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Decomposition of Demographic Effects on the German Pension System

Abstract

The paper analyses the impact of demographic developments on the German pension system until the year 2060. The projections are simulated for a range of assumptions on the latest demographic trends and on the labour market and comprise the latest pension legislation. As a central innovation we present a decomposition approach which allows to identify the isolated effects of mortality, fertility and migration developments on the dynamics of the German pension system. We show that the past population structure - driven by past fertility changes - and future mortality improvements will be the most important factors shaping the development of the German pension system. The results have a number of implications for effective and sustainable pension reforms.

JEL-Codes: H550.

Keywords: population ageing, German pension system, labour market.

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1 Introduction

In the coming decades, Germany will face a significant process of population ageing. 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 financial sustainability of the German Statutory Pension System ("*Gesetzliche Rentenversicherung*", GRV) is challenged as its primary pay-as-you-go (PAYG) financing scheme puts a major 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.

Several questions arise; given the demographic development in the next 40 years, how will contribution and replacement rates of the German pension system change? If pension reforms are necessary to retard those changes what will be the main demographic factors of this future development to be addressed by the reforms?

An identification of adequate reform strategies requires a detailed analysis of the factors that affect the budget of the GRV. Interestingly, when analysing pension systems, population ageing is predominantly regarded as a change of the population structure without a further analysis of the underlying demographic mechanisms that determine that change. An ageing population results from the interplay of fertility, migration and the development of life expectancy. It seems obvious that, for example, mortality as the main driving force of demographic change in the future would necessitate other reform measures of the pension system than migration or fertility. Also, past changes of these demographic factors influence population ageing as they shaped the population structure of today.

Next to the understanding of the impact of population ageing on the German pension system at large, our contribution is to complement the existing literature[1] by isolating the influence of single demographic variables on the GRV. We therefore develop a decomposition approach by adapting well-known analysis strategies – e.g. used by sensitivity analysis – in order to enrich the analysis of the impact of population ageing on the German pension system. We combine specifically conceptualised demographic scenarios to disentangle the single effects of fertility, mortality, migration and the actual population structure on central parameters of the GRV. The decomposition refers to 2010 as the reference year and the starting point of our projection. We chose this year in order not to confound the demographic effects with later changes in the pension legislation. The analysis and our presented long-run projections for Germany rest upon actual demographic and labour market trends and the latest pension legislation of 2017. To account for the large degree

[1] See e.g. Holthausen et al. (2012); Werding (2013b); Börsch-Supan et al. (2016).

of uncertainty that underlies forecast results of the distant future with different independent scenarios, we simulate how sensitive our resulting pension system parameters react to variations of labour market and demographic developments. These results give rise to a number of proposals to be taken into account in upcoming pension reforms.

The paper comprises six sections and begins with a short overview of the history of the GRV in Section 2. In Section 3 we describe the simulation model including the incorporated economic and demographic assumptions. The results of the pension projection are presented together with sensitivity analysis and a comparison to the existing literature in Section 4. Section 5 focuses on the decomposition of the impact of demographic determinants. We introduce our decomposition approach and present the results for the impact of the actual population structure and the future impact of mortality, fertility and migration. Section 6 concludes.

2 History of the German Statutory Pension System in a Nutshell

The German Statutory Pension System has a long history of over 120 years. In 1889 chancellor Bismarck laid the foundation of social security with the 'law concerning disability and old-age security' (*"Gesetz, betreffend die Invaliditäts- und Alterssicherung"*, IAVG).[2] The IAVG introduced a disability and an old-age pension for blue collar workers and lower civil servants. Also medical rehabilitation was provided.[3] The main focus of the system was put on disability (Eichenhofer et al., 2012, Rn. 27-28, p. 12.). The pension benefits had 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.[4] The funding of the GRV was gradually converted to a PAYG scheme and the remaining capital stock of the former funded system was spent by 1967 (Börsch-Supan, 2000, p. F25.). The amount 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

[2]See Deutsches Reichsgesetzblatt volume 1889, No. 13, pp. 97 - 144.
[3]See § 12 (4) IAVG.
[4]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.

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 a deduction factor for early retirement was introduced, so that early retirement led to lower future pensions. Furthermore, pension benefit indexation was changed to net wages (Rürup, 2002, pp. 143.).[5] 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 now by a funded scheme. Also the pension-benefit indexation was changed to 'modified gross wages' – considering the development of gross wages, contribution rates to the public pension and the evolving burden of private pension saving. As a further response to demographic ageing, 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.

The latest major pension reform in 2014 introduced an early retirement option without penalties at the age of 63 for people with a long working career with 45 and more years of contributions. Starting in 2015, this earliest age increases by two months each year up to the age of 65. The same reform introduced an additional credited earning point for having raised children born before 1992 and included an improvement for disability pensions.

3 The Pension Simulation Model

The focus of our simulation model is on the impact of population ageing on the German Statutory Pension System as it is financed by a pay-as-you-go scheme that strongly reacts to changes in the population structure. The GRV is the most prevalent old-age provision for a majority of the German population (Kortmann and Heckmann, 2012).[6] Aspects of additional (funded) private and occupational pension plans are not incorporated in the model. Within the German PAYG system in general current contributions have to meet

[5] High unemployment in the 1990s and demographic ageing 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.).

[6] In the year 2011 in Western Germany, around 89 percent of the male and 86 percent of the female population above age 65 had an own GRV pension. In Eastern Germany this share was about 99 percent for men and women.

the current expenditures. In a given year t the simplified budget ignoring further costs and subsidies is as follows:

$$C_t \cdot cr_t \cdot W_t = P_t \cdot rr_t \cdot W_t \quad . \tag{1}$$

The contributions are paid by contributors (number of contributors $= C$) according to the contribution rate (cr) on average gross wage income (W). The pensioners (number of pensioners $= P$) receive benefits according to the replacement rate (rr) of the current average gross wage income (W). Equation 1 highlights the importance of the population as the number of pensioners and contributors is the major determinant of the budget. To balance the budget, the German pension legislation arranges an adjustment of the contribution rate:

$$cr_t = \frac{P_t}{C_t} \cdot rr_t \quad .$$

Our model simulates the pension legislation of 2017 in detail and provides a flexible framework for the analysis of the coming developments of the pension system. The reference year of our decomposition and the starting point for our projection is 2010. We decided to use this early date as it is prior to the phase-in of a legislated increase in retirement ages starting in 2012. With this set-up we prevent a bias of the evaluation of demographic effects. With a later reference year, increasing retirement ages would counteract the impact of demography and our decomposition results would also include the effects of legislative changes. The model combines several different demographic and economic scenarios. We treat all scenarios as independent from each other and assume a homogeneous population. Potential systematic individual behavioural responses to different pension system parameters or effects of the population size on employment rates and wages or differences in education and its effects on labour market behaviour are not modelled.[7] Furthermore, differences in demographic and in labour force developments and differences in the specific pension legislation between Eastern and Western Germany are not modelled. First, we introduce the projection of future population developments by describing assumptions on fertility, mortality and migration. Second, we explain the projection method of labour force participation rates and further assumptions on the labour market, wages and the determination of the number of pensioners. Third, we model the revenues and expenditures of the GRV.

[7]This is another potential source of uncertainty. Increasing contribution rates might have feedback effects on participation rates, especially those of part-time workers and low income earners as analysed by Chetty et al. (2011).

3.1 Demographic Development

The population projection is essential 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 as the decomposition approach draws on combining various demographic assumptions. The underlying scenarios for our calculations are guided by demographic scenarios provided by the "13th coordinated population projection for Germany" (Federal Statistical Office, 2015a). Additionally we updated actual data available for migration and fertility for the years 2013 to 2015.

3.1.1 Fertility

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

Our *baseline scenario* refers to a total fertility rate reaching 1.6 children per woman in 2028 and remaining at that level until 2060. This characterises the fertility scenario G2 of the official projections (Federal Statistical Office, 2015a, p. 31 ff.).[8] It is assumed that fertility below age 30 stabilises while fertility rates above age 30 will rise further. We prefer a higher TFR for the baseline scenario 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; Federal Statistical Office, 2015b, 2016a).

An alternative *low fertility scenario* refers to a total fertility rate converging to 1.4 children per woman in 2028 and remaining at that level until 2060. This is comparable to the G1 assumption of Federal Statistical Office (2015a). But in contrast to the official projection we include the latest data on TFR up to 2015 so that fertility decreases slightly after a short rise of the TFR to 1.50 in 2015 (Federal Statistical Office, 2015b, 2016a). For a comparison of the potential impact of fertility we also consider a hypothetical *high fertility scenario*. Here, we assume that fertility in Germany in 2025 reaches a TFR of 2.01 the same level as observed in France in the year 2010 (HFD, 2012). This set-up allows us to discuss more distinct fertility changes than actual trends are indicating.

[8] This describes a slower fertility increase than assumed in the previous official projection (Federal Statistical Office, 2009, 2013b; Pötzsch, 2010).

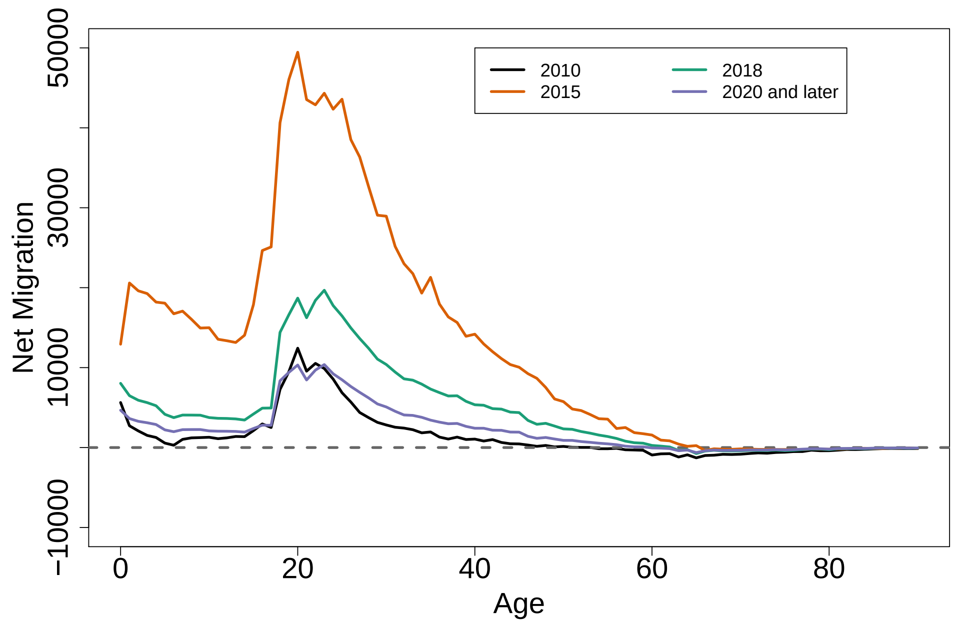
3.1.2 Life Expectancy

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, 2015a). Our *baseline scenario* assumes an increase in life expectancy at birth by 6.0 years for women and 7.0 years for men until 2060 so that a newborn girl is expected to live 88.8 years and a newborn boy 84.8 years. A *high life expectancy scenario* assumes that life expectancy at birth reaches 90.4 years for women and 86.7 years for men in 2060.[9]

3.1.3 Migration

Three different assumptions on yearly net migration numbers are included in the model to capture the high political and geo-political uncertainty of future developments. We use the latest age-specific immigration and emigration data for women and men provided by the Federal Statistical Office (Federal Statistical Office, 2016c, 2017).

