Profitability of pension contributions – Evidence from real-life employment biographies

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Abstract. Micro-econometric intra-cohort profitability analyses of pay-as-you-go (PAYG) pension contributions are rare. We use representative employment histories of a birth cohort of German PAYG pension insurants retiring in year 2005 to econometrically examine the determinants of the profitability of such contributions using nominal internal rates of return (IRR) as profitability measure. When future nominal pension entitlements are frozen at today's level, average IRR is slightly above three percent. At the same time, IRR differs substantially across beneficiaries. IRR is increasing in beneficiaries' remaining life expectancies at retirement and in the length of non-contribution periods resulting, for example, from child care or care for an ill partner. Due to survivor pensions, married insurants benefit from higher IRR as compared to the non-married. Interestingly, IRR is decreasing in insurants' earnings capacity, indicating that the system entails an intra-cohort progressive element.

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1 Introduction

As shown by Samuelson (1958), in a two-age groups overlapping generations model (OLG) with an infinite time horizon, an exogenous production sector and a constant contribution rate, the steady-state rate of return on contributions in a pay-as-you-go (PAYG) pension system is equal to the rate of growth in the labor force and in productivity. Hence, in countries experiencing population ageing, low fertility and low productivity growth, pre-funded pension systems with privately defined contribution plans may appear a superior alternative. Indeed, the two most propagated arguments in favor of privately defined contribution plans are that such plans raise national savings and thus stimulate growth, and that returns on contributions are higher than in PAYG systems (e.g., Palacios and Whitehouse, 1998).[1]

Models that quantitatively investigate rates of return on pension contributions almost exclusively focus on the *inter*-generational dimension. Recent literatures include Settergren and Mikula (2005) and Knell (2010). Only a few studies address the *intra*-cohort dimension (i.e., Cubeddu, 2000, Auerbach and Kotlikoff, 1987, Imrohoroglu et al., 1995, and Fullerton and Rogers, 1993). This is surprising as the intra-cohort dimension is of key relevance for policymakers: PAYG pension schemes approach maturity worldwide and the *intra*-cohort distribution of rates of return can be seen as an indicator of life-time redistribution within the pension system. Particularly, the intra-cohort dimension reveals how well, in monetary terms, an insurant is treated relative to other insurants in her cohort, and how well-off the birth cohort as a whole is (e.g., Liebman, 2001, pp. 5-6).

In many countries neither experts nor the public know how intra-cohort distributions of rates of return on pension contributions look like, largely because the necessary micro data, i.e. insurances' biographies together with their pension entitlements, is not available. Instead, rates of return on pension contributions are typically computed for some types of "representative" insurants with stylized biographies. Yet, such representative beneficiaries are rarely an efficient simplification, and the exception rather than the rule: Even within the same birth cohort, labor-market shocks, human capital investments, marriage and fertility decisions, and other factors cause substantial heterogeneity in individuals' employment biographies. All these factors affect individual pension contributions and entitlements, and this may map in

[1] Of course, the rate of return is only one evaluation criterion. Potentially favorable effects of PAYG systems include the elimination of adverse selection (Townley and Boadway, 1988; Feldstein, 1990) and the avoidance of free riding by parents at the expense of their altruistic children (Lindbeck and Weibull, 1988). They can also serve as a device for intergenerational risk sharing (e.g., Smith, 1982, and Gordon and Varian, 1988), and as an insurance against not having children (Sinn, 2004). Moreover, they may act as an enforcement device for ungrateful children (Sinn, 2004).

differences in rates of return across insurants.[2] Furthermore, computations based on representative beneficiary types do not shed light on the intra-cohort redistributive channels inherent in pension systems, coming from the fact that pension entitlements depend on various factors other than earnings. For example, in the German system as in many others, pension entitlements of married insurants can be transferred to the partner after the insurant's death; insurants with children benefit from regulations that compensate for income losses during periods of child rising.

For such and other reasons, Bosworth et al. (1999) argue that stylized hypothetical earnings biographies assuming steady earnings throughout earnings careers are misleading, and argue that researchers should consider real-life earnings patterns that can be seen in micro data. The present work seeks to contribute in this direction by providing the intra-cohort distribution of internal rates of return (IRR) on pension contributions in Germany's PAYG system, the blueprint of Bismarck-type pension systems worldwide.

In our analysis, we focus on old-age pensioners with West German employment biographies retiring in year 2005. These insurants realized an average expected nominal IRR of about 3.3 percent. At the same time, IRR substantially differs across different beneficiary groups. In particular, IRR is significantly influenced by the beneficiaries' gender: it is about one percentage point higher for female compared with male beneficiaries. The IRR gender divide results from the fact that the German PAYG system credits periods of child rising or care for ill/handicapped partners and that female insurants undertake these activities more often. Another important finding is that the IRR is decreasing in insurants' lifetime earnings, suggesting that the German system entails an intra-cohort lifetime progressive element.

The IRR distribution is derived from authentic representative social security records from a recently released database, the "Completed Insurant Lives"[3] (CIB) provided to us by the German Pension Insurance. For a representative sample of pension insurants retiring in year 2005, the CIB contains monthly-level information on insurants' employment biographies. Particularly, the database documents, for each insurant, the entire stream of pension contributions before retirement together with actual annual pension entitlements at the moment of retirement. Unfortunately, the CIB does not include insurants who did not survive until retirement. Accordingly, our IRR estimates are *conditional* upon survival. Due to a positive risk of pre-retirement death, *unconditional* IRR estimates should be lower. In sum,

[2] Also the "timing" of earnings through the employment biography can affect internal rates of return.
[3] The original German title of the database is "Vollendete Versichertenleben".

our approach takes a *forward*-looking perspective on retirement and a *backward*-looking perspective on employment.[4]

Empirical studies on the intra-cohort IRR distribution, such as ours, are scarce due to the lack of adequate data. Only a handful of studies exist, including Burkhauser and Warlick (1981), Hurd and Shoven (1985), Duggan et al. (1993), Gustman and Steinmeier (1999), and Liebman (2001). To the best of our knowledge, previous studies for Germany exclusively focused on stylized biographies (e.g., Schnabel and Ottnad, 2008, Ohsmann and Stolz, 2004, or Schnabel, 1998).

The remainder of the article is organized as follows. Section 2 presents the database and its preparation. Section 3 contains the technical framework. The sample breakdown is presented in Section 4, and Section 5 provides our empirical results. Section 6 deals with the implications of our results, and Section 7 concludes.

2 Database and data preparation

2.1 Completed Insurant Lives 2005

The scientific use file "Completed Insurant Lives" (CIB) from year 2005 is an excerpt of all German social insurance accounts. It stores representative administrative employment biographies of 37,716 pension beneficiaries born between year 1940 and 1975 entitled to public pension benefits (old age and reduced-earnings capacity pensions) from year 2005 and on. The database is split into two parts. The first part contains several time-invariant variables, e.g., the beneficiary's gender, nationality, date of birth, or type of pension entitlement. The second part documents the employment histories. For each beneficiary, it reports monthly data on pension contributions, employment status, child raising activity, etc. Up to 624 elements of monthly information (equivalent to 52 insurance years) are stored in a $37{,}716 \times 624$ matrix for every reported variable. No other German database provides longitudinal biographical information for a longer time horizon.

We have discarded several biographies from the database for reasons listed below:

(1) Sometimes biographical information is fragmented and incomplete. This can happen if the pension entitlement of a beneficiary has been computed manually by an employee of the German pension insurance (see German Pension Insurance, 2007, p. 15, for details). This affects 2,222 cases which have been discarded from the database.

[4] We would like to thank two anonymous referees for their most helpful comments concerning the impact of the sample restrictions on our (conditional) IRR estimates.

(2) As our focus is on old-age pensioners (according to Social Security Code (SSC), Book VI §§35, 36, 37, 237, 237a), we have excluded all beneficiaries receiving a pension for a limited duration only, e.g. due to a serious illness.[5] Including such cases would have urged us to make (arbitrary) assumptions about the duration of illness and the future ability/capacity to work. For this reason 7,133 cases have been discarded.

(3) Altogether, 5,991 beneficiaries have made contributions to the pension system of the Former German Democratic Republic.[6] These are discarded as a meaningful conversion of contributions made in Marks to pension entitlements in Euro seems impossible to us.

(4) Some beneficiaries are entitled to an old-age pension without ever having made sizable own contributions from earned income subject to mandatory insurance. Such a beneficiary's IRR can be quite high. To avoid outlier-driven bias, we have excluded the one percent of beneficiaries with the highest IRR. For symmetry reasons, we have also excluded the one percent with the lowest IRR. Altogether, this results in dropping 562 $(= 2 \cdot 281)$ cases.

By construction, the resulting working sample underlying all further calculations is not "representative" in the sense of the original CIB database. The CIB represents all the insurants born between 1940 and 1975 entitled to an old age or a reduced-earnings capacity pension from year 2005 onwards. Instead, our working sample of 21,509 insurants contains West German old-age pensioners born between 1940 and 1945. Accordingly, our analysis sheds light on a specific, yet prominent sub-population of the original CIB database: old-age pensioners with West German employment biographies.

2.2 Survival probabilities

To assess the expected value of pension entitlements, insurants' survival probabilities are required. Survival probabilities are derived from official gender- and age-specific mortality statistics for West Germany (see German Federal Statistical Office, 2007, for details). For persons of age 60 to 65 in year 2005, Figure 1 depicts survival probabilities up to an age of 100 years. Altogether, six graphs are provided, one for each age in year 2005 (60 to 65 years). Within each graph, survival probabilities are further distinguished by gender. For example, the graph in the bottom left corner of Figure 1 indicates that in year 2005 a 64 year old woman's (man's) probability to survive another 20 years is about 60 (40) percent.

[5] A similar approach is also adopted in Liebman (2001).

[6] The number includes five cases for which the region of residence is not provided.

