable increases in net migration and fertility have a positive impact on the development of the financial situation of the pension system. But, these effects will not be able to counteract the pressure arising from the population structure and the life expectancy developments.

Our results clarify, that a reform of the pension system will be inevitably in the subsequent future. Furthermore, the development of the GRV will be significantly affected by the structural effect – caused by past developments. It could be asked how the arising burden could be allocated between generations. Importantly, the prominent and further increasing impact of life expectancy developments on the pension system constitutes a persistent trend. A consequent option could be to make use of the increased life expectancy and to promote reforms that allow for a reorganization of the labor force exit.

Appenix

Figure 12: Gross Replacement Rate - Reference Scenario



Source: Own calculations.

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