Figure 1: Age Structure of Net Migration (Baseline Assumption)

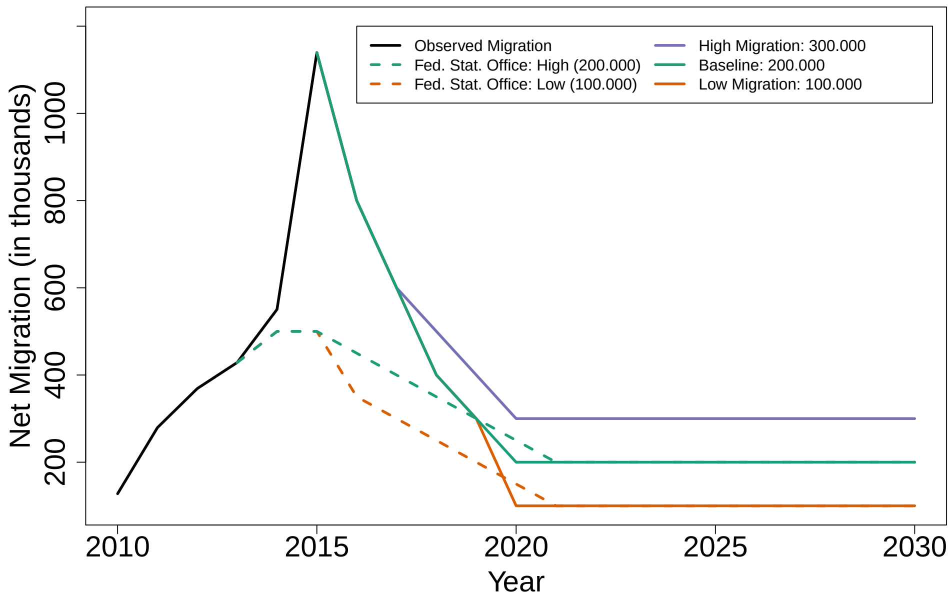


Source: Federal Statistical Office (2016c, 2017), own calculations.

[9]The previous official projection in 2009 utilised scenarios with higher life expectancies at birth of 89.2 (91.2) years for women and 85.0 (87.7) years for men (Federal Statistical Office, 2009).

Our *baseline scenario* includes a decreasing net migration starting from over 1.1 million people in 2015 and reaching 200,000 people from 2020. This assumption follows the latest official projections and is guided by average long-term migration variations of the past Federal Statistical Office (2015a).

Figure 2: Net Migration Scenarios



Source: Federal Statistical Office (2015a), own calculations.

However, not only is the number of migrants important but also the age-structure. Figure 1 depicts the age-specific net migration in our baseline scenario and illustrates the importance of the age structure of migration. In net terms, migration 'rejuvenates' the population as predominantly younger people in their working ages immigrate.

Due to the exceptional migration development in 2015 we also include a *high migration scenario* with a net migration of 300,000 from 2020 onwards. A *low migration scenario* with a net migration of 100,000 people from 2020 onwards completes our set of assumptions. With these three migration scenarios we provide a broader view compared to the latest official projection in 2015 Federal Statistical Office (2015a). Figure 2 shows the observed net migration until 2015 and contrasts the assumptions of the federal statistical office with our scenarios.

3.2 Labour Market Development and Pensioners

3.2.1 Labour Force Participation Rate Projection

In addition to demographic variations of the population in working ages, the development of the labour force participation rates will noticeably determine the future size of the labour force. For our *baseline scenario* of labour force participation rates we apply a dynamic cohort approach developed by the OECD and further extended by the European Working Group on Ageing to project future participation rates (European Commission, 2005; Carone, 2005; Burniaux et al., 2004).

The dynamic approach explicitly considers future effects of legislated pension reforms and systematic differences in labour force participation between cohorts and gender groups and projects these cohort-specific trends into the future. Different developments between cohorts are primarily driven by varying trends of labour 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 labour participation of younger women in their reproductive ages has undergone substantial changes and increased in recent 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 labour force participation in older ages shows an increasing trend presumably initiated by a raise of legal retirement ages (Werding and Hofmann, 2008, p. 22 ff.).

In a first step of the projection, we use micro data provided by the German Microcensus (Federal Statistical Office, 2013a) for the years 2007 to 2010 to calculate gender-specific average labour force entry and exit rates for single ages.

In line with the European Commission (2005) and Werding and Hofmann (2008), the estimated rate of entry into the labour market $\widehat{Ren}_{x+1}$ results from the average of yearly entry rates into the labour market $Ren_{x+1,t}$ and describes the share of persons of cohort t+1 who were still inactive at age x and enter the labour market at age $x+1$. Assuming identical entry behaviour of successive cohorts t and $t+1$, average entry rates can be calculated based on the underlying participation rates Pr using Equation 2.

$$\widehat{Ren}_{x+1} = \frac{1}{4} \cdot \sum_{t=2007}^{2010} Ren_{x+1,\,t} \quad \text{with} \tag{2}$$
$$Ren_{x+1,\,t} = 1 - \frac{Pr_{max} - Pr_{x+1,\,t+1}}{Pr_{max} - Pr_{x,\,t}} \geq 0$$

We assume an upper limit for labour force participation rates Pr_{max} of 0.99 for men and women.[10] The calculation of exit rates follows an identical strategy. Equation 3 characterises the share of persons of cohort $t+1$ who where active at age x and will have left the labour force at age $x+1$ under the assumption of identical exit behaviours of successive cohorts t and $t+1$.

$$\widehat{Rex}_{x+1} = \frac{1}{4} \cdot \sum_{t=2007}^{2010} Rex_{x+1,\,t} \quad \text{with} \tag{3}$$
$$Rex_{x+1,\,t} = 1 - \frac{Pr_{x+1,\,t+1}}{Pr_{x,\,t}} \geq 0$$

The average entry and exit rates are further used to project future labour force participation rates ($\widehat{Pr}$). Within our model an entry into the labour force is possible until the age of 49. Labour force participation rates evolve according to Equation 4. Starting at the age of 50 only exits from the labour force are considered for projecting labour force participation according to Equation 5.

$$\widehat{Pr}_{x+1,\,t+1} = \widehat{Ren}_{x+1} \cdot (Pr_{max} - Pr_{x,\,t}) + Pr_{x,\,t} \tag{4}$$

$$\widehat{Pr}_{x+1,\,t+1} = \left(1 - \widehat{Rex}_{x+1}\right) \cdot Pr_{x,\,t} \tag{5}$$

These entry and exit rates are then used to project future participation rates. This rather "mechanical calculation" (Werding and Hofmann, 2008, p. 25.) reproduces cohort-specific differences in labour force participation but ignores actual trends.

Therefore, in a second step these raw participation rates have to be adjusted with regard to three aspects. First, extended duration of schooling and higher education explain a drop in labour force participation in younger ages. However, higher education only postpones the entry of younger cohorts into labour force. To avoid an extrapolation of low labour participation of younger cohorts within the rather mechanical projection, we define a lower floor for participation rates below age 20.[11] Participation rates for the ages 15 to 19 are

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

[11] An extrapolation of a lower labour force participation in younger ages would negatively bias the overall

allowed to increase if this is the result of the cohort projection.

Otherwise, the rates remain constant at the level of 2010 (European Commission, 2005, p. 50 ff.). Second, micro data for previous years show clear effects of the legal retirement age on labour 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 labour 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 data and data of national accounts on labour 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.

In the last step the raise of the legal retirement age from 65 to 67 and the implied increase of the average effective retirement age are modelled. The previously described methodology reflects observable development trends caused by already implemented laws. The raise of retirement ages[12] gradually phases in between 2012 and 2031.[13] To incorporate the raise of retirement ages in our model we follow Werding (2011) and Werding (2013b) and assume that an increase of legal retirement ages by 2 years will (further) increase the effective retirement age by 1.5 years.[14] 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 labour force utilising our projected participation rates that are based on a legal retirement age of 65 (European Commission, 2005, Annex 5). Thereafter, we proportionally rescale the participation rates starting at the age with the highest labour force participation rate, 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 after the age with the maximum labour force participation:

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

Figure 3 illustrates the resulting developments in the labour force participation rate

labour force participation in later ages. The applied correction mechanism avoids negative effects of schooling on the labour force development.

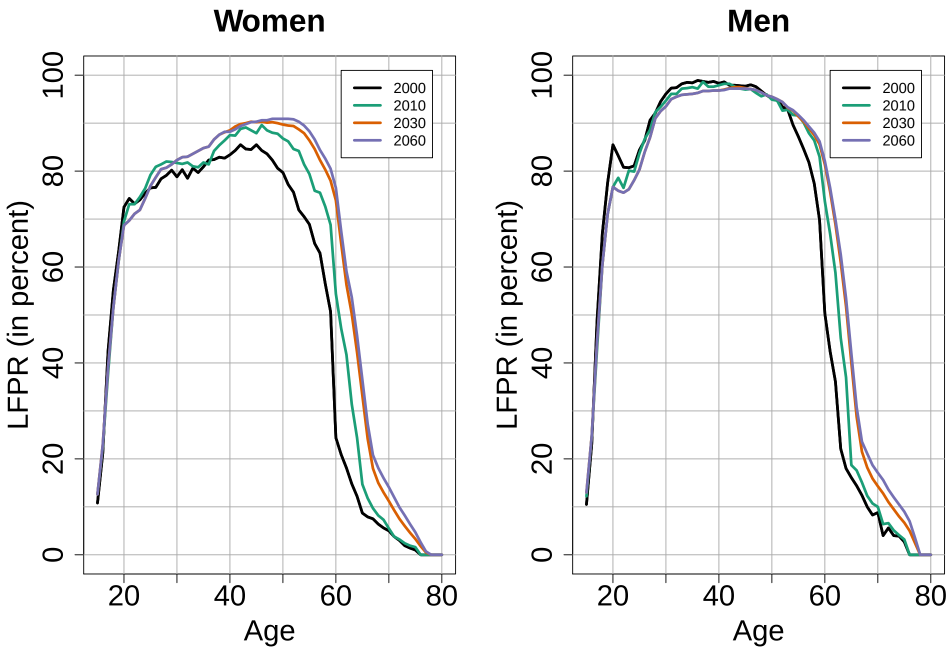
[12]See RV-Altersgrenzenanpassungsgesetz (RVAGAnpG), § 235 SGB VI.

[13]Between 2012 and 2024 the legal retirement age increases by 1 month a year for the cohorts born 1947 to 1958. For the years 2024 to 2031 the legal retirement age is adjusted by 2 months a year for the cohorts born between 1959 and 1963. Cohorts born in 1964 (and later) can claim a full old-age pension without any deductions starting at the age of 67 from 2031 onwards (§ 235 SGB VI).

[14]While past reforms already lead to an increase in effective retirement ages the further raise of the legal retirement age will enhance postponement of retirement.

(LFPR) for women and men.

Figure 3: Labour Force Participation Rates

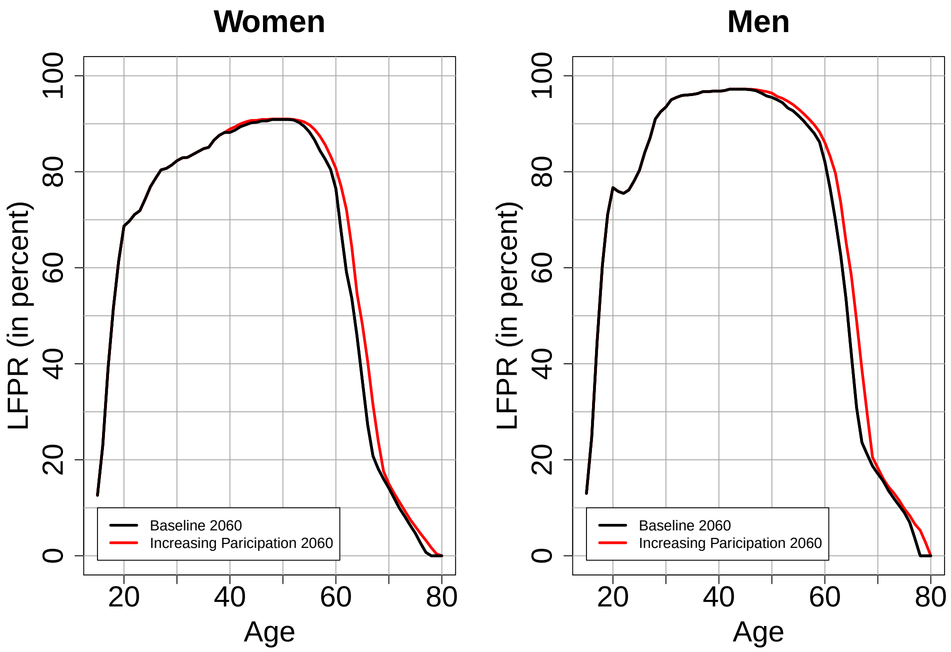


Source: Own calculations.

As the future development of labour force participation is a crucial factor in pension projections, we also analyse a scenario with higher labour force participation rates in older ages (see Figure 4). We assume that in addition to the effects of higher legal retirement ages between 2012 and 2031, labour force participation rates in older ages – starting between age of 40 and 50 – will rise continuously from 2031 onwards (*higher old-age participation scenario*). In comparison our baseline assumption, until 2060 female (male) participation rates rise in the age group 40-59 on average by 0.92 (0.77) percentage points, in the age-group 60-64 on average by 9.2 (8.7) percentage points, in the age-group 65-69 on average by 8.6 (12.0) percentage points and in the age group 70-79 on average by 1.4 (1.8) percentage points. The largest effects can be found between age 65 and 66.