In case of an insurant's death, the surviving partner can receive a survivor pension which constitutes a further return component on the insurant's contributions. To derive the expected value of survivor pensions, we have also computed the probability that an insurant deceases in a specific year after retirement while the partner is still alive (and hence is credited a survivor pension). Resulting joint probabilities are summarized in Figure 2. Again, graphs are decomposed by retirement age and gender. The joint probabilities rely on the assumption that the partner of a male (female) insurant is three years younger (older). Higher survival probabilities of females together with the age difference between the partners lead to a substantial gap in the joint probabilities for female and male insurants.[7]

Mortality tables provided by the German Federal Statistical Office do not differentiate with respect to income. However, several studies suggest that people with higher incomes tend to live longer (e.g., Rogot et al., 1992, and Pappas et al., 1993). This affects the IRR distribution: our approach tends to underestimate IRR of insurants with high income. We will come back to this issue in Section 5.2. Official mortality statistics also do not reveal the interdependencies in the remaining lifetimes of spouses. According to Luciano et al. (2008), when one of the spouses dies, the partner's probability of dying rises. Then our IRR estimates for married insurants are too high as expected returns from widow(er) pensions are overvalued. Finally, the possibility of future improvements in life expectancy is not taken into account, potentially leading to downward-biased IRR estimates.

3 Definitions, legal and technical framework

3.1 IRR – unique, nominal, and gross

IRR measures the profitability of an investment. It is the interest rate, i, for which the net present value of an investment is zero. As our perspective is forward-looking on retirement, returns are weighted by survival probabilities.[8] As we take a *backward*-looking perspective on employment, the flow of investment, i.e. the pension contributions, enter the computations in non-weighted form. Let t denote a period, $B_t \geq 0$ the pension contribution in t, and $E[R_t]$ the expected value of the pension $R_t \geq 0$, then the expected IRR at the moment of retirement (year 2005) ensures that

[7] See German Federal Statistical Office (2007) for information on life expectancies and age differences between male and female spouses.
[8] See Section 2.2 for details.

(1) $$\sum_{t=1954}^{2005} B_{j,t} \cdot (1+\mathrm{i}_j)^{2005\text{-t}} = \mathrm{R}_{\mathrm{j},2005} + \sum_{t=2006}^{T} \mathrm{E}\left(\mathrm{R}_{\mathrm{j,t}}\right) \Big/ (1+\mathrm{i}_j)^{\text{t-}2005}.$$

Generally, if the sign of cash flows repeatedly changes over time, multiple IRR can be obtained, making it difficult to decide which IRR to use. This complication does not apply in our case as the sign changes only once, namely from exclusively negative during the contribution phase to positive in the retirement phase. Hence, individual IRR functions are continuous and unique, potentially ranging from plus infinity to minus infinity.

In principle, IRR can be obtained from cash flows denominated in real or nominal terms. In the first case, contributions and pension entitlements are expressed in prices as of the time of occurrence of the flow. In the second case, they are expressed in prices as of the day of the evaluation. Using data on past consumer prices, it is possible to convert previous contributions in real terms. Expressing future returns in real terms, however, would require price forecasts for the next decades. As forecast errors can be huge, we have expressed all flows in nominal terms. Measuring IRR in nominal terms has a second merit as it allows comparisons with nominal capital market interest rates.

The German pension system is stabilized via substantial tax-financed state subsidies. Non-insurance-related benefits such as transfers to the new federal states, to families, immigrants and minimum pensions, which are not entirely covered by own contributions, are the rationale for these subsidies. The rise in VAT rates in April 1998 was justified by a rising deficit in the public pension system and the political will not to further increase contribution rates. Since year 1990, the share of total PAYG expenses that was covered by state subsidies rose from 18.7 to 27.8 percent (see Figure 3 for details). Our IRR estimates do not reflect that such subsidies are financed by taxes, also imposed on the beneficiaries. Moreover, tax-subsidization may have additional distributional effects. Germany’s income-tax tariff, for example, is progressive. Taking such an effect into account would reduce the IRR of “rich” relative to the “poor.”

Finally, our IRR estimates are gross. In the German PAYG system, pension contributions are equally financed by the beneficiary and her employer. Eventually, both reduce the beneficiary’s net earnings so that we interpret the sum of both as the beneficiary’s investment.[9] To be consistent, we consider gross pension entitlements before tax deductions, health care or care insurance contributions when calculating the IRR.

[9] For empirical evidence that the incidence of payroll taxation is fully on wages see, for example, Gruber (1997).

3.2 Deriving IRR from the database

This subsection first sketches the legal framework determining pension contributions and entitlements. Then we show how the necessary information can be derived from CIB and complementary external databases and summarize our working assumptions.

Book six of the Social Security Code contains the legal framework of Germany's statutory pay-as-you-go pension system. A central characteristic of the system is a close relation between the sum of earnings liable to compulsory insurance from so-called "contribution periods" and monthly pension entitlement after retirement. However, pension entitlements can also be gained during so-called "non-contribution periods". For example, when a mother withdraws from the labor market after the birth of a child, pension contributions (and corresponding entitlements) are credited for a limited period although she did not make pension contributions from own earnings in the same period. Non-contribution periods can be credited for the following reasons: (i) sickness, rehabilitation, studies or higher education, and others (so-called "Anrechnungszeiten"); (ii) military service or detention due to political reasons (so-called "Ersatzzeiten"); (iii) child-raising or care of dependants ("Berücksichtigungszeiten").

The sum of all the credited pension contributions of a beneficiary j in period t, $b_{j,t}$, (in Euro) equals

$$(2) \qquad b_{j,t} = \overline{E}_t \cdot CR_t \cdot RP_{j,t} .$$

In equation (2), $\overline{E}_t$ is the national average of earnings in t (expressed in Euro), CR_t the contribution rate in t, and $RP_{j,t}$ denotes the remuneration points accumulated by j in t. $\overline{E}_t$ and CR_t are identical for all beneficiaries and can be taken from official statistics. $RP_{j,t}$ is beneficiary-specific and is stored in CIB's variable part. Remuneration points from own employment are directly linked with annual earnings subject to compulsory insurance. If j's earnings in period t coincide with average earnings of all employed workers in the same year (50 percent of the national average), $RP_{j,t} = 1.0$ ($RP_{j,t} = 0.5$). Accumulated remuneration points during aforementioned non-contribution period do not reflect an investment. For this reason, they are not included when a beneficiary's investment is computed. However, they are considered when the pension entitlement is defined.

It is possible to distinguish remuneration points from own contributions and from non-contribution periods through combining, month per month, the information contained in the variables $mEGPT_1,...,mEGPT_{624}$, $gmEGPT_1,...,gmEGPT_{624}$, $SES_1,...,SES_{624}$, and $JKUM_1,...,JKUM_{624}$. The variable $mEGPT_m$ provides the remuneration points from principal employment in month m. The variable $gmEGPT_m$ is an aggregate including remuneration points from principal *and* non-principal employment *as well as* from non-contribution periods. The variable SES_m describes the insurant's social status, e.g. whether the insurant is employed, unemployed, is raising a child or caring for an ill partner. The dummy variable $JKUM_m$ indicates whether the insurant has more than one employment contract subject to mandatory insurance.

In our calculations, monthly pension contributions are defined by $mEGPT_m$ whenever $JKUM_m$ does not indicate more than one employment contract subject to mandatory insurance. Otherwise, we use $gmEGPT_m$. Our approach may lead to some error in the value of the derived investment if beneficiaries have two or more employment contracts and, in the same month, are credited remuneration points for a non-contribution period. Such cases should be a rare exception.

When computing actual insurants' investments, only contributions from own earnings should matter. Accordingly, let $m = a$ denote the first and $m = a + 11$ the last month of a year t, then *remuneration points from own contributions* are determined via

$$(3) \qquad RP_{t,j}^{own} = \sum_{m=a}^{a+11} mEGPT_{j,m} \cdot E1_{j,m} + \sum_{m=a}^{a+11} gmEGPT_{j,m} \cdot E2_{j,m} .$$

In equation (3), $E1_{j,m}$ and $E2_{j,m}$ denote dummy variables. $E1_{j,m}$ ($E2_{j,m}$) equals one if beneficiary j earns exactly one income (more than one income) subject to compulsory insurance in month m. Otherwise, the respective dummy is zero.[10] Then, j 's annual contributions from own earnings in t equal $b_{j,t}^{own} = \bar{\bar{E}}_t \cdot CR_t \cdot RP_{j,t}$. The sum of contributions made by the beneficiary and her employer is $B_{j,t} = 2 \cdot b_{j,t}^{own}$.

Pension entitlements are defined by the so-called "pension formula". According to SSC VI §64, the *annual* pension entitlement of an insurant j in year t is

$$(4) \qquad R_{j,t} = 12 \cdot A_t \cdot E_j \cdot RA_j .$$

The variable A_t denotes the aggregate level of current pensions ("Aktueller Rentenwert"), a monetary amount that links up the pension entitlement with several macro variables including

[10] Further details on the handling of the data and the STATA codes can be provided by the author upon request.

the wage sum, the nation-wide sum of pension contributions, the demographic structure of the population, etc. (see SSC VI §68 for details). In year 2005, for example, the current pension level in Germany's Old Federal States was €26.13. The variable E_j is the number of *personal* remuneration points a beneficiary has accrued over the lifetime (stored in the variable *psegpt90* in the fix part of the CIB database), i.e. the sum of all remuneration points (from own contributions and also from non-contribution periods) corrected for the so-called "Zugangsfaktor". The latter reduces annual pension entitlements in case of early retirement (see SSC VI §77 for details).[11] Finally, the "Rentenartfaktor", RA_j, differs by the type of pension that is defined in the variable *LEAT* in CIB's fix part. For example, the Rentenartfaktor equals 1.0 when an old-age pension according to SSC Book VI, §§ 35, 36, 37, 237, 237a is granted. It is 0.55 when a "large" widow(er) pension is granted (see SSC VI §77 for details). Now, the actual pension entitlement of an insurant can be computed. However, an assumption is necessary concerning the evolution of pension entitlements for future years. We assume a rather conservative scenario where all future pension entitlements (from year 2009 and on) are frozen at the nominal level of year 2008.[12]

With the streams of contributions, pension entitlements and survival probabilities, the expected nominal IRR for every beneficiary can be computed. When no survivor pension must be taken into account, IRR equalizes the value of annual contributions (from own earnings) during the active phase and the expected annual pension entitlements in the passive phase

$$(5) \qquad \sum_{t=1954}^{2005} B_{j,t} \cdot (1+\mathrm{i}_j)^{2005\text{-t}} = \sum_{t=2005}^{2046} \mathrm{R}_{\mathrm{j,t}} \cdot P_{j,t}\left(a_j, g_j\right) \Big/ (1+\mathrm{i}_j)^{\text{t-}2005} .$$

In equation (5), $B_{j,1954}$, for example, denotes the annual amount of pension contributions from own employment of beneficiary j (and her employer) in year 1954, and $R_{j,2006}$ is the pension entitlement in year 2006. The term $P_{j,t}\left(a_j, g_j\right)$ denotes the probability that a person j of gender g_j retiring at age a_j is alive in period t.