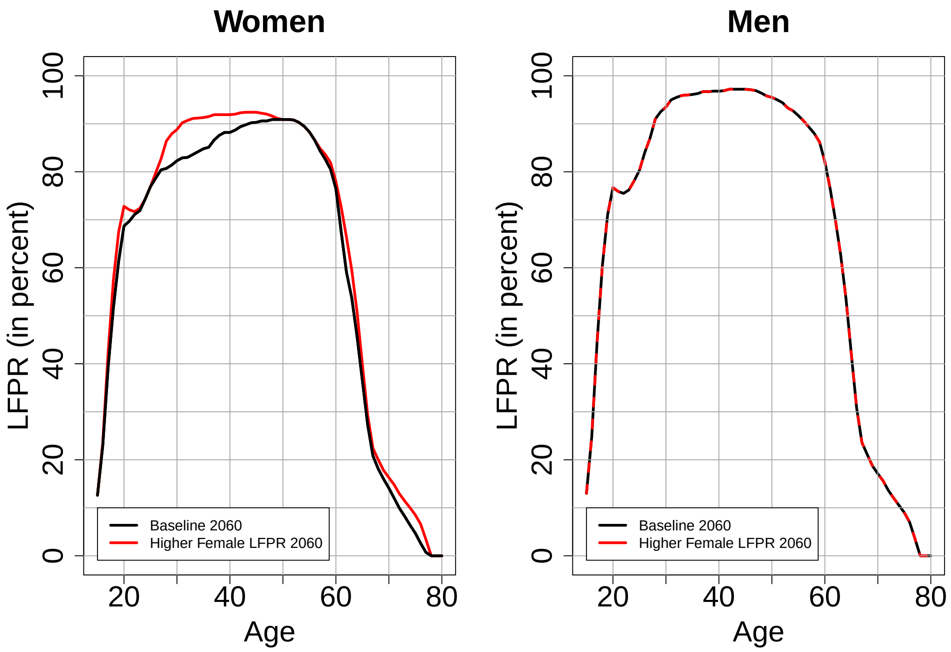
An *increasing female participation scenario*, where female labour force participation rates at any age approaching a 95-percent-level of male participation rates until 2040, completes our set of assumptions (see Figure 5). Until 2060 the major improvements take place between the ages of 25 and 49 with average increases of 4.7 percentage points. Participation rates of the younger age group 15-24 improve on average by 2.9 percentage points while the participation rates of the older age-group 50-64 rise on average 3.7 percentage

Figure 4: Variation of Labour Force Participation - Increasing Participation in Older Ages



Source: Own calculations.

Figure 5: Variation of Labour Force Participation Rates - Higher Female Participation



Source: Own calculations.

points and the participation rates in the age group 65-79 increases on average by 0.9 percentage points.

3.2.2 Labour Force, Employment and Wages

To derive the number of employed persons from the labour force we additionally need assumptions on future unemployment rates. In our model the uncertainty in future labour market developments is reflected by three diverse unemployment scenarios. The *baseline scenario* combines the observed unemployment rates between 2010 and 2015 – starting from 7.7 percent in 2010 and reaching a floor of 6.4 percent in 2015 – with an assumed increase to 7.0 percent in 2020 and a constant level thereafter (Bundesagentur für Arbeit, 2015). In a *low unemployment scenario* 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 and 6.4 percent in 2015 to 10 percent in 2060 in a *high unemployment scenario.* Together, these three scenarios cover a broad range of possible employment developments.

In our pension simulation model we further have to calculate the number of employees subject to social insurance contributions. First, we identify the number of self-employed persons and civil servants – who are not insured in the GRV – by applying age-specific rates calculated from Microcensus data (Federal Statistical Office, 2013a). We assume that the age-specific shares of self-employed persons and civil servants in the labour market develop proportionally to the change of legal retirement ages of the GRV.[15]

Next, we approximate the share of employees subject to social insurance contributions on the overall employed persons using the yearly averages of the quarterly data on employees subject to social insurance contributions provided by the Federal Employment Agency (Bundesagentur für Arbeit, 2016).

Data on average earnings subject to social insurance contributions of the contributors is provided by the German Statutory Pension Insurance (Deutsche Rentenversicherung, 2012, p. 262.). From 2010 onwards, three different scenarios of gross wage growth characterise future developments. In the *baseline scenario* wage growth follows the observed rates until 2015 followed by a constant gross wage growth rate of 2.5 percent per year. Compared to the baseline scenario, a *low wage scenario* assumes a 1 percentage point lower and a *high wage scenario* a 1 percentage point higher gross wage growth rate. Based on the average gross wages, we derive earning profiles from age-specific income data (Federal Statistical

[15]We use the averages of the latest observed rates for each group 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) assume constant rates.

Office, 2013c).

3.2.3 The Number of Pensioners

Our pension simulation model comprises old-age pensions, disability pensions and survivors' 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 old-age pensioners and disability pensioners as the number of non-working individuals eligible for a pension using age-specific labour force participation rates and population numbers.

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 labour force participation rate ($Pr_{x,t}$) and the underlying population ($N_{x,t}$):

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

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 labour force.[16] The number of retired self-employed persons and retired civil servants (${}^{ret}N_{x,t}^{se,cs}$) is calculated with the age-specific rates of self-employed persons ($Pr_{x,t}^{se}$) and civil servants ($Pr_{x,t}^{cs}$):

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

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

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

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

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

from the non-working individuals:

$$\begin{aligned} N^{pp}_{x,t} &= {}^{nw}N_{x,t} - {}^{ret}N^{se,cs}_{x,t} - {}^{not}N_{x,t} \\ &= N_{x,t} \cdot \overline{Pr}_{c,t} \cdot (1 - Pr_{x,t}) \cdot \Big(1 - \Big(Pr^{se}_{x,t} + Pr^{cs}_{x,t}\Big)\Big) \quad . \end{aligned}$$

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 $da_{x,t}$ (Deutsche Rentenversicherung, 2013):

$$ {}^{dis}N^{pp}_{x,t} = N^{pp}_{x,t} \cdot da_{x,t} \quad . \tag{6}$$

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 63:

$$ {}^{old}N^{pp}_{x,t} = N^{pp}_{x,t} - {}^{dis}N^{pp}_{x,t} \quad , \forall x \geq 63 \quad . \tag{7}$$

This modelling approach bases the estimation of pensioners on population developments and labour force participation. An increasing labour 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 (aggregated) 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:

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

The shares wf_t and wm_t are calculated based on information provided by the Deutsche

Rentenversicherung (2016) and are kept constant from 2010 onwards.[17]

3.3 Revenues and Expenditures of the German Pension System

The simulation of the pension system follows a detailed accounting approach of revenues and expenditures within the pay-as-you-go funding scheme. Therefore we model the current pension legislation.

3.3.1 Revenues

The main revenues of the German pension system consist of contributions paid by employees subject to social insurance contributions (${}^{w}N^{SV}_{x,t}$)[18] and of 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 wage ($W_{t,x}$) and the actual contribution rate (cr_t) of the German Statutory Pension System. Considering age-specific income profiles, Equation 8 describes the contributions ($Con^{wp}_{t,x}$) of employed people at age x in year t .

$$Con^{wp}_{t,x} = {}^{w}N^{SV}_{x,t} \cdot cr_t \cdot W_{t,x} \tag{8}$$

Additionally, the Federal Employment Agency pays contributions for unemployed people (${}^{w}N^{uep}_{x,t}$) receiving regular unemployment benefits (benefits of type I) based on 80 percent of the previous wage.[19] Over the last 10 years, approximately 32 percent of all unemployed people received unemployment benefits type I (Bundesagentur für Arbeit, 2017). Therefore, we use the share $\gamma = 0.32$ of people receiving unemployment benefits of type I within the total number of unemployed to model the contributions made by the Federal Employment Agency.[20] Equation 9 describes the contributions of unemployed people at age x in year t ($Con^{uep}_{t,x}$).

$$Con^{uep}_{t,x} = \gamma \cdot {}^{w}N^{ue}_{x,t} \cdot cr_t \cdot 0.8 \cdot W_{t-1,x} \tag{9}$$

[17] With this set-up we focus on effects of changing age patterns on the German pension system. Other studies investigating the broader impact of demographic change on public expenditures on the German local and state level, e.g. Baum et al. (2002), also incorporate information on the family structure.
[18] See 3.2.2.
[19] Unemployed people receive temporary unemployment benefits (unemployment benefits type I) based on their previous individual wage. The eligibility depends on specific qualifying conditions and the duration of payments is up to 24 months (§ 147 No. 2 SGB III).
[20] See § 166 (1) No. 2 SGB VI and § 149 No. 2 SGB III.

Additionally, the federal government makes contributions for periods of raising children ("Beitragszahlung für Kindererziehungszeiten"CRC). In our model these contributions are adjusted to the development of wages between the last year and the year before, the change of the contribution rate of the GRV between the actual year and the last year and the change of the number of children under age 3 (N_{U3}) from two to three years ago:[21]

$$CRC_t = CRC_{t-1} \cdot \frac{W_{t-1}}{W_{t-2}} \cdot \frac{N_{U3,t-2}}{N_{U3,t-3}} \qquad .$$

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

The general federal subsidy[22] develops in line with the change of average gross wages and changes in the contribution rate of the GRV. 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:

$$GFS_t = GFS_{t-1} \cdot \frac{W_{t-2}}{W_{t-3}} \cdot \frac{cr_t^{vir}}{cr_{t-1}^{vir}} \quad .$$

In our model, we use a simplified updating mechanism and base the development of the general subsidy to the changes of gross wages and effective contribution rates:

$$GFS_t = GFS_{t-1} \cdot \frac{W_{t-1}}{W_{t-2}} \cdot \frac{cr_{t-1}}{cr_{t-2}} \quad . \tag{10}$$

The additional federal subsidy[23] develops proportionally to sales tax revenues and includes the enhancement allowance[24] ("Erhöhungsbetrag", EA). In our model, we simplistically update the additional federal subsidy according to the gross wage development. The enhancement allowance is adjusted to the change of the sum of gross wages that is based on gross wages and the number of employees subject to social insurance contributions (${}^{w}N_t^{SV}$). The changes over time are represented in Equation 11.

$$AFS_t = AFS_{t-1} \cdot \frac{W_{t-1}}{W_{t-2}} + EA_{t-1} \cdot \frac{{}^{w}N_{t-1}^{SV} \cdot W_{t-1}}{{}^{w}N_{t-2}^{SV} \cdot W_{t-2}} \tag{11}$$

Further income sources – e.g. income from assets and refunds – play a minor role in the

[21]See § 177 SGB VI.
[22]See § 213 (2) SGB VI.
[23]See § 213 (3) SGB VI.
[24]See § 213 (4) SGB VI.

total budget and are not modelled.[25]

3.3.2 Expenditures

The pension simulation model comprises the expenditures for old-age pensions, disability pensions and survivors' pensions. Additionally, costs for health insurance, rehabilitation costs and administrative costs are modelled. Further minor expenditures are summarised in our model.

Within the GRV the individual pension reflects the income history of a working individual. For each completed working year individuals obtain earning points corresponding to the relation of individual earnings to average gross wages. 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 earning points are received for that year. Also, raising children is credited with two earning points when the child was born before 1992 and three earning points when the child was born after 1992.

In our model, the development of earning points depends on cohort-specific labour force participation and the development of unemployment. For each cohort, the earning points obtained by contributions when employed and by contributions when receiving type I unemployment benefits are summed up.[26] This allows for a higher amount of earning points when, for example, working lives are prolonged (e.g. Holthausen et al., 2012). 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.[27]

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 labour force participation rates[28] and age-specific earning profiles[29] – 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.[30] The

[25] 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). The observed amount of other income sources accumulates from distinct sources and varied over the years. We therefore abstain from modelling a systematic development of future values.

[26] For example, a person with an employment record from age 20 through 65 who is earning the average wage every year will accumulate 45 earning points.

[27] See Section 3.3.3.

[28] See Section 3.2.1.

[29] See Section 3.2.2.

[30] See Section 3.2.3.

sum of earning points (${}^{sum}EP_t$) in year t is calculated based on the number of pensioners of a cohort $N^{pp}_{c,t}$ and the average cohort-specific earning points ($\widehat{EP}_{t-c,c}$):

$$EP_t = \sum_{c=t-50}^{c=t-100} \left(N^{pp}_{c,t} \cdot \widehat{EP}_{t-c,c} \right) \quad . \tag{12}$$

The yearly sum of pension expenditures (${}^{sum}Pen_t$) in year t results from sum of earning points (EP_t) and the actual pension value (aPV_t):

$${}^{sum}Pen_t = EP_t \cdot aPV_t \quad . \tag{13}$$

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

Starting at the age of 50 disability pensions are included in our model.[31] The German pension legislation differentiates between a 'full' disability pension and a 'partial' disability pension.[32] We only consider full disability pensions without any reductions. When disability pensioners reach the legal retirement age (LRA_t), disability pensions are converted into old-age pensions. Disability pension payments are calculated as:

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

In our model old-age pensions are included starting at an early retirement age $x_{min} = 63$. This early retirement age x_{min} is shifted by 2 years according to the raise of the legal retirement age. Our modelling 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

[31] 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.

[32] See §33 (3) SGB VI and §67 SGB VI.

[33] See § 33 SGB VI.

month of later retirement.[34]

Therefore, for the calculation of old-age pension payments, the sum of earning points is additionally multiplied with an adjustment factor (AF) for early or later retirement.

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

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 under-age 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 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 (${}^{wf}Pen_t$) are calculated as:

$$ {}^{wf}Pen_t = {}^{wf}N^{pp}_t \cdot \frac{{}^{old}_{male}Pen_t}{\sum_{c=t-x_{min}}^{c=t-100} {}^{old}_{male}N^{pp}_{c,t}} \cdot 0.55 \quad . $$

Using average female earning points widower's pension payments (${}^{wm}Pen_t$) are calculated as:

$$ {}^{wm}Pen_t = {}^{wm}N^{pp}_t \cdot \frac{{}^{old}_{fem}Pen_t}{\sum_{c=t-x_{min}}^{c=t-100} {}^{old}_{fem}N^{pp}_{c,t}} \cdot 0.55 \quad . $$

In addition to pension payments, we also consider further expenditures of the GRV. 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 E^{health}_t are paid on the base of the total pension expenditures. The contribution rate attributable to the GRV expenditures equals half of contribution rate for the statutory health insurance (hc_t)[37] – 7.3 percent from 2010 onwards – and are paid on the base of the total pension expenditures

[34]See § 77 SGB VI.
[35]The same applies for widower's pensions.
[36]See § 67 (5,6) SGB VI and § 46 SGB VI.
[37]See § 249a SGB V.

${}^{total}Pen_t$:

$$E_t^{health} = {}^{total}Pen_t \cdot \frac{hc_t}{2} \quad .$$

Data on the contribution rate for health insurance was provided by Deutsche Rentenversicherung (2016).

Administrative costs (E_t^{admin}) are updated in relation to the evolution of average gross wages (W) 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:

$$E_t^{admin} = E_{t-1}^{admin} \cdot \frac{W_{t-1}}{W_{t-2}} \cdot \left(1 + \phi \cdot \left(\frac{N_{t-1}^{pp}}{N_{t-2}^{pp}} - 1\right)\right) \quad .$$

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

$$E_t^{reha} = E_{t-1}^{reha} \cdot \frac{W_{t-1}}{W_{t-2}}$$

Additional expenditures are not modelled.[38]

3.3.3 Pension Indexation and Budget Balancing

Pensions are indexed annually to previous economic and demographic developments. Therefore the pension point value (aPV) is adjusted firstly in direct relation to the prior development of average gross wages (*Gross Wage Factor*), secondly in inverse relation to the previous development of the contribution rates of the statutory pension scheme and the subsidised private pension scheme (*Contribution Factor*) and thirdly in inverse relation to the prior change of the ratio of pensioners to contributors (*Sustainability Factor*).[39] Equation 14 characterises the current indexation of pensions in the German pension system in

[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] Additionally a protective clause prevents a negative pension adjustment. In the following years, halving positive pension adjustments makes good for suspended pension reductions (see §68a SGB VI).

detail.[40]

$$aPV_t = aPV_{t-1} \cdot \underbrace{\frac{W_{t-1}}{W_{t-2} \cdot \left(\frac{\frac{W_{t-2}}{W_{t-3}}}{\frac{W^{Soc}_{t-2}}{W^{Soc}_{t-3}}} \right)}}_{\text{Gross Wage Factor}} \cdot \underbrace{\frac{100 - cr^{priv}_{t-1} - cr_{t-1}}{100 - cr^{priv}_{t-2} - cr_{t-2}}}_{\text{Old Age Provision Factor}} \cdot \underbrace{\left(\left(1 - \frac{PQ_{t-1}}{PQ_{t-2}} \right) \cdot \alpha + 1 \right)}_{\text{Sustainability Factor}} \quad (14)$$

The changes of average gross wages (W), average gross wages subjected to social insurance contributions (W^{Soc}), developments of the contribution rate for a subsidised private pension plan (cr^{priv}) and the contribution rate (cr) as well as the pensioner ratio ("Rentnerquotient", PQ) determine the pension value. The factor α is set to 0.25.[41] Summarising, 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 average gross wages and average wages subjected to social insurance ($W^{Soc}_t = b \cdot W_t$). Thus, the Gross Wage Factor simplifies to $\frac{W_{t-1}}{W_{t-2}}$. Equation 15 describes the simplified pension indexation in our simulation model.[42]

$$aPV_t = aPV_{t-1} \cdot \frac{W_{t-1}}{W_{t-2}} \cdot \frac{100 - cr^{priv}_{t-1} - cr_{t-1}}{100 - cr^{priv}_{t-2} - cr_{t-2}} \cdot \left(\left(1 - \frac{PQ_{t-1}}{PQ_{t-2}} \right) \cdot \alpha + 1 \right) \quad (15)$$

The Old Age Provision Factor reflects the changing cost for pension contributions and additional private pension plans. It therefore comprises the contribution rate of the GRV (cr) and the required contribution rate for voluntary private pension plans (cr^{priv}) which are promoted by the federal government.[43]

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 contrib-

[40] See §68 SGB VI.

[41] See § 68 (4) SGB VI.

[42] The modelling approach considers average wages subjected to social insurance contributions as a fixed share b of gross wages. The term $\frac{\frac{W_{t-2}}{W_{t-3}}}{\frac{W^{Soc}_{t-2}}{W^{Soc}_{t-3}}}$ cancels out: $\frac{\frac{W_{t-2}}{W_{t-3}}}{\frac{W^{Soc}_{t-2}}{W^{Soc}_{t-3}}} = \frac{b}{b} \cdot \frac{\frac{W_{t-2}}{W_{t-3}}}{\frac{W_{t-2}}{W_{t-3}}} = 1$.

[43] 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 ageing.

utors grows. The calculation is based on a standardisation of the number of pensioners and contributors.[44] The standardised number of pensioners results from dividing the sum of pension payments by a normalised pension based on 45 earning points. The standardisation of contributors is done by dividing the sum of contributions by the contributions based on the average gross wages. 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.[45] Our pension model accounts for that aspect of the GRV.

Overall, the total expenditures and the total revenues of the GRV have to compensate one another to achieve a balanced budget.[46] The German pension legislation regulates that the contribution rate of the GRV has to be adjusted to balance budget differences.[47]. The budget constraint writes:

$$Con_t^{wp} + Con_t^{uep} + CRC_t + GFS_t + AFS_t = {}^{total}Pen_t + E_t^{health} + E_t^{admin} + E_t^{reha} \quad . \tag{16}$$

Here, ${}^{total}Pen_t$ $(= {}^{dis}Pen_t + {}^{old}Pen_t + {}^{wf}Pen_t + {}^{um}Pen_t)$ describes the total pension expenditures for disability, old-age and survivor pensions. Rearranging Equation 16 together with Equation 8 and Equation 9 and solving for the contribution rate yields to:

$$cr_t = \frac{{}^{total}Pen_t + E_t^{health} + E_t^{admin} + E_t^{reha} - CRC_t - GFS_t - AFS_t}{W_t \cdot \left({}^{w}N_t^{SV} + \gamma \cdot 0.8 \cdot {}^{w}N_t^{ue}\right)} \quad .$$

However, the effective balancing of the budget is further allocated between pensioners and the general federal budget. Due to the automatic adjustment of federal subsidies, increasing contribution rates also raise the amount of tax financed subsidies. Additionally, a higher burden due to the demographic development of contributors and pensioners reduces the net replacement rate via the sustainability factor in the indexation of pensions.

To allow for minor budget fluctuations over the year and to avoid permanent marginal contribution rate adjustments, the Statutory Pension System holds a liquidity reserve LR_t

[44] See § 68 (4) SGB VI.
[45] See § 68a SGB VI.
[46] The simplified budget restriction is characterised in equation1.
[47] See §158 SGB VI.

of 0.2 to 1.5 monthly payments of own expenditures. Here, monthly payments of own expenditures of the GRV refer to total expenditures of the GRV diminished by subsidies, refunds and other compensations payments.[48] We model the own expenditures of the GRV as a share β_t of total expenditures (${}^{total}E_t$) using data provided by Deutsche Rentenversicherung (2012). For simplicity, we assume that subsidies, refunds and other compensations account for a constant share ($\beta_{t>2010} = \beta$) of total expenditures after 2010. When the reserve fund is expected to fall short of (or exceeds) the statutory bounds, the contribution rate is adjusted stepwise until equation 17 is fulfilled.

$$cr_t = \frac{LR_t + {}^{total}Pen_t + E_t^{health} + E_t^{admin} + E_t^{reha} - CRC_t - GFS_t - AFS_t}{W_t \cdot \left({}^{w}N_t^{SV} + \gamma \cdot 0.8 \cdot {}^{w}N_x^{ue}\right)} \tag{17}$$
$$\text{with:} \quad 0.2 \leq \frac{LR_t}{\beta \cdot {}^{total}E_t} \leq 1.5$$

4 Simulation Results and Sensitivity Analysis

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 and the net replacement rate as the central characteristics of the pension scheme. All developments from 2010, our reference year, onwards, result from the simulation model.

The illustrated simulation results refer to the presented baseline assumptions on economic and demographic assumptions.[49]

4.1 Contribution Rate

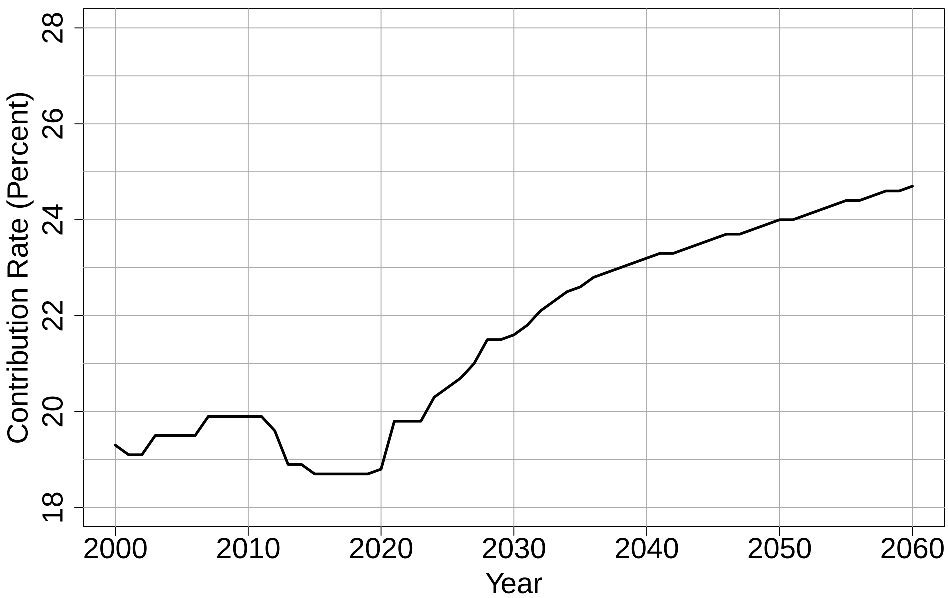
Figure 6 illustrates the contribution rate development in the baseline scenario from the year 2000 to 2060.