The returns from an insurant's contributions do not necessarily end after her death, i.e. if a surviving partner exists who is credited a widow(er) pension.[13] We interpret survivor pensions

[11] Today's pension entitlements are reduced by 0.3 percent per month of early retirement.
[12] Even if future replacement rates decline, it is quite unlikely that future *nominal* pension entitlements will fall.
[13] The variable FMSD from the fix part of the VVL database allows a distinction between non-married and widowed as well as between married and re-married beneficiaries.

as a further but risky return component on beneficiaries' pension contributions.[14] The expected value of the survivor pension is derived using the joint probabilities from Section 2.2. Let $W_{k,t}$ be the survivor pension being paid to j's partner k, then equation (5) becomes

$$(5a) \qquad \sum_{t=1954}^{2005} \mathrm{B}_{\mathrm{j,t}} \cdot (1+\mathrm{i}_j)^{2005\text{-t}} = \sum_{t=2005}^{2046} \left[\left[\mathrm{R}_{\mathrm{j,t}} \cdot P_{j,t}\left(a_j, g_j\right) + \mathrm{W}_{k,t}\left(\mathrm{R}_{j,t}, \mathrm{Y}_k\right) \cdot Q_{j,t}\left(a_j, g_j\right) \right] \Big/ \left(1+i_j\right)^{t-2005} \right]$$

with $Q_{j,t}$ indicating the joint probability that an insurant with characteristics $\left(a_j, g_j\right)$ in year t is dead whereas the married partner is still alive. The level of the survivor pension depends on j's pension entitlement and several socio-economic characteristics of the partner, captured by the vector Y_k: the partner's own pension entitlement, age, health status, etc. Unfortunately, CIB does not provide information on the partner's characteristics. We assume that the surviving partner always receives a "large" widow(er) pension and that the corresponding income equals the mean pension entitlement of a married beneficiary of the same gender. According to SSC VI, any Euro of a survivor's income exceeding a threshold amount of 26.4 times the current pension level reduces the survivor pension by € 0.40. As "large" widow(er) pensions are granted if the surviving partner has reached the age of 47 and all insurants in the working sample are of age 60 or older, using "large" widow(er) pensions in the computations should be an appropriate procedure.

4 Sample description

Table 1 provides the sample composition. The sample is about equally split in male and female beneficiaries. About three out of four beneficiaries are married or re-married. The average age at retirement is about 63 years with hardly any difference between male and female beneficiaries. Accordingly, compared to the official retirement age of 65 years in year 2005, the average beneficiary retires about two years earlier. Indeed, as can be seen from Figure 4, a substantial fraction of the working sample already retires around the age of 60 years.

Table 2 illustrates the sample composition by type of old-age pension. Most beneficiaries receive an old-age retirement pension according to SSC VI §35, a so-called "Regelaltersrente". Entitlement to "Regelaltersrente" requires that a beneficiary has completed her 65th life year, and has been insured for a specific time period (the so-called "Wartezeit"). Other beneficiaries in the sample receive an unemployment or part time work

[14] Orphans' pensions (see SSC VI §48) or child-raising pensions (see SSC VI §47) cannot be modeled adequately and are not considered in our calculations.

old-age pension. Such an old-age pension is credited to beneficiaries of age 60 or older in case of unemployment or part time employment around retirement (see SSC VI §237 for details). For female beneficiaries further regulations may apply (SSC VI §237a). Altogether 4,241 female beneficiaries are entitled to old-age pensions according to SSC VI §237 and §237a.

Specific regulations also apply to handicapped persons. A handicapped person is granted an old-age pension after having completed her 63rd year of life if she can claim a "Wartezeit" of at least 35 years.[15] Altogether, 2,151 beneficiaries are entitled to such a pension, the predominant fraction of them being male. Finally, old-age pensions for long-term insured persons ("Altersrente für langjährig Versicherte", SSC VI §36) are granted to beneficiaries of age 62 to 65 years with a "Wartezeit" of 35 years. With 1,888 out of 2,161 cases, male beneficiaries constitute the dominant part of this sub-sample.

Gender-specific distributions of remuneration points accumulated over their lifetimes can be taken from Figure 5. It is transparent that male beneficiaries, on average, accrue more remuneration points and hence are entitled to higher annual pensions than female beneficiaries. As can be taken from Figure 6, most of the difference can be explained by the fact that male beneficiaries typically have longer contribution periods compared to female beneficiaries. Yet, also the composition of the remuneration points is gender-specific.[16] As outlined above, remuneration points can be gained from own contribution periods but also from non-contribution periods. Table 3 gives the shares of remuneration points accrued during periods when no own contributions were made. On average, about 15 percent of a beneficiary's remuneration points stem from non-contribution periods, and about 85 percent result from own contribution periods. The fraction of remuneration points from non-contribution periods is substantially higher for female beneficiaries (22.226 percent compared to 7.489 percent). Particularly, remuneration points for child raising periods and care for an ill partner are driving this divide.

5 IRR estimates and the IRR distribution

Section 5 consists of two parts. Section 5.1 provides descriptive statistics of the IRR and its distribution. A regression analysis quantifying the determinants of IRR follows in Section 5.2.

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[15] Under specific conditions, the pension can already be granted at an age of 60 year.

[16] Remuneration points from contribution-free periods (VVL05 variable: byfhep90); remuneration points from periods of reduced contribution (VVL05 variable: bygmep90); additional remuneration points from periods of reduced contributions (VVL05 variable: zbygme90); remuneration points for childcare (VVL05 variable: dvki90); additional remuneration points for childcare and care (zqegki90).

5.1 Descriptive statistics

Table 4 presents the IRR sample means and standard deviations for the entire working sample, differentiated by gender and also by type of old-age pension. For example, consider the entry in row “Standard old-age retirement pension (SSC VI §35)” in column “Female insurants”. It indicates that the expected average IRR on pension contributions for female beneficiaries receiving a standard old-age retirement pension is 4.753 percent. We would like to remind the reader that all IRR estimates are conditional upon insurants’ survival until retirement and healthy completion of employment history (i.e., not being disabled). Moreover, it is assumed future pension entitlements are frozen on 2008 level.

An immediate observation following from the figures is that female beneficiaries benefit from an above-average expected IRR, i.e. 3.884 percent compared with 2.572 percent for male beneficiaries. The difference in gender-specific average IRR can be explained by a longer payoff phase for females resulting from a higher life-expectancy. Another reason is that particularly females benefit from remuneration points credited in non-contribution periods for childcare, etc. By type of old-age pension, recipients of a standard old-age retirement pension benefit from a particularly high IRR. The regression analysis following in Section 5.2 investigates these and other relationships in more detail.

Figures 7 and 8 complement the information provided in Table 4 by IRR histograms. In each graph, the horizontal axis gives IRR, and the vertical axis the relative frequency of beneficiaries with a respective IRR level. Figure 7 provides the gender-specific information for the full sample, and Figure 8 provides IRR histograms by type of old-age pension. Black bars always relate to female beneficiaries, grey bars to male beneficiaries.

Figure 7 suggests that IRR distributions are highly gender-specific. For male beneficiaries, the distribution looks lognormal with a peak slightly above two percent and a fatter right than left tail. For female beneficiaries, the distribution is about uniformly distributed between 2.0 and 4.5 percent, and it possesses a fatter right tail. Histograms by pension-type in Figure 8 support the impression of systematic gender-specific differences even after controlling for the type of pension. Most pronounced, is the difference in SSC VI §35-related pensions. Here the shape is uniform for female beneficiaries with a peak at an IRR level of about 4.5 percent. For male insurants, the distribution has two peaks, one at an IRR level of about 2.0 percent and another around 4.0 percent. The graph for §237a pension-recipients contains only one histogram. The reason is that only female insurants are credited §237a pensions. The peak of the histogram is at an IRR level of around 2.5 percent.

5.2 Regression analysis

The subsequent regression analysis is performed for two purposes. First, it quantifies how insurants' individual characteristics and PAYG system inherent regulations affect IRR. Second, it sheds light on whether such regulations have similar effects on the IRR of female and male beneficiaries after controlling for individual characteristics.

The regression model is

$$(6) \qquad i_j = \alpha + \sum_r \beta_r \cdot s_{j,r} + \zeta \cdot \Delta RP_j + \sum_p \delta_p \cdot D_{j,p} + \phi \cdot Partner_j + \varphi \cdot \Delta Age_j + \varepsilon_j .$$

The left-hand variable i_j is the nominal internal rate of return for beneficiary j in percent. The parameter α denotes the regression constant. The variable $s_{j,r}$ gives the share of remuneration points of type r, excluding the share of remuneration points from own contributions to avoid multi-collinearity. As remuneration points from own contributions are excluded from the regression, β_r should be positive for non-contribution periods when remuneration points are credited as a result of specific regulations, e.g. childcare.[17] To assess how earnings capacity affects IRR, we further include the variable $\Delta RP_j = \frac{RP_j}{\overline{RP}}$. It reveals how much, in relative terms, the total sum of remuneration points from own contributions, RP_j, deviates from the sample mean, $\overline{RP}$. If $\zeta > 0$ ($\zeta < 0$), IRR is positively (negatively) related with earnings capacity and the system entails a lifetime regressive (progressive) element. $D_{j,p}$ is a dummy variable. It takes the value 1 if beneficiary j receives an old-age pension according to paragraph p (other than SSC VI §35 which serves as the reference). Hence, parameter δ_p captures IRR differences across different types of old-age pensions. $Partner_j$ is a dummy indicating the marital status of the insurant. It is set equal to one if the insurant is married and zero else. Due to survival pensions, we should expect the respective regression coefficient ϕ to be positive. The variable ΔAge_j gives the difference between the official retirement age and insurants' age at retirement, so that φ captures the effect of early

[17] See also Sinn (2004), and Cigno et al. (2003) for the resulting incentive effects.

retirement on IRR.[18] Finally, ε_j denotes the error term. In addition to a regression based on the full working sample, we also run gender-specific regressions and apply χ^2 tests to investigate whether the right hand side variables have the same effects for male and female insurants.