Between 2000 and 2010 the contribution rate increased from 19.3 percent to a plateau of 19.9 percent. Starting in 2010, our pension simulation model projects – in line with the observed development – a stepwise downturn of the contribution rate to 18.7 percent for the years 2015 to 2019. Later, the contribution rate expands with a noticeable pace and reaches 24.7 percent in 2060. Altogether, the contribution rate will rise significantly by almost 5 percentage points between 2010 and 2060 .

[48]See § 158 (1) SGB VI.

[49]See sections 3.1.1 to 3.1.3 and section 3.2.2.

Figure 6: Projection of the Contribution Rate



Source: Deutsche Rentenversicherung (2012), own calculations.

4.2 Net Replacement Rate

The net replacement rate before taxes (NRR_t) is another central variable characterising the German pension system.[50] It is defined as the ratio of a standardised pension (corresponding to 45 earning points) reduced by long-term care insurance and average health care insurance contributions and the average gross income corrected for average social insurance contributions. Social insurance contributions include contribution rates for long-term care insurance (ltc_t), health care insurance (hc_t), unemployment insurance (ue_t) and statutory pension contributions (cr_t):

$$NRR_t = \frac{45 \cdot aPV_t \cdot 12 \cdot \left(100 - ltc_t - \frac{hc_t}{2}\right)}{W_t \cdot \left(100 - ltc_t - \frac{hc_t}{2} - ue_t - cr_t\right)} \quad . \tag{18}$$

Altogether, the net replacement rate describes the fraction of disposable standardised income provided by the pension system to the average disposable income of the working population without tax effects. It reflects the relative generosity of the pension system and the relative income situation of pensioners in comparison to the working population. Figure 7 illustrates the development of the net replacement rate. With several breaks between 2007 and 2009, the net replacement rate decreases with an attenuating slope from 51.6 percent in 2010 to 40.9 percent in 2060. Here, the sustainability factor extenuates the indexation of pensions as the ratio of pensioners to contributors increases (see section 3.3.3).

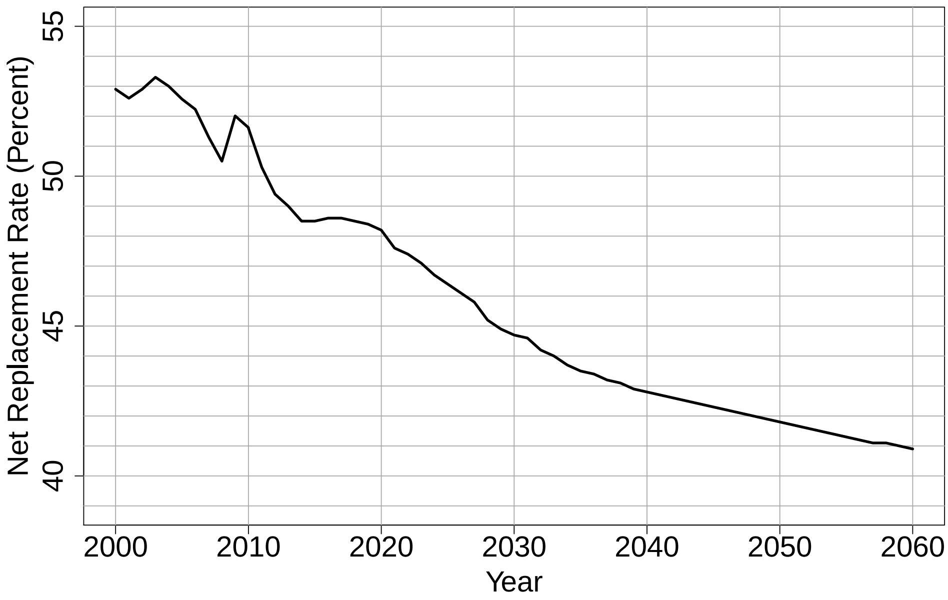
In addition to higher contributions to the GRV also the long-term decreasing development of net replacement rate shows that the pressure on the pension system will increase.

4.3 Sensitivity Analysis

The previously presented simulation results refer to the baseline scenarios for demographic and economic developments. To account for the large degree of uncertainty that generally underlies projections to the distant future we conduct a sensitivity analysis and analyse the effects of variations in wage growth and unemployment rates as well as the impact of varying demographic assumptions for mortality, fertility and migration (also see the appendix).

[50] In the following we refer to the *net replacement rate* instead of *net replacement rate before taxes.*

Figure 7: Projection of the Net Replacement Rate



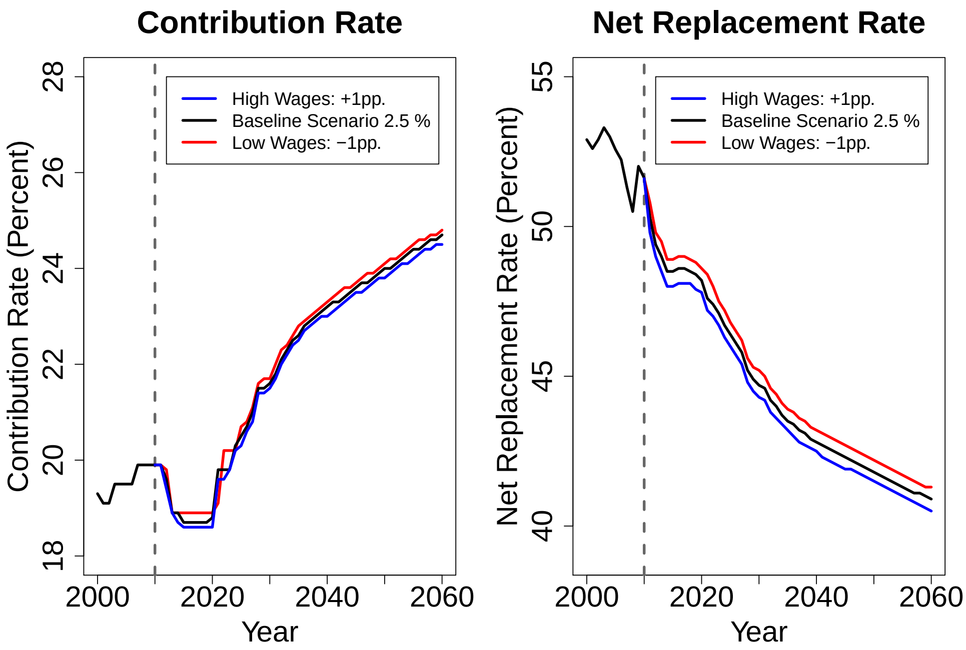
Source: Deutsche Rentenversicherung (2012), own calculations.

4.3.1 Labour Market

In the baseline scenario gross wage growth follows the observed rates until 2015 followed by a constant gross growth rate of 2.5 percent per year. Here, we analyse the effects of varying this rate by 1 percentage point (see Figure 8). A permanent higher long-run gross wage growth rate of 3.5 percent reduces the contribution rate by 0.1 to 0.2 percentage points compared to the baseline scenario. Conversely, a permanent lower long-run gross wage growth rate of 1.5 percent yields a contribution rate which will be between 0.1 and 0.2 percentage points higher. Focusing on the relative generosity of the pension system – characterised by the net replacement rate – an increase (decrease) of the wage growth rate by one percentage point will cause a reduction, or respectively, a rise, of the net replacement rate between 0.3 and 0.4 percentage points in the long run. Temporarily, between 2020 and 2025 slightly higher differences appear.

In general, contributions to the GRV and the indexation of pension benefits are linked to the development of wages while there is a time gap between wage growth and the adjustment of pension benefits. That is the reason why the effects of permanent changes of wage growth rate have little effect on the pension system (Holthausen et al., 2012).

Figure 8: Variations in Wage Growth



Source: Own calculations.

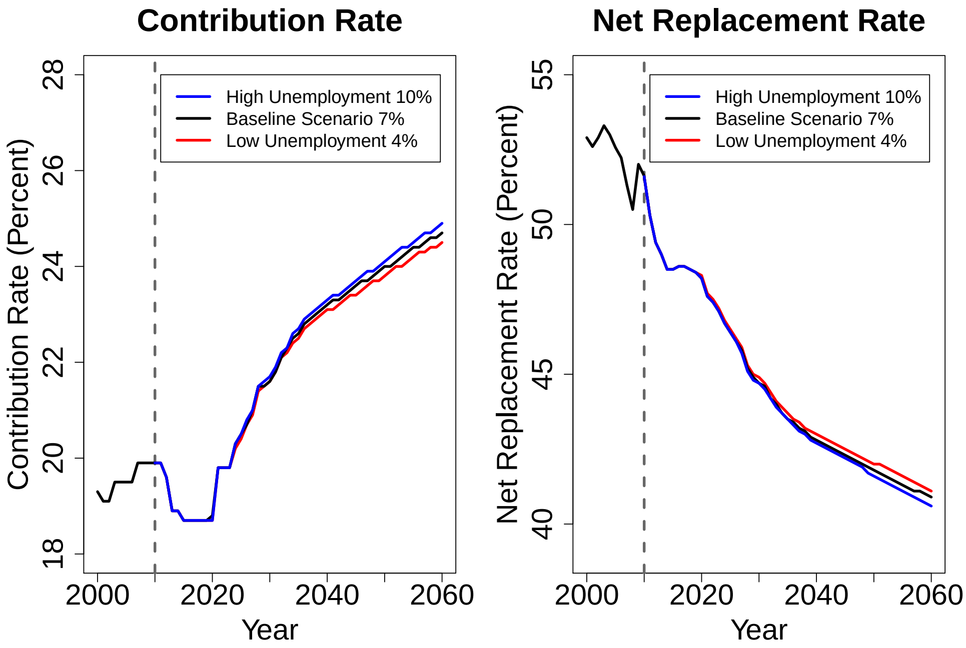
With regards to unemployment we assume an unemployment rate of 7 percent in the baseline scenario. Here, we show the effects when the unemployment rate varies in the long run by 3 percentage points (see Figure 9).

With a higher unemployment rate the contribution rate further increases and in 2060 reaches a 0.2 percentage points higher level. Lower unemployment reduces the contribution rate by 0.2 percentage points in the long run. A higher (lower) unemployment rate decreases (increases) the net replacement rate between 0.2 and 0.3 percentage points.

Figure 10 characterises the contribution rate and net replacement rate development when labour force participation continuously increases in older-ages and female participation rates converge to a 95 percent level of the male counterparts.

In general, the sensitivity analysis on increasing labour force participation reveals positive effects on the contribution rate and the net replacement rate of the GRV. A higher female labour force participation, especially between the ages 25 and 50, with a catching up to 95 percent of the male participation rates until 2040 reduces the contribution rate by 0.1 to 0.2 percentage points while the net replacement rate gains 0.1 to 0.4 percentage points.

Figure 9: Variations in Unemployment

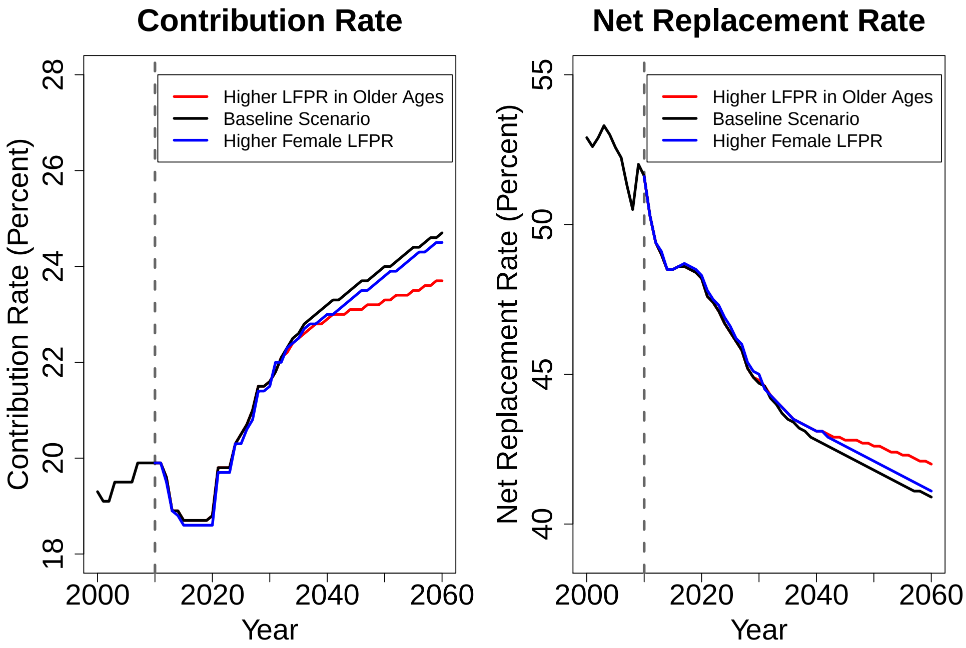


Source: Own calculations.

A continuous increase of labour participation in older ages from 2031 onwards shows more noticeable effects. In 2060, the contribution rate reduces by 1.0 percentage point and, at the same time, the net replacement rate improves by 1.1 percentage points higher. In both scenarios the observed effects occur especially through higher participation in older ages that strengthen the contribution side of the GRV while simultaneously reducing the pension costs.

In summary, varying the economic assumptions on unemployment and gross wage growth quite substantially shows comparatively little effects on the rise of the contribution rate or the decline of the replacement rate until 2060. In contrast, enhancing labour force participation shows a higher potential of temporary unburdening the financial situation of the GRV. Especially increasing labour force participation after age 50 shows noticeable effects. This suggests that pension reforms in order to stabilise contribution rates and replacement rates should focus on labour force participation since improvements in wage growth or unemployment are not very effective. In the long-run higher contributions will generate higher pension claims so that the unburdening effect diminishes.

Figure 10: Variations in Labour Force Participation



Source: Own calculations.

4.3.2 Demography

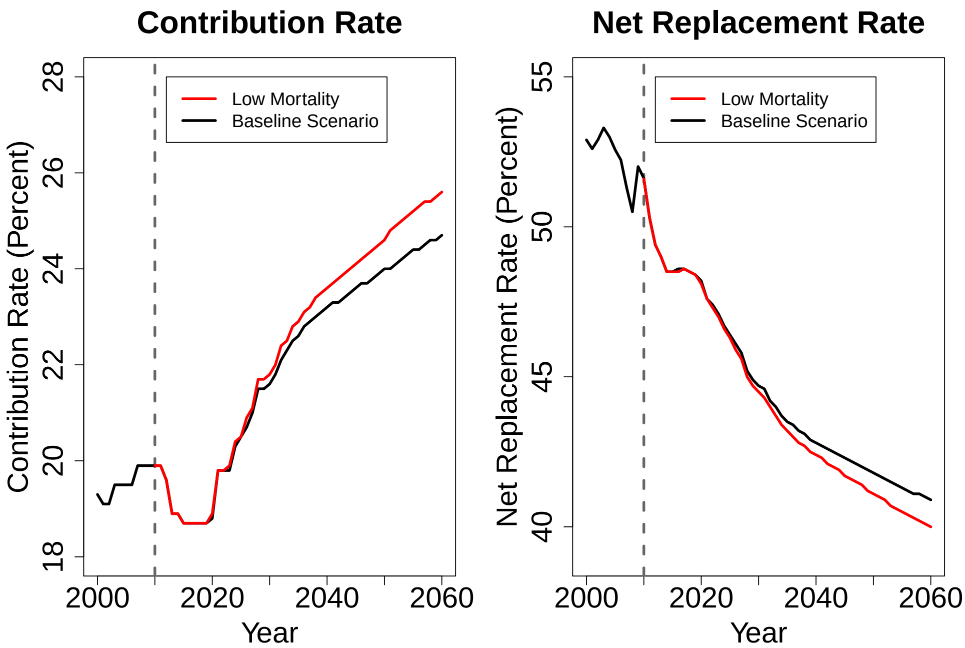
First, we modify our baseline mortality assumption to a low mortality scenario where life expectancy at birth further advances to 90.4 years for girls and 86.7 years for boys in 2060. This corresponds to a further increase by 1.6 years for girls and 1.9 years for boys compared to the baseline scenario.

When mortality improves, according to this high life expectancy scenario the population will further age. As a result the contribution rate will rise in comparison to the baseline scenario by additional 0.9 percentage points more rapidly and reaches 25.6 percent in 2060. At the same time the net replacement rate further decreases by 0.9 percentage points to 40.0 percent (see Figure 11).

When life expectancy increases more rapidly than proposed in our baseline assumptions, the financial sustainability of the pension system is further endangered. Given the stunning fact that life expectancy improved in a worldwide context steadily by a quarter of a year per year, future challenges of the German pension system are highlighted (Oeppen and Vaupel, 2002, p. 1031.).

Second, we calculate the development of the pension parameters in a low fertility sce-

Figure 11: Variations in Mortality



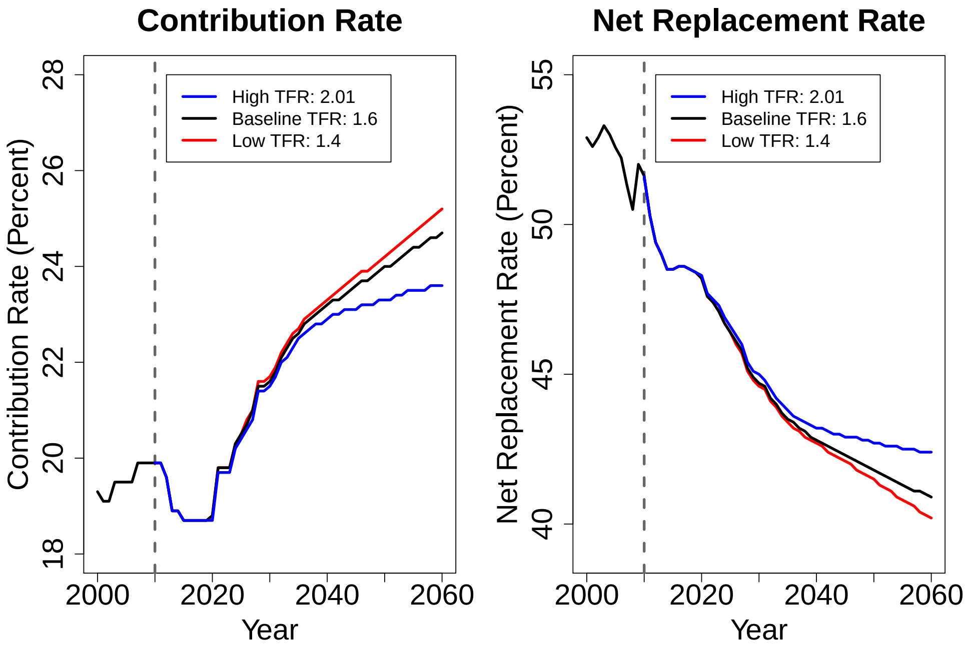
Source: Own calculations.

nario reaching a TFR of 1.4 in 2028 and in a high fertility scenario with TFR of 2.01. When fertility rates would increase substantially reaching a TFR of 2.01 the contribution rate of the GRV could be decreased by 1.1 percentage points compared to the baseline assumptions and would approach 23.6 percent in 2060. Here, increasing federal contributions for periods of raising children have immediate effects on the pension system in addition to a reduction of population ageing in the medium term. At the same time the net replacement rate would gain 1.5 percentage points reaching 42.4 percent in 2060 (see Figure 12).

A lower fertility rate with a TFR of 1.4 has opposing effects. The contribution rate with 25.2 percent in 2060 would reach a 0.5 percentage point higher level compared to the baseline scenario. The difference emerges from a steeper rise of the contribution rate starting in 2040. The net replacement rate is also negatively affected by lower fertility rates. After a uniformly development in line with the baseline fertility scenario, the net replacement rate decreases faster after 2040. In 2060, the replacement rate is with 40.2 percent approximately 0.7 percentage points lower compared to the baseline scenario.

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 with a lag of about 20 years as the newborns have to enter the labour

Figure 12: Variations in Fertility



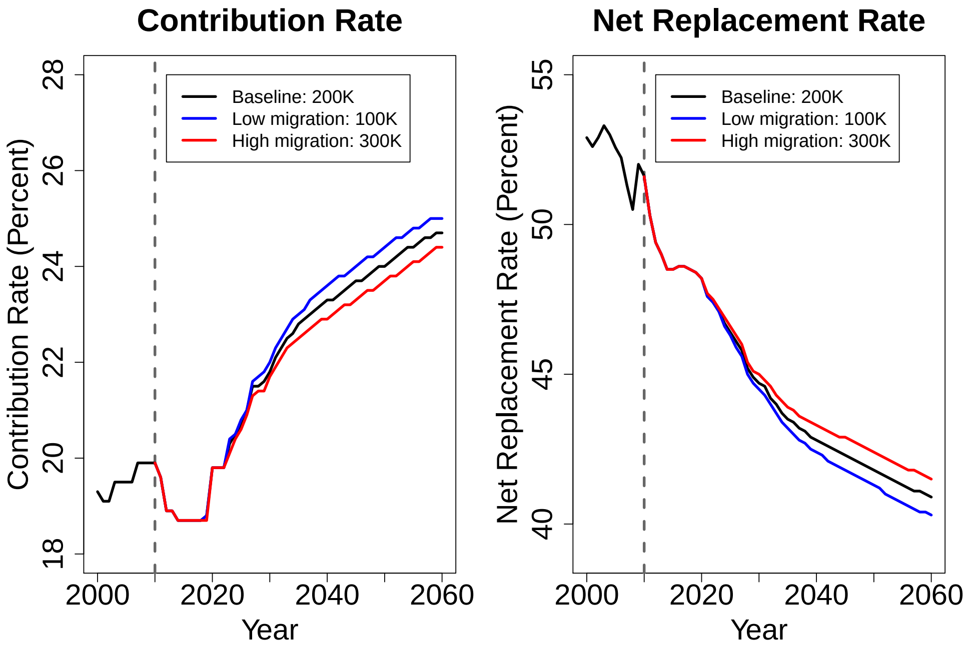
Source: Own calculations.

market first, before the system is affected. Thus, higher fertility rates start to impact the pension system between the years 2035 and 2040.

Third, we compare the baseline scenario of a net migration approaching 200,000 people per year with a low migration scenario with net migration of 100,000 people per year and a high migration scenario with net migration of 300,000 people per year.

As migration occurs, predominantly in working ages, a variation of assumptions on net migration has immediate effects on the pension system. It reduces the burden of population ageing and 'rejuvenates' the German population. With a low net migration of 100,000 people per year the contribution rate is higher and reaches 25.0 percent in 2060. Compared to the baseline assumptions the difference is up to 0.3 percentage points. This is mainly the effect of a smaller number of contributors. Simultaneously, until 2060 the net replacement rate drops by 0.6 percentage points to 40.3 percent (see Figure 13) as a smaller number of contributors increase the share of pensioners in the GRV further dampens the pension indexation through the sustainability factor. Accordingly, higher net migration has opposing effects and reduces the contribution rate by 0.3 percentage points to 24.7 percent in 2060 while the net replacement rate gains 0.6 percentage points and reaches 41.5 percent.

Figure 13: Variations in Migration



Source: Own calculations.

Migration can help to reduce the financial burden of the pension system temporarily when net migration is positive, and permanent and migrants are able to enter the labour market. But, with positive net migration future pension payments will also increase as former migrants obtain pension entitlements when they contribute to the system. The estimated effects can be interpreted as an upper bound of potential effects as our results are based on the assumption of a homogeneous population. Over the medium-term, asylum seekers show lower participation rates compared to the native population (Brücker, 2016). Thus, the practical potential of long-lasting stabilising a pensions system with migration policies is limited as for that migration has to take place with a positive and sustained flow. Another precondition for positive effects for the GRV is an adapting of labour force participation and wages of migrants to the levels of natives.

Varying the assumptions on demographic developments has significant effects on the development of the pension parameters. While changes in mortality and net migration work immediately, the impact of a change in fertility will arise after some 20 years.

4.4 Discussion of Related Literature

Our model builds on approaches described in the literature and includes a comparable detailed accounting approach of revenues and expenditures within the pay-as-you-go funding scheme of the GRV (Wilke, 2004; Werding and Hofmann, 2008; Werding, 2011; Holthausen et al., 2012; Werding, 2013b; Buslei and Peters, 2016; Börsch-Supan et al., 2016). Differences can be found in the actuality of underlying assumptions. Our composed simulation framework rests upon actual official demographic projections (Federal Statistical Office, 2015a) and includes the latest migration and fertility developments as well as the latest pension legislation (Federal Statistical Office, 2015b, 2016c,a). Developments of labour force participation rates refer to a cohort projection method (Burniaux et al., 2004; European Commission, 2005; Carone, 2005). In this way we provide the latest long-run projections for Germany.