The regression results are provided in Table 5. Adjusted coefficients of determination suggest that the regression models capture heterogeneity in IRR satisfactorily well. F statistics reject the null-hypothesis that all the regression coefficients (excluding the constant) are zero.

Concerning the composition of remuneration points, remuneration points from childcare and care have a particularly positive impact on IRR. The χ^2 test statistic indicates that the effect is more pronounced for females (at 10 percent significance level). Moreover, such remuneration points are typically accumulated by female beneficiaries, contributing to the gender divide in IRR observed in Section 5.1. For the full sample, the regression coefficient pertaining to the share of additional/credited remuneration points for childcare has no significant effect. For the male sub-sample, it has a strong and negative effect. However, the result should not be overrated: only eight male insurants are credited additional/credited remuneration points, and the share of such remuneration points in the total sum of remuneration points for the eight insurants is quite low (ranging between 0.204 and 0.341 percent). The regression coefficient for the "share of remuneration points from contribution-free periods" exhibits a negative sign for all three samples. The effect of contribution-free periods on IRR is quantitatively stronger for females (at five percent level). Contribution-free periods include periods when no own contributions have been made for reasons not in the responsibility of the insurant (so-called "Ersatzzeiten"). Particularly, such periods include war captivity and prosecution during Nazi dictatorship. Contribution-free periods also encompass none-insured periods due to sickness, maternity or unemployment (so-called "Anrechungszeiten"). IRR decreases in the "share of remuneration points from such contribution-free periods," and the effect is stronger for female insurants. The "share of remuneration points from periods of reduced contributions" rises IRR, at least for male insurants. For female insurants, the effect is insignificant. Periods of reduced contributions are a mixture of own-contribution periods and "Anrechnungszeiten", for example, a month where an insurant is working part-time and simultaneously is enrolled as a student. If, during such

[18] The expected life expectancy of the partner after the beneficiary's death and the beneficiary's life expectancy after retirement are highly correlated. The same applies to the difference between official retirement age and the beneficiary's age at retirement. To avoid problems of multi-collinearity, we refrained from including the retiree's life expectancy in the regression.

periods, remuneration points from own contributions fall below a specific threshold, additional remuneration points are granted (see SSC VI, § 71, para. 2). The effect is particularly strong for male insurants. The "share of additional remuneration points from periods of reduced contributions" also has a positive effect on IRR. Again, the effect is more pronounced for male compared to female insurants.

Earnings capacity, measured by ΔRP^j, turns out to be negatively related with IRR: the more contributions from own earnings an insurant has provided over her/his lifetime, the lower is IRR. Interpreting IRR as an indicator of the life-time redistribution, the finding indicates that Germany's pension system is progressive, redistributing in favor of insurants with a lower earnings capacity. The effect is more pronounced for male compared to female insurants. We would like to remind the reader that the survival probabilities underlying our calculations do not differentiate with respect to income. Differential mortality may weaken or even offset the progressive effect.[19]

Via survivor pensions, the system also redistributes in favor of married insurants. Compared with non-married beneficiaries, average IRR for the married is significantly higher. The longer life expectancy of females in combination with the positive age difference between husbands and spouses explain why the effect is more pronounced for male insurants (regression coefficients of 0.456 for male and 0.126 for female insurants, and a highly significant χ^2 statistic).

Early retiring beneficiaries receive below-average returns reflecting regulations punishing early retirement (for the role of early retirement on returns on pension contributions see also Börsch-Supan, 2000, and references cited therein). As indicated by an insignificant χ^2 statistic, the impact of such regulations is the same for male and female insurants.

Concerning the set of dummy variables distinguishing retirees by type of pension, full sample estimates indicate no differences in IRR for §35 retirees, our reference group, §36 and §237 retirees. However, recipients of a old-age pensions for handicapped persons (SSC VI, §37) benefit from a slightly higher IRR, while the opposite is true for females receiving a §237a pension. The latter finding is driven by the fact that female §237a-pension recipients, on average, retire 2.893 years earlier than female insurants falling into another pension category.

[19] Empirical evidence on the quantitative impact of income-differentiated mortality on the progressiveness of Social Security is mixed. For an overview see Liebman (2001).

Finally, the regression constant is the same for female and male insurants. After controlling for all the right-hand side variables, regressions do not indicate IRR of male and female insurants to be different.

6 Implications

To get a better idea about what an average IRR of 3.3 percent means, it may be interesting to compare this number to the returns of a risk-free asset. We have chosen German Federal Treasury notes (with a seven-year life) as a benchmark. Between years 1969 and 2005, the average rate of return on such notes was 6.31 percent, although rates of return are lower from year 2000 and on. This can be seen from Figure 9 that provides time series of rates of return on seven-year life German Federal Treasury notes. Accordingly, in a world where insurants would have had an option to invest their PAYG contributions in bonds, they had been better-off.

Making such a direct comparison of returns is naive for a number of reasons. The PAYG system involves a life-insurance element. In particular, there are two issues concerning the timing of death. First, the capital stock from an investment in treasury notes may be exhausted too early in case the person lives longer than expected. On the contrary, the PAYG system covers the insurant until the random date of death. The second issue about the timing of death is that the insurant might die “too young”, even many years before retirement age. Then the PAYG system can serve, via survivor pensions, as insurance for the surviving partner (or children). Such a risk is not insured by an investment in treasury notes. Via pensions for the disabled, the PAYG system also provides insurance in case of reduced earning capacity. Risk-averse insurants may be reluctant to accept a low but stable rate of return on PAYG contributions rather than higher yet more volatile returns on bonds. Another aspect is that it is not ruled out that capital markets are affected by population ageing, too (with some delay). The asset market meltdown hypothesis predicts that, when the baby boomers retire, they will sell bonds and stocks and this will negatively affect the value of such assets (see Poterba, 2001). Then returns on assets in the past are a too optimistic predictor for their future returns. Also, the recent turbulence in financial markets indicates that even conservative saving plans do not assure that saving wealth will be enough to pay for an adequate living standard during retirement.

To better understand the meaning of our IRR estimates it is also interesting to examine the specific macro-economic conditions in the contribution phase of the 2005 retirees and the actual conditions when the entitlements must be financed by today's contributors. For this reason, Figure 10 depicts the long-run trends of several macroeconomic variables since the early/mid 1950s. Our working sample experienced a long phase with low unemployment rates, particularly in the 1950s until the early 1970s. Also labor productivity and wage growth have been quite high particularly in the earlier years, yet slowing down over the observation period. Particularly in the early years, a huge gap in gender-specific labor force participation rates existed, but the gap continuously narrowed. Low birth rates together with a rising life expectancy doubled the dependency ratio from about 16 percent in year 1950 to about 32 percent in the late 2000. Compared to the later periods, inflation rates have been relatively high in the 1970s and in the early years after unification.

Particularly the upward trend in the dependency ratio puts "stress" on the PAYG system. The higher the dependency ratio, the more retirees' pension entitlements each actual contributor needs to finance. Ensuring a positive IRR for today's elderly may result in higher contribution rates for today's active generation and/or require higher tax-financed transfers thereby shedding doubts on the sustainability and economic attractiveness of the system for later generations. Nevertheless, only recently the German government has passed a law that nominal pension entitlements of today's pensioners will never decline, most likely resulting in higher contribution rates in the next years. Accordingly, our scenario with inter-temporally constant nominal pension entitlements may be a good benchmark for the actual IRR levels for the birth cohort 1940 to 1945.

Low inflation rates and low nominal wage growth in recent years tend to lower average IRR. Given that inflation rates remain at a low level, future pensioner generations, ceteris paribus, are likely to realize lower nominal returns on their pension investments than the birth cohorts investigated in the present paper. If inflation rates systematically change over time, a fair profitability comparison, however, requires an IRR measurement in real terms.

The decline in fertility together with the rise of female labor supply will have implications for the IRR distribution of future pensioner cohorts. Both trends are likely to reduce the length of non-contribution periods of female insurants, and this should translate into lower IRR for future female pensioner cohorts. Accordingly, it is likely that the gender divide in IRR becomes lower in the next decades. Converging labor-force participation rates of females and males should work in the same direction.

Finally, given the political will to guarantee a minimal living standard for pensioners together with rising unemployment rates and discontinuous employment biographies, more redistribution will be required in the future. A provision of the funds via higher PAYG contributions or lower returns, ceteris paribus, puts further pressure on the returns of insurants whose pension exceeds the legal minimum. An alternative financing via taxes results in a higher tax burden for particular economic groups or for the entire economy. If the sum of total earnings is negatively affected by such a policy, pension cuts and lower IRR for future cohorts are likely.

7 Concluding remarks

Based on real-life employment biographies for German PAYG pension insurants retiring in year 2005, the present paper has provided the distribution of intra-cohort internal rates of return on pension contributions. Such information should be particularly useful to policy makers who want to understand the intra-cohort redistributive effects of Bismarck-type pension systems.

Under the conservative assumption that nominal future pension entitlements are frozen at year 2008 level, we find that the expected average nominal internal rate of return is slightly above three percent. Differences in life expectancy, earnings capacity, marital status and other socio-economic characteristics, however, translate into substantial differences in IRR across insurants. Our findings suggest that the German pension system, at least within the cohort retiring in 2005, redistributes towards female insurants (due to a higher life expectancy), married insurants (due to survivor pensions), and towards insurants with children (as periods of child-care are credited in the German pension system). Moreover, it turns out that the system is intra-cohort progressive, as indicated by a negative correlation between rates of return and lifetime earnings-capacity.

Finally, some words on the limitations of our analysis. First, our IRR estimates are conditional upon reaching retirement age. Insurants deceasing earlier are not included in our calculations. The fraction of the population not reaching retirement age is about 15 percent for male and eight percent of female insurants. If no survivor pension is granted, the de-facto IRR of these insurants is minus infinity (positive investments but zero returns). Second, insurants with East German employment biographies are not included in our working sample. Germany’s pension system, however, grants pension entitlements to people with East German employment biographies. As we see no sensible way to convert Mark, the currency in the former GDR to Euro, we have excluded these insurants from the analysis. Third, the working sample exclusively consists of old-age pensioners. Accordingly, our estimates do not reflect that the system redistributes resources to recipients of a pension of limited duration paid during a period of a serious illness. The inclusion of such benefits may affect both level and patterns of intra-cohort redistribution. Finally, the IRR estimates do not reflect that billions of taxes are spent to stabilize the system year by year, and that pensioners bear part of the tax burden. In year 1990, taxes in the amount of € 20.371 Billion have been transferred to stabilize the system. Until 2008, the amount has more than tripled to € 78.615 Billion (see German Pension Insurance, 2009, p. 221).

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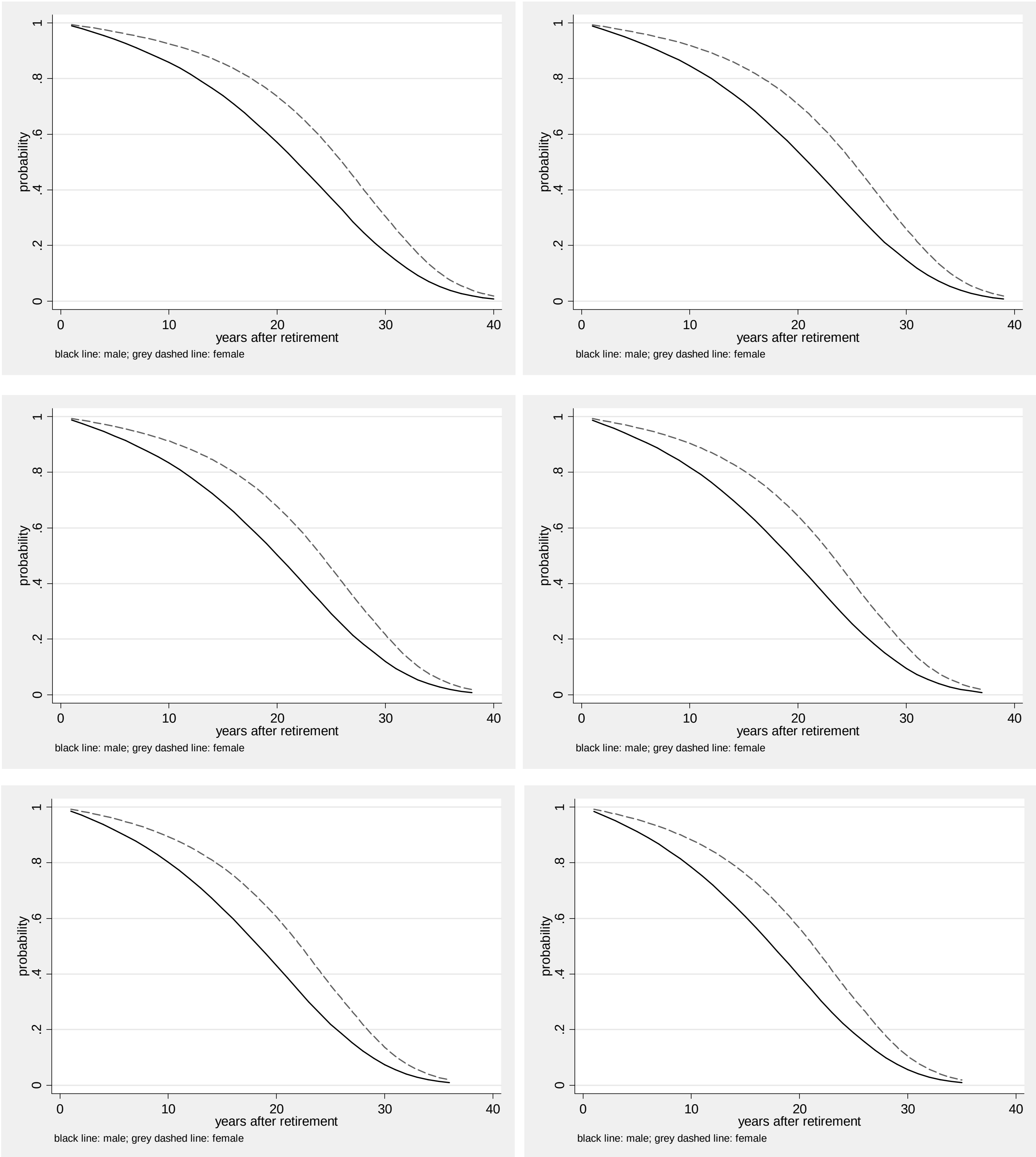

Figure 1. Survival probabilities by age cohort.

Note. From left to right and top to bottom: insurants retiring at age 60, 61, 62, 63, 64, and 65. Data from German Federal Statistical Office (2007).

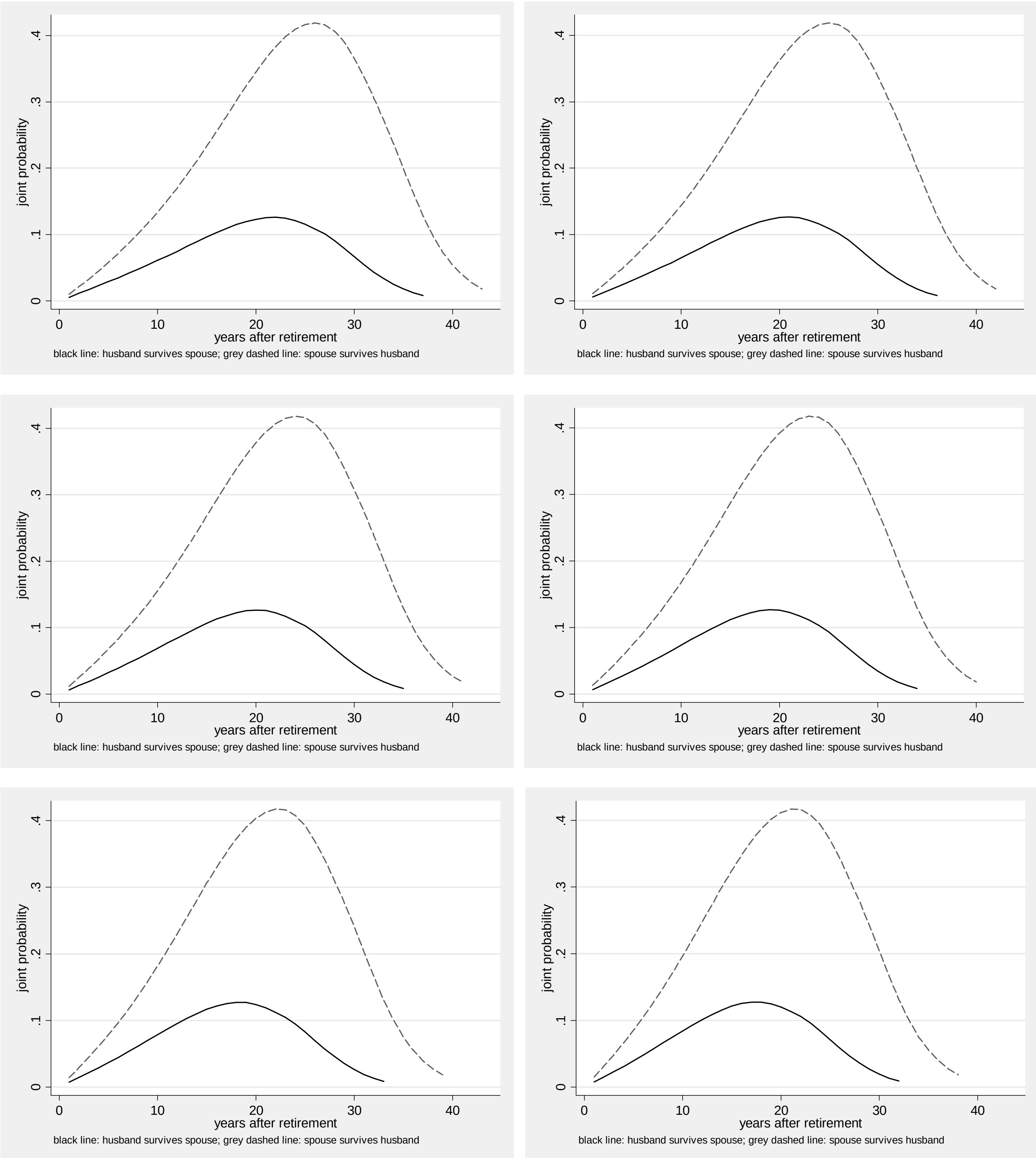

Figure 2. Joint survival probabilities by age cohort.

Note. From left to right and top to bottom: insurants retiring at age 60, 61, 62, 63, 64, and 65. Data from German Federal Statistical Office (2007).