Compared to our actual baseline scenario, the older pension projections reveal higher contribution rates and lower replacements rates while the overall development trends follows similar paths. Compared to our baseline result of a contribution rate reaching 24.7 percent in 2060, Holthausen et al. (2012) projects in a similar fertility scenario a higher level of 25.0 percent and Werding (2013a) calculates a reference contribution rate of 27.2 percent. Related similarities can be observed for the development of replacement rates.[51] 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. Comparably, the other studies project a net replacement rate of 41.1 percent (Werding, 2013a) and a gross replacement rate of approximately 36.8 percent in 2060 (Holthausen et al., 2012).

The observed differences in projected developments can be attributed mainly to distinct utilised demographic assumptions. [52] Compared to our baseline scenario which is grounded on the latest demographic trends Werding (2013b) considers no fertility increases and assumes a higher 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 1.6 and a life expectancy at birth of 92.3 years for girls and 89.2 years for boys in 2060 in their similar fertility scenario. In relation to our baseline scenario, both studies apply lower net migration numbers of 150,000 people per year.

The more recent projections by Buslei and Peters (2016) and Börsch-Supan et al. (2016)

[51] In contrast to Werding (2013b) and to our presentation of results in Section 4.2, Holthausen et al. (2012) only provide information for the gross replacement rate.

[52] 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.

are based on the 13th coordinated population projection for Germany (Federal Statistical Office, 2015a). The latest migration and fertility developments until 2015 are not considered. The projection results by Buslei and Peters (2016) for the period 2015 to 2029 diverge from our results. Here, the projected contribution rates for 2016 (19.4 percent) and 2017 (19.3 percent) exceed the observed values and our results. Conversely, in 2029 the results of Buslei and Peters (2016) show a more optimistic picture with a contribution rate of 21.4 percent.

Compared to our model the recent study by Börsch-Supan et al. (2016) shows a similar development until around 2035. Later on the contribution rate development is lower than our projection reveals so that for 2060 they present a contribution rate between 23 and 24 percent while our model results in 24.7 percent. The lower long-run contribution rates can be explained by their assumption of low increases for the costs of survivors pensions (Börsch-Supan et al., 2016, p.35.). In the long run the replacement rates show comparable developments on a lower level.

Summarising, while other projections are more pessimistic in the developments of next decades, our projection concludes in line with those former studies that further pension reforms are inevitable in order to stabilise the development of future pension parameters in the long run.

5 Decomposition of Demographic Effects

For the projections of our pension simulation model we develop a decomposition approach to identify and quantify the separate impact of the different demographic factors and the present population structure on the development of central parameters of the German pension system. For the evaluation of the decomposed effects we refer to the reference year 2010 and the baseline assumptions on demographic and labour market development (see 3.1 and 3.2.2).[53]

Our decomposition approach relies on comparative benchmark projections and refines well-known analysis strategies e.g. used by sensitivity analysis. Here, the specifically conceptualised and combined variation of demographic assumptions allows for a deeper analysis of the effects of population ageing on the GRV. Therefore, we run our pension simulation with an underlying demographic development that refers to fixed mortality and fertility rates of 2010 without any net migration.[54] This scenario 'freezes' the demographic flows

[53]Varying the underlying assumptions will alter the results of the decomposition. The effects of changing economic assumptions follow the changes presented in the sensitivity analysis (see section 4).

[54]Fixed mortality and fertility rates correspond to a life expectancy at birth of 82.8 years for women and 77.7 years for men and a total fertility rate of 1.39 children per woman.

to the rates of the reference year in the absence of net migration. After that, these results are successively compared with the outcome of the simulations where the evaluated demographic variable develops, according to the respective baseline assumptions in order to isolate the impact of each demographic factor. Thus, the model focuses on first-order effects of each demographic variable separately. The interplay of changing demographic variables or interactions and feedback effects with the economic development are summarised in a residual effect.

5.1 Definition and Measurement of Effects

Starting from the reference year 2010, the total change of a pension parameter – the contribution rate or the net replacement rate – due to the demographic development in the baseline scenario is denoted as the *total effect*. With our decomposition set-up we can divide this total effect into four effects: the impact of the future fertility development (*fertility effect*), future life expectancy development (*mortality effect*), future changes in net migration (*migration effect*) and the impact of past developments prior to the reference year (*structural effect*). A *residual effect* completes the decomposition and accounts for e.g. multiple interactions or developments not captured by the analysed first-order effects.

Denoting by cr the contribution rate in the pension system, we show exemplarily how the development of the contribution in the baseline scenario (see Figure 6) is decomposed into those separate effects in the following. In the same way the differentials d for the development of the net replacement rate in the pension system (see Figure 7) can be derived similarly.

Total Effect

The *total effect* (d^{total}) on the contribution rate is the simulation projection of the change of this pension system parameter since the starting year 2010 under our baseline assumptions about future demographic and economic developments. The total effect in the year T (d_T^{total}) is the sum of the yearly changes of the contribution rate between the years 2010 and T. Thus the total effect adds up the differences between two successive years in this period:

$$d_T^{total} = cr_T - cr_{2010} \quad .$$

Structural Effect

The *structural effect* (d^{struc}) quantifies the changes of the pension system parameter in the absence of net migration and when demographic rates are constant at the level of the reference year. There are still births and deaths but changes in the rates are excluded from the analysis.

$$d_T^{struc} = cr_T^{struc} - cr_{2010}^{struc} \quad .$$

Under these assumptions, the development of the contribution rate and net replacement rate is mainly driven by economic and demographic conditions in the reference year and the population structure in place.

With this modelling approach the structural effect captures the persistent influence of the past on future developments. As the conditions of the reference year remain the same the structural effect is immanent in all simulation results. We therefore treat the structural component as the underlying basic development of pension variables for the estimation of all future demographic effects. The other demographic effects emerge on top of the structural effect (see section 5.2).

Mortality Effect

The *mortality effect* (d^{mort}) refers to a simulation where only mortality rates change after 2010. Thereby, with constant fertility rates at the level of 2010 and in the absence of net migration only mortality rates improve according to the assumptions of the baseline scenario. The mortality effect quantifies the total 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:

$$d_T^{mort} = cr_T^{mort} - cr_{2010}^{mort} - d_T^{struc} \quad .$$

Fertility Effect

Running the pension simulation where only fertility changes characterised by constant mortality and the absence of net migration leads, together with the correction for the structural effect, to the *fertility effect* (d^{fert}). Here, the fertility effect characterises the impact of fertility developments in the baseline scenario in comparison to fertility rates in 2010:

$$d_T^{fert} = cr_T^{fert} - cr_{2010}^{fert} - d_T^{struc} \quad .$$

Migration Effect

The *migration effect* (d^{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:

$$d_T^{mig} = cr_T^{mig} - cr_{2010}^{mig} - d_T^{struc} \quad .$$

Residual Effect

Finally, the emerging residuals can be summarised as (ϵ^{res}):

$$\epsilon_T^{res} = d_T^{total} - d_T^{struc} - d_T^{mort} - d_T^{fert} - d_T^{mig} \quad .$$

5.2 Analysing the Structural Effect

The structural effect describes the future dynamics of the pension system that are driven by the conditions in place in the reference year. The development of the structural effect is shaped by the impact of different cohort sizes on revenues and expenditures of the GRV. As the population structure in a given year is the result of previous demographic developments, preceding mortality, fertility and migration are the decisive factors for the structural effect. The projection of the structural effect bases on constant mortality and fertility rates at the level present in the reference year 2010. As mortality and fertility still advance we analyse a population with 'constant dynamics' rather than a constant population. With this set-up, the structural effect quantifies the future impact of the past demographic developments on the pension system. In contrast, the other demographic effects are forward-looking approaches to characterise the impact of future demographic changes on the GRV. This distinguishes the structural effect from the other demographic effects.

Having a look at the population in the reference year, the development of the structural effect is caused by different sub-populations that evolved from previous mortality, migration and fertility developments. Furthermore, these sub-populations differ in size and structure. Thus, the situation of the GRV in the reference year is already affected by the impact of the several sub-populations. In other words, without the past demographic developments, the pension system parameters in the reference year would be different. We therefore estimate the relative impact of the single demographic developments before 2010 on the contribution rate to approximate its effect on the change of the structural effect.

Our analysis approach matches within the actual population in 2010 the number of virtually additional people that result from demographic developments of the previous decades. Then, contributions and expenditures in the GRV are assigned to these identified sub-populations to identify the impact on the projected contribution rate.

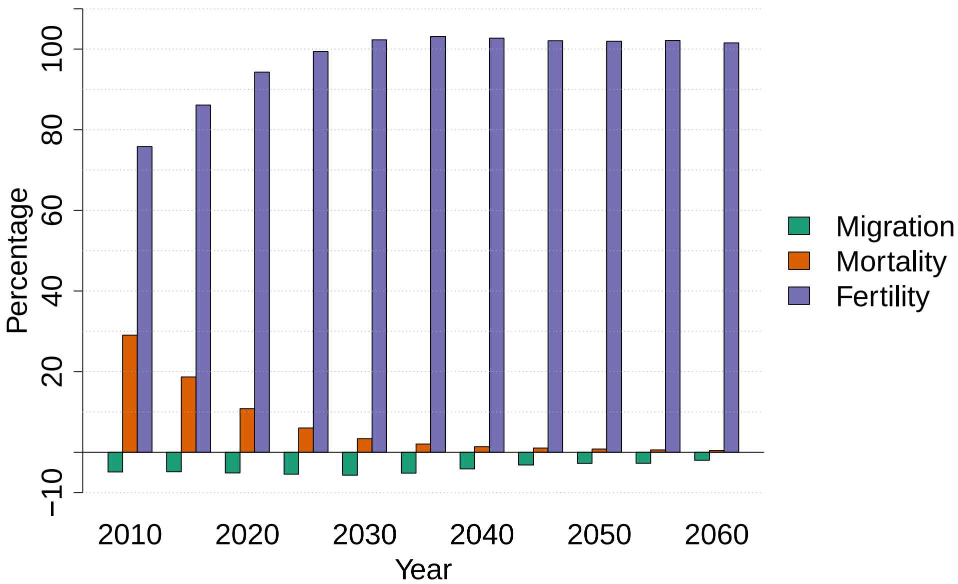
We utilise data on age- and sex-specific mortality rates for East and West Germany for the available years 1956 to 2010 provided by the Human Mortality Database to estimate the number of people 'additionally alive' in 2010 due to improved mortality (HMD, 2013). Entries to the projected sub-population result from mortality improvements in comparison to the previous year. For example, the entries to the sub-population as of 31/12/1960 result from multiplying the actual population as of the 31/12/1959 with the difference in mortality rates between 1959 and 1960. Within the sub-population individuals decease according to the observed mortality rates of the given year. To identify the number of 'additional people' due to migration in 2010 we draw on Microcensus survey data on migrant background (Federal Statistical Office, 2016b).

These identified 'sub-populations' within the population in 2010 are then projected forward with the assumptions used to calculate the structural effect. As a result, we observe the size of the respective sub-population over the complete projection period. With this information we are able to compute actual contributions and expenditures of those identified sub-populations necessary to calculate the balance of these payments.

While the impact of mortality and migration is estimated directly, we deduce the impact of previous fertility developments – in Germany mainly characterised by a sharp fertility decline after the baby-boomer generations of the 1960s – on the contribution rate in the structural effect scenario implicitly as a remaining residual. Thus, the impact of fertility is an approximation. Figure 14 illustrates the composition of the contribution rate within the structural effect projection. In 2010 the mortality improvements between 1956 and 2010 explain about 29.0 percent of the contribution rate – respectively 5.8 percentage points of the contribution rate in 2010. This is caused by approximately 8.3 million predominantly older people that are 'additionally alive' in 2010 due to better mortality conditions. This assignable share decreases sharply to 0.4 percent in 2060 as the underlying individuals decease. That equals 0.1 percentage points of the contribution rate in 2060.

Migration shows a different impact. In 2010, the identified 15.7 million people with a migrant background account for a virtual surplus of about 4.9 percentage points of the contribution rate. That equals a potential reduction of the contribution rate by 1.0 percentage point. Thus, previous migration reduces the burden on the contribution rate in the beginning of the analysed period. As these individuals age, the effect lowers so that in 2060 the contribution rate is unburdened by around 0.5 percentage points by migration prior to 2010. As a joint consequence, the deduced impact of fertility, approximated as the residual share of the change of the contribution rate, increases from 75.8 percent in 2010 to 101.5 percent in 2060.