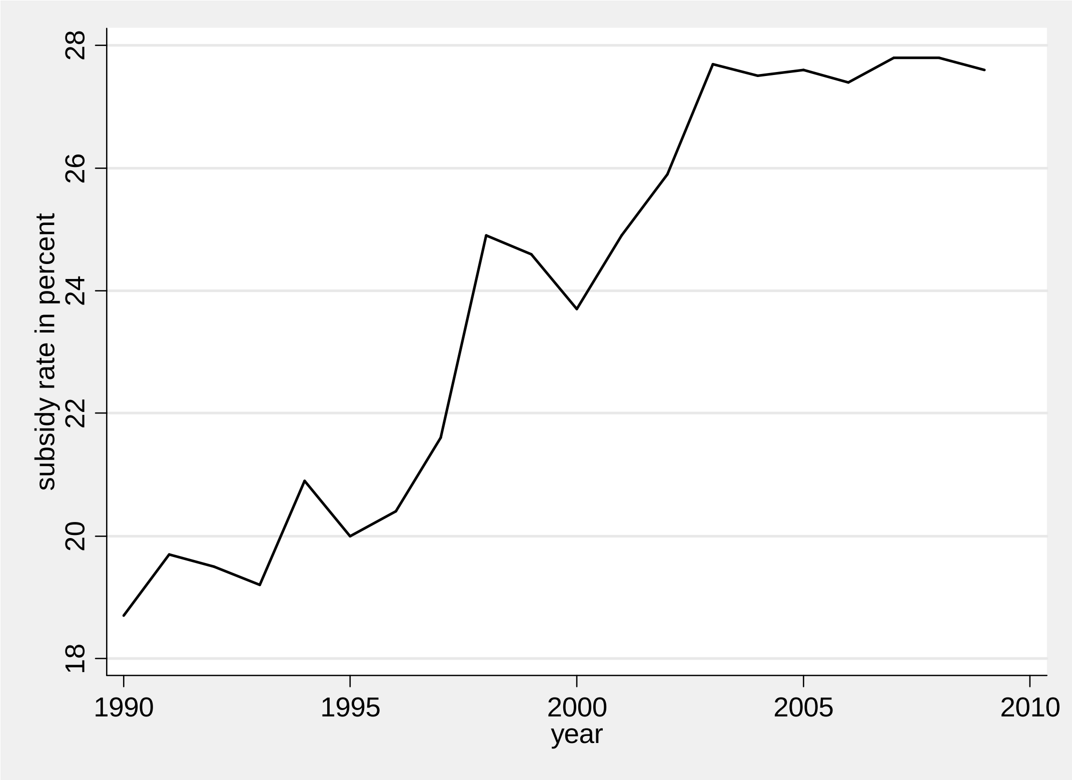

Figure 3. Share of tax financed expenditures of the German PAYG system.
Note. Data from German Pension Insurance (2009). Own calculations.

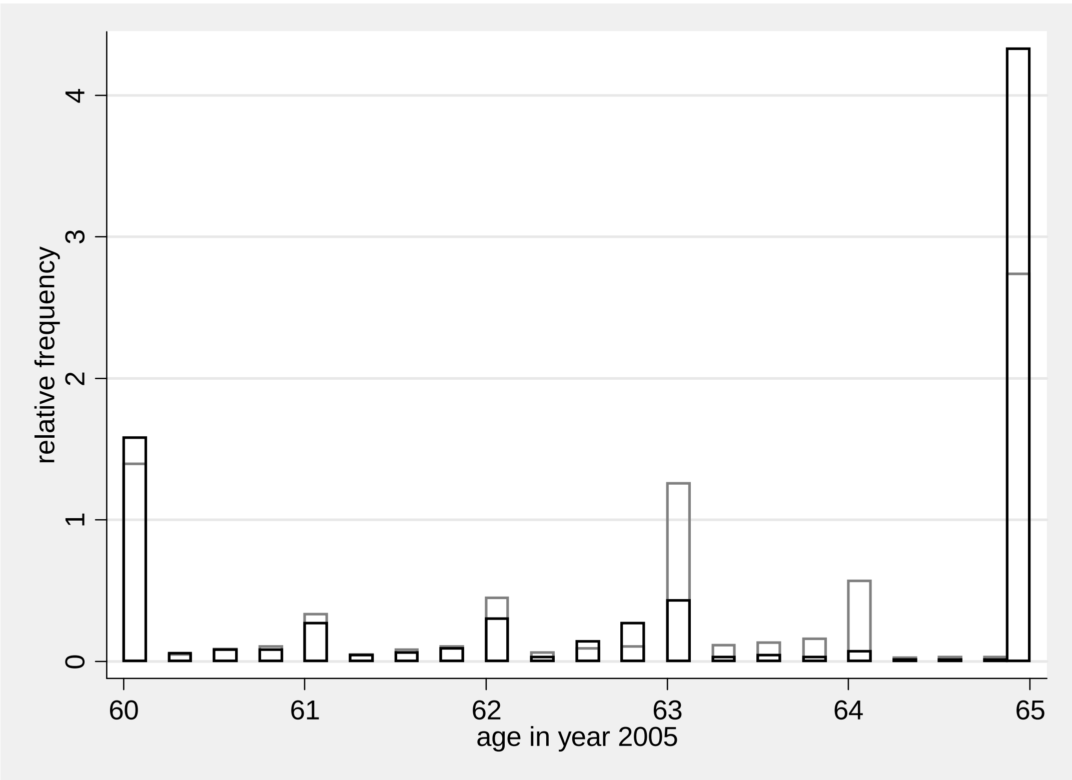

Figure 4. Retirement age, decomposed by gender.
Note. Database is CIB 2005. Own calculations. Female beneficiaries: black bars; male beneficiaries: grey bars.

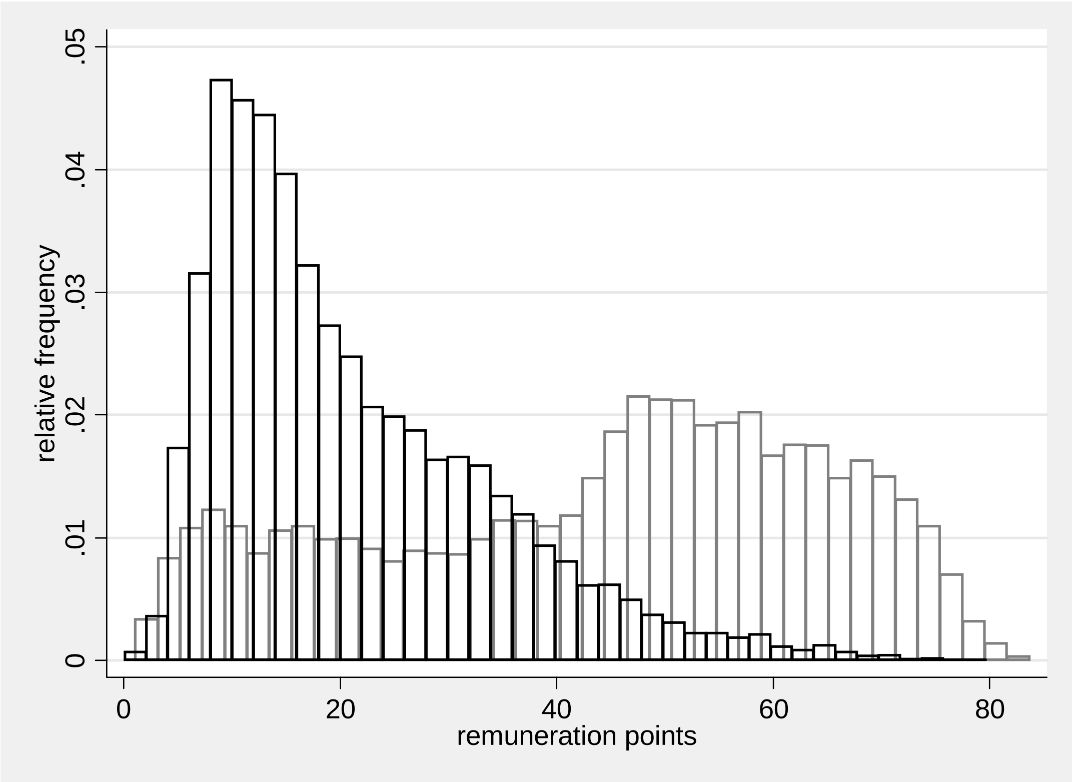

Figure 5. Remuneration points, decomposed by gender.
Note. Database is CIB 2005. Own calculations. Female beneficiaries: black bars; male beneficiaries: grey bars.

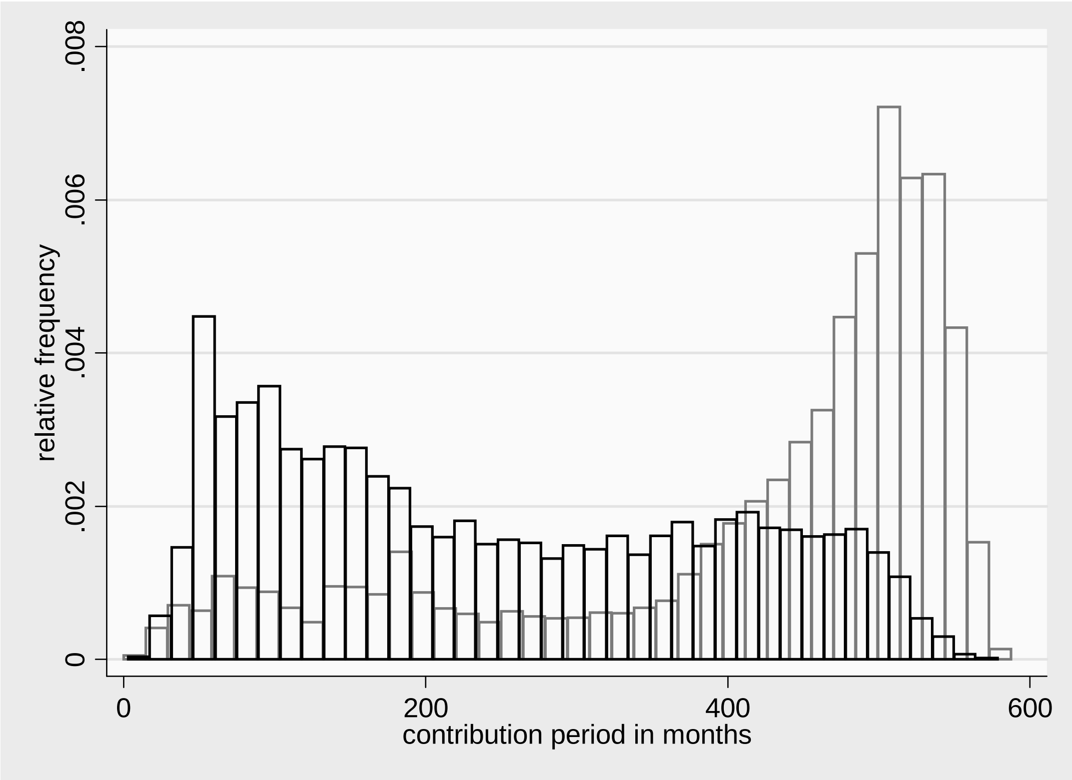

Figure 6. Length of contribution period by gender.
Note. Database is CIB 2005. Own calculations. Female beneficiaries: black bars; male beneficiaries: grey bars.

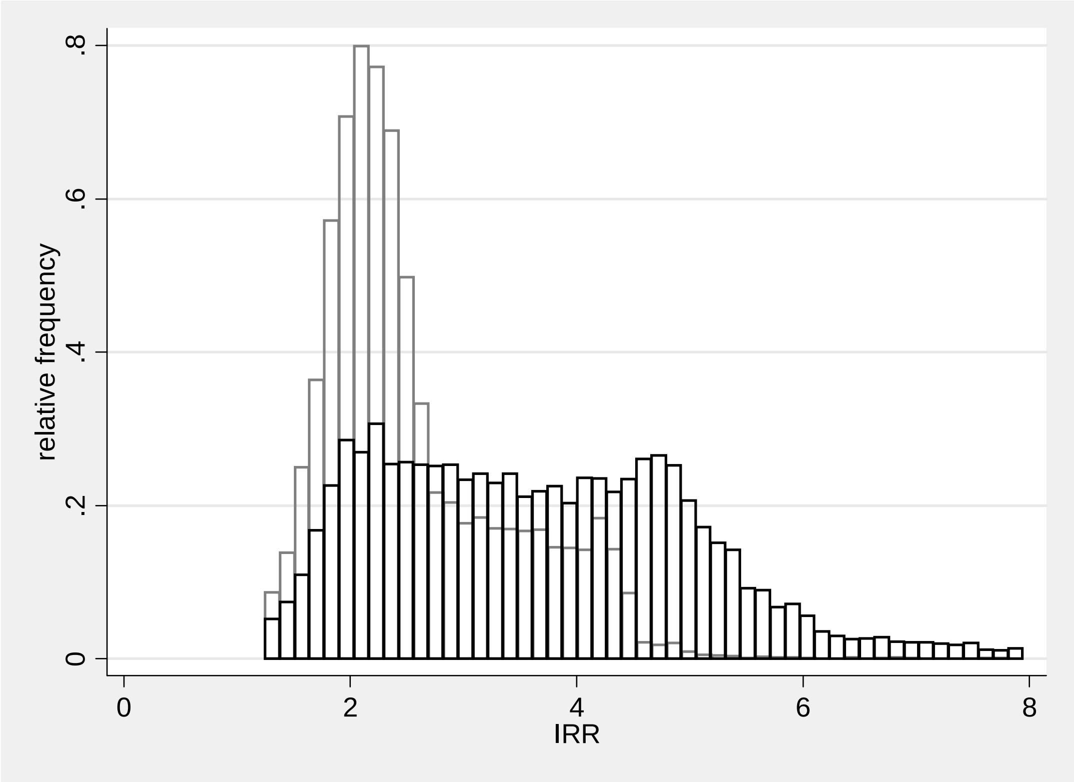

Figure 7. Rate of returns, decomposed by gender.

Note. Database is CIB 2005. Own calculations. Female beneficiaries: black bars; male beneficiaries: grey bars.

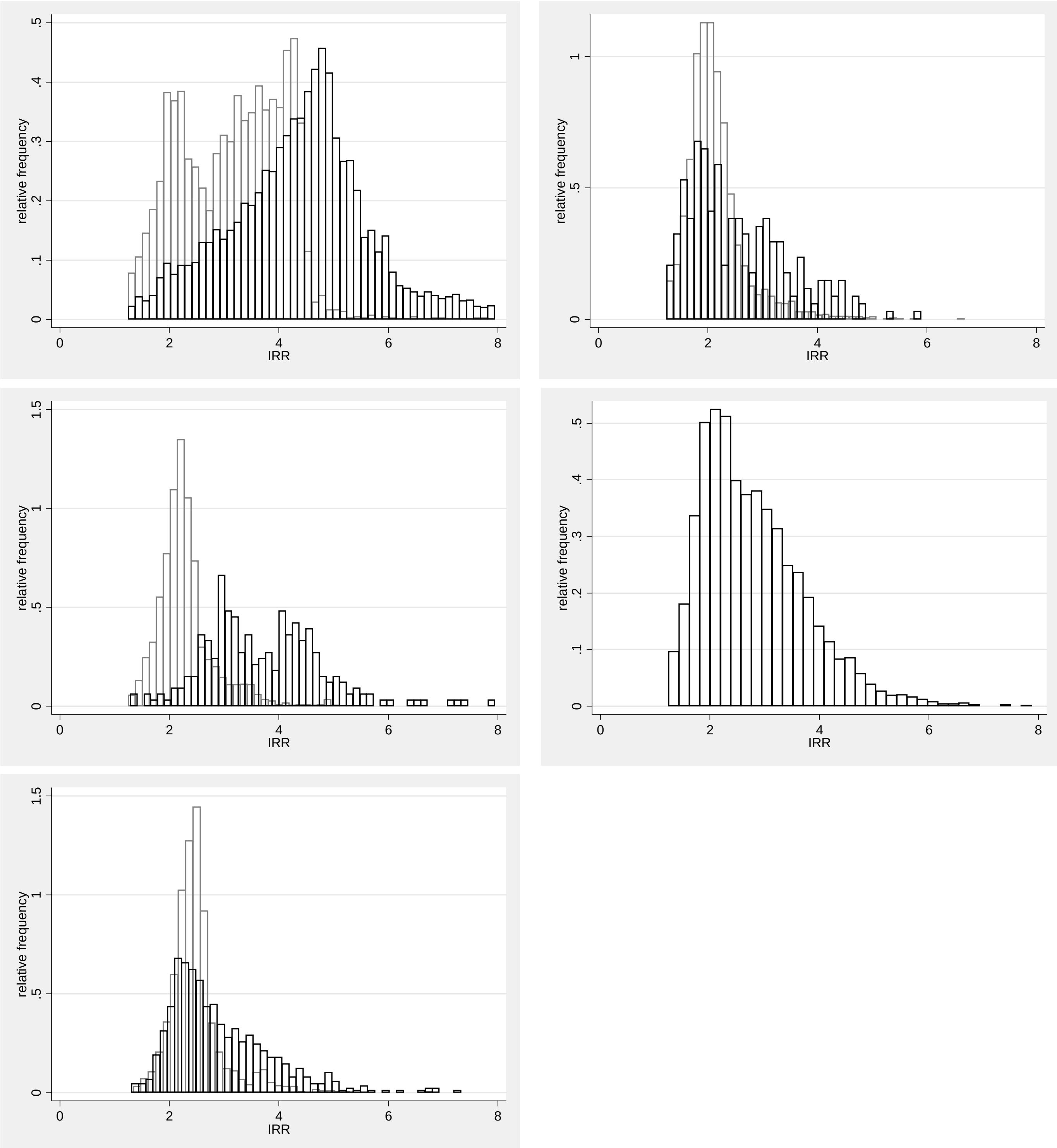

Figure 8. Rates of return, decomposed by type of pension and gender of insurants.

Note. Database is CIB 2005. Own calculations. Left column from top to bottom: old age pension according to § 35 SGB VI, § 36 SGB VI, § 37 SGB VI. Right column from top to bottom: old age pension according to § 237 SGB VI, § 237a SGB VI. Female beneficiaries: black bars; male beneficiaries: grey bars.

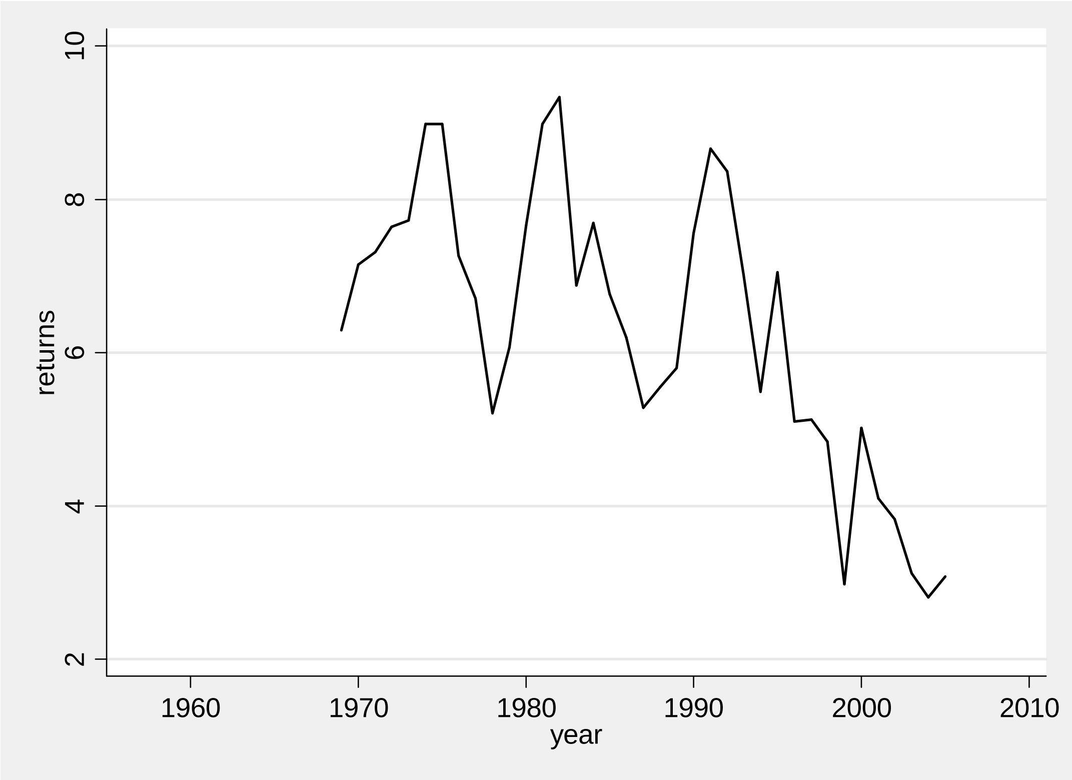

Figure 9. Rates of return on seven-year life German Federal Treasury notes.