Figure 14: Composition of the Structural Effect - Attributable Shares to the Contribution Rate



Source: Own calculations.

Together, these results show that the impact of preceding demographic developments differs over time. However, fertility developments before 2010, primarily the baby-boomers and the sharp fertility decline after that, explains the main part of the contribution rate within the structural effect estimation. Past mortality and migration developments prior to 2010 have a comparatively small effect in the long run. This leads to the conclusion that the structural effect mainly captures the future impact of past fertility changes on the GRV.

5.3 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 GRV separately. We present the decomposition results based on our baseline scenarios for the period 2010 to 2060. The total yearly change is divided into the impact of the structural effect of the population in 2010, the fertility effect, the mortality effect, the migration effect and the remaining residual. Our presented results refer to the demographic and economic baseline scenarios.[55]

Contribution Rate Changes

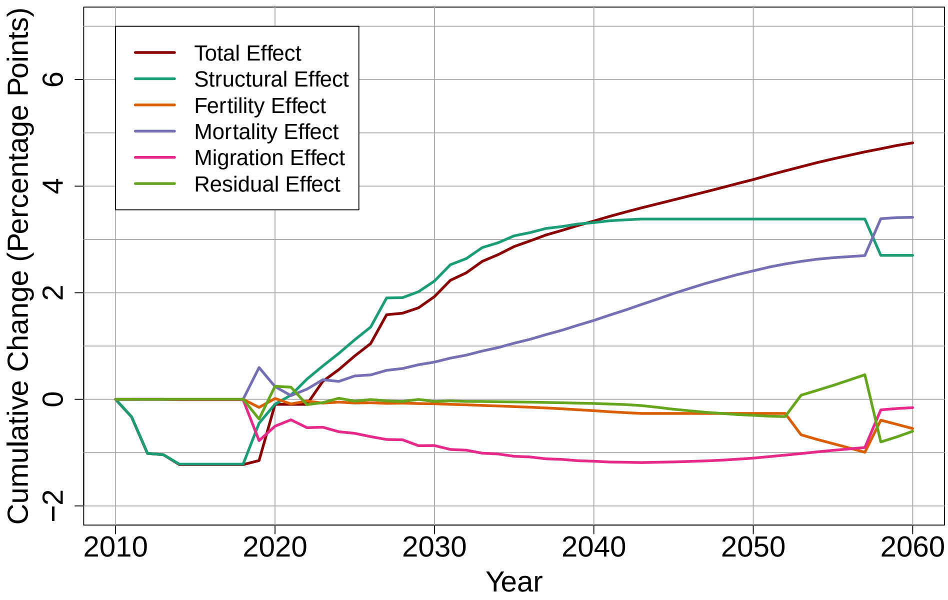
Figure 15 illustrates the total demographic effects on the contribution rate. Depicted are the total increase of the contribution rate, characterised by the total effect, and the impact of the underlying demographic factors. Overall, the contribution rate of the GRV will rise by about 4.8 percentage points between 2010 and 2060.[56]

Within the first 8 years of the projection period the structural effect is the single driver for a decline in the contribution rate by 1.2 percentage points. Subsequently, until 2057 it remains the main factor for the enlargement of the contribution rate as about 3.4 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 2.7 percentage points of the total contribution rate increase is caused by the structural effect. The imbalances of population structure in the reference year 2010 are the main drivers of this development. The retirement of 'baby-boomers' will amplify the increase of the contribution rate. Conversely, when the 'baby-boomer' generations decease, the financial pressure on the GRV diminishes.

[55] See Section 3.1, Section 3.2.2 and Section 4.

[56] The observed jumps are caused by the liquidity reserve of the GRV that prevents from continuous minor changes of the contribution rate.

Figure 15: Effects of Demographic Factors on the Contribution Rate



Source: Own calculations.

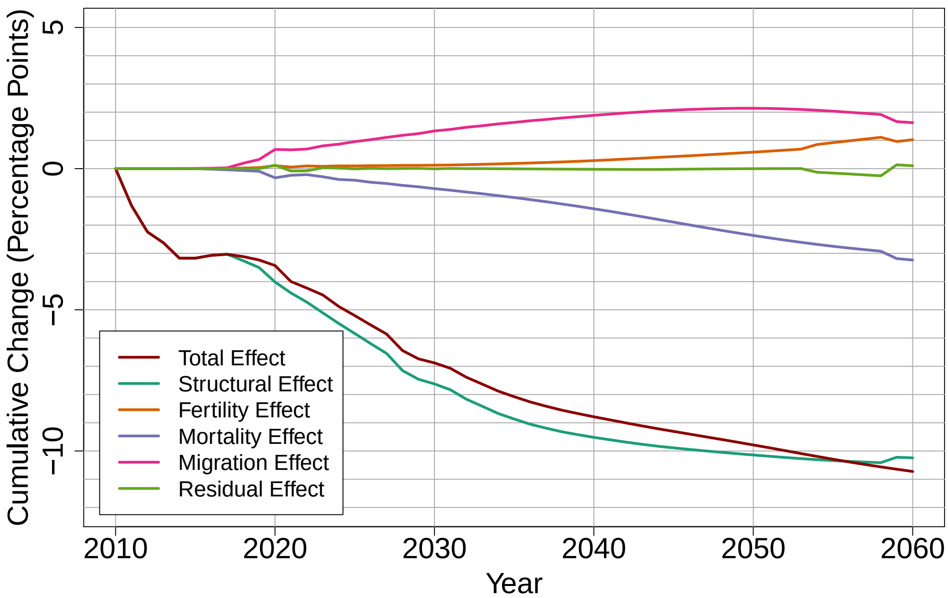
The mortality effect increases until 2057 almost linearly, followed by a larger step in 2056, and increases the contribution rate by 3.4 percentage points in 2060. Altogether, the mortality effect has the most important impact on the future pension contribution rate in the long-run. Here, improving mortality reinforces population ageing persistently increasing the financial pressure on the GRV.

On the other hand, the fertility effect reduces the contribution rate almost linearly by 0.5 percentage points in the long run. The higher number of newborns first have to enter the labour market before they affect the pension system. The migration effect temporary lowers the contribution rate by up to 1.2 percentage point between 2039 and 2047. However, in 2060 it has a minor impact and reduces the contribution rate by 0.2 percentage points. In contrast to fertility, migration in working ages instantly strengthens the contribution side of the GRV. As the migrants age and start to retire, the effect changes and the financial pressure on the GRV increases. In the baseline scenario the diminishing impact of migration and fertility on the contribution rate cannot counteract contribution rate growth caused by the population structure and mortality improvements.

Net Replacement Rate Changes

The analysis of the net replacement rate – illustrated in Figure 16 – shows a comparable but reverse picture. As seen by the contribution rate development, the structural effect and mortality effect are the main drivers 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, it stabilises between 2015 and 2019. In the following years the net replacement rate diminishes noticeably while the pace of the reduction slows down between 2030 and 2040. These developments can be mainly explained by the working of the sustainability factor when calculating the net replacement rate. A higher share of pensioners in the GRV dampens the pension indexation.[57]

Figure 16: Effects of Demographic Factors on the Net Replacement Rate



Source: Own calculations.

The structural effect remarkably lowers the net replacement rate by about 10.2 percentage points with the maximum in 2056 to 2058. Until 2060 a further reduction of the replacement rate by 3.2 percentage points is caused by the mortality effect. Thereby starting in 2018, the mortality effect persistently reduces the replacement rate.

The migration and fertility effect stabilise the net replacement rate by 1.6 and 1.0

[57]See Section 3.3.3.

percentage points respectively. Both demographic factors have a continuous impact on the replacement rate and despite the similarities, the stabilising impact of migration will already start in 2018, while the fertility effect starts to influence the replacement rate later on.

6 Conclusion

This paper gives detailed insights into the composition and comparative relevance of demographic effects that explain the changes of central parameters of the pension system. We use a simulation model of the pay-as-you-go financed pension scheme in Germany and incorporate the latest forecast of the demographic development until 2060. Based on that model, we simulate potential future development paths of the contribution rate and the net replacement rate of the German pension scheme. To evaluate the impact of economic and demographic assumptions we also provide a sensitivity analysis. We consider a range of scenarios which enables us to discuss our results in a broader context and to take account of the uncertainty involved in the projections.

The sensitivity analysis of the baseline scenario shows that changes in wage growth or unemployment have a small impact on the stabilisation of the pension system, while an increasing labour force participation of women and, in particular, of older people is more effective. Often discussed as useful reform measures a permanent increase in labour productivity and wages by 1 percentage point or a significant reduction of unemployment by 3 percentage points turn out to slow down the increase of the pension contribution rate by only 0.1 to 0.2 percentage points in the long run. Similarly, minor effects arise with respect to the replacement rate. However, raising the labour force participation of individuals aged older than 40 years may reduce the increase of the contribution rate by 1 percentage point and, at the same time, increase the replacement rate by 1.1 percentage points by 2060. These results illustrate the strong link of the German pension system to wages and that pensions reflect lifetime earnings. Higher wages cause increasing contributions and simultaneously increasing pensions and vice versa so that the effect on the contribution rate is limited. Pensions develop proportionally to lifetime earnings. In the long run, for example higher unemployment reduces the pension claims and the payments of contributions too. Distinct effects evolve when labour force participation further increases, especially at older ages. The burden on the budget is reduced as more contributors stabilise the revenues and fewer pensioners reduce the expenditures of the pension system. Hence, pension reforms via better labour market conditions should focus on enabling a higher labour force participation of women and older people.

Our decomposition approach allows for evaluating the impact of life expectancy, fertility, migration and the past demographic developments, realised by the population structure in place, independently. The results provide a picture of the relevance each determinant has on the future development of the pension system which can help to deal with misunderstandings in the political and social debate regarding the challenges the German Pension system faces. Furthermore, it allows for focusing on the most important aspects of population ageing and a more purposeful development of pension reforms.

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 characterises the impact of previous demographic changes. As the examination of this structural effect shows it reflects predominantly the significant fertility changes in the 1960s and 1970s. Overall, this past fertility profile mainly explains the developments of the pension system variables between 2010 and 2057. However, later the influence declines as the large cohorts decease. Other studies, such as Rausch (2017), refer to the impact of the initial demographic situation when comparing different countries and pension systems. Our result shows that the status quo and potential imbalances in the population structure in the reference year are of central importance and account in Germany for approximately half of the contribution rate increase until 2060.

Analysing the impact of future demographic trends, mortality improvements affect the German pension system nearly to the same extent as the past fertility change. This result holds even for our moderate assumptions on life expectancy increase. Our decomposition results elucidate the continuously growing influence of the mortality effect on the GRV. Starting in 2058, it is the main driver for the contribution rate development. Fertility and migration changes in the future affect the development of pension system parameters less prominently. Assuming a remarkable rise of fertility to a TFR of 2.01 until 2025 would have as comparable effects on the pension system as a higher net migration of 300,000 people per year. However, 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 labour 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 will have 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. However, these effects will not be able to counteract the pressure arising from the population structure and the life expectancy developments.

This insight also raises important questions about a fair and equitable distribution of the fiscal burden to younger and older generations. While political discussions focus on freezing the net replacement rate at present values which would allocate a major part of the burden to younger generations, our findings may give rise to think about other reform options. As the structural effect shows, a major reason for the future fiscal strains of the pension budget lies in the past. About half of the higher burden - measured by the increase of the contribution rate - is caused by the past fertility decisions. This suggests that a share of this burden might be placed on present pensioners. The current pensions to which those generations have a legal claim cannot be reduced appropriately. However, other policy measures outside the pension system, such as wealth taxation may be feasible in order to compensate for this legacy of a high implicit debt caused by those generations.

While the structural effect, caused by past developments, mitigates and becomes less important, the predominant impact of an increasing life expectancy in the future constitutes a persistent trend causing a permanent pressure on the budget of the pension system. Upcoming pension reforms would have to manage the consequences of this ongoing demographic development. A straightforward policy option would be to develop reforms that directly address the implication of longevity: a shift of the relation between working life and retirement. A sustainable pension reform should allow for a rule-based adjustment of the retirement age in accordance with the increasing life expectancy. How to model such an adjustment rule in order to neutralise the mortality effect on the pension system is left for further research.

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