Note. Data from German Central Bank (2010).

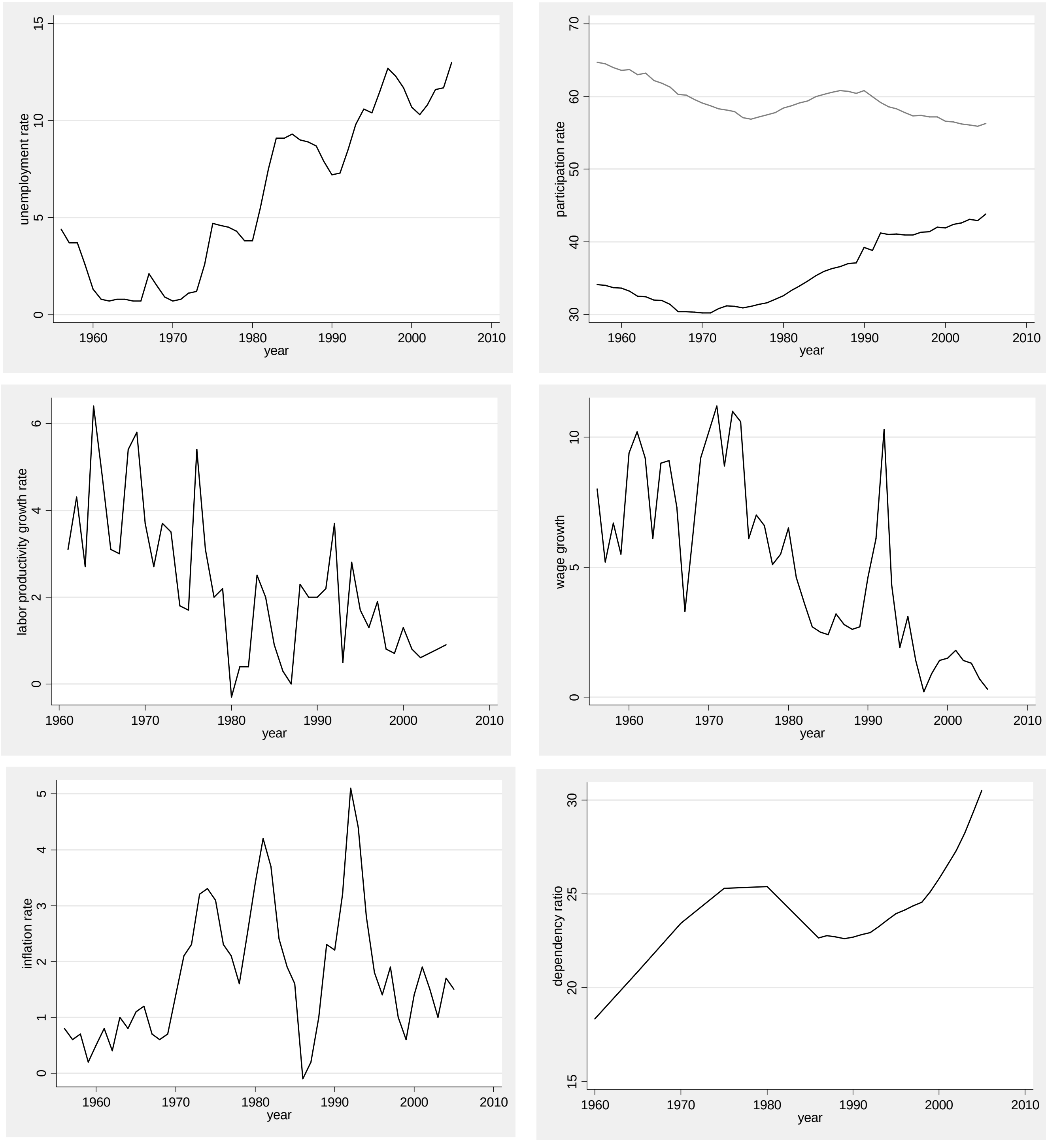

Figure 10. The macro picture.

Note. Figures before unification relate to the Federal Republic of Germany. Figures after unification relate to unified Germany. Left panel from top to bottom: (a) unemployment rate; data from German Federal Statistical Office (2009); (b) labor productivity growth rate per employee; data from German Federal Statistical Office (2009); (c) inflation rates; data from DIA (2010). Right panel from top to bottom: (a) labor force participation rates (black: female; grey: male); data from German Federal Statistical Office (2009); (b) changes in nominal wages; data from German Federal Statistical Office (2009); (c) dependency ratio (population age 65 and above divided by population of age 18-64); data from German Federal Statistical Office (2009).

Table 1. Socio-demographics of the sample

	Full sample	Male	Female
Number of beneficiaries	21,509	10,209	11,300
Number of non-married or widowed beneficiaries	4,835	1,858	2,977
Number of (re)married beneficiaries	16,674	8,351	8,323
Age at retirement	63.151	63.003	63.284
	(1.989)	(1.882)	(2.071)

Note. Standard deviation in parentheses. Database is CIB 2005.

Table 2. Number of beneficiaries by type of pension

	LEAT	Full sample	Male	Female
Old age retirement pension (SSC VI § 35)	16	9,575	3,478	6,097
Old age pension long-term insured persons (SSC VI § 36)	63	2,161	1,888	273
Old age pension handicapped persons (SSC VI § 37)	62	2,151	1,462	689
Old age pension in case of early retirement/unemployment (SSC VI § 237)	17	3,652	3,381	271
Specific old age pension, female (SSC VI § 237a)	18	3,970	---	3,970

Note. Column 'LEAT' gives the value of the variable LEAT which defines the corresponding type of pension. SSC VI denotes Social Security Code Book VI. Database is CIB 2005.

Table 3. Composition of remuneration points

Percentage of remuneration points from	Full sample	Male	Female
Contribution periods	84.711	92.486	77.686
	(12.705)	(5.538)	(13.068)
Non-contribution periods	15.289	7.514	22.314
	(12.605)	(5.538)	(13.068)
Non-contribution periods in detail			
Contribution free periods	1.730	1.350	2.073
	(2.553)	(2.378)	(2.656)
Reduced contribution periods	5.175	3.916	6.312
	(5.177)	(4.731)	(5.298)
Reduced contribution periods (additional)	1.789	2.123	1.258
	(1.933)	(1.576)	(1.975)
Child care and care	6.588	0.128	12.429
	(10.125)	(5.254)	(10.981)
Additional/credited Child care and care	0.007	0.001	0.013
	(0.148)	(0.053)	(0.198)

Note. Standard deviation in parentheses. SSC VI denotes Social Security Code Book VI. Database is CIB 2005.

Table 4. Rates of return by type of pension

	Full sample	Male insurants	Female insurants
All considered types of pensions	3.261	2.572	3.884
	(1.636)	(0.839)	(1.910)
Standard old age retirement pension (SSC VI § 35)	4.177	3.167	4.753
	(1.896)	(0.967)	(2.048)
Old age pension long-term insured persons (SSC VI § 36)	2.485	2.293	3.816
	(0.854)	(0.510)	(1.393)
Old age pension handicapped persons (SSC VI § 37)	2.636	2.494	2.936
	(0.715)	(0.498)	(0.968)
Old age pension in case of early retirement/unemployment (SSC VI § 237)	2.180	2.149	2.571
	(0.588)	(0.544)	(0.900)
Specific old age pension, female (SSC VI § 237a)	2.807	---	2.807
	(1.000)	---	(1.000)

Note. Standard deviation in parentheses. SSC VI denotes Social Security Code Book VI. Database is CIB 2005.

Table 5. Results from regression analysis

	Full sample		Male insurants		Female insurants		Gender comparison
Variable	Coef.	t stat.	Coef.	t stat.	Coef.	t stat.	Chi-square test
Share of remuneration points from contribution-free periods	-2.353 (0.281)	-8.39***	-1.256 (0.210)	-5.98***	-2.860 (0.471)	-6.07***	4.34**
Share of remuneration points from periods of reduced contributions	1.483 (0.158)	9.36***	4.557 (0.133)	34.15***	0.047 (0.252)	0.19	172.95***
Share of additional remuneration points from periods of reduced contributions	2.177 (0.391)	5.57***	4.372 (0.359)	12.19***	2.426 (0.596)	4.07***	9.76***
Share of remuneration points for childcare and care	8.668 (0.087)	99.44***	7.360 (0.285)	25.83***	9.927 (0.153)	65.02***	2.93*
Share of additional/credited remuneration points for childcare and care	-6.514 (4.723)	-1.38	-63.671 (9.320)	-6.83***	-3.809 (6.232)	-0.61	10.11***
Earnings capacity	-0.581 (0.017)	-35.07***	-0.624 (0.010)	-60.72***	-0.464 (0.046)	-10.14***	14.84***
Dummy for married partner	0.260 (0.017)	15.44***	0.456 (0.013)	35.39***	0.126 (0.028)	4.45***	116.21***
Difference between official retirement age and own age at time of retirement	-0.109 (0.007)	-15.25***	-0.088 (0.005)	-18.72***	-0.098 (0.014)	-7.12***	0.80
Dummy SSC VI Paragraph 36	-0.018 (0.031)	-0.58	-0.066 (0.018)	-3.58***	0.101 (0.085)	1.19	3.95**
Dummy SSC VI Paragraph 37	0.243 (0.039)	6.22***	0.224 (0.024)	9.20***	0.078 (0.082)	0.96	5.12**
Dummy SSC VI Paragraph 237	-0.006 (0.035)	-0.16	-0.074 (0.021)	-3.58***	-0.300 (0.102)	-2.93***	9.49***
Dummy SSC VI Paragraph 237a	-0.288 (0.032)	-8.90***	---		-0.215 (0.059)	-3.65**	---
Constant	3.216 (0.029)	112.72***	3.006 (0.021)	140.51***	3.093 (0.056)	55.69***	1.59
F statistic	2,813.02		1,724.58		1,077.83		
Adjusted R-squared	0.611		0.650		0.533		

Note. Three stars denote significance at the 1 percent level; two stars at the five percent level; one star at the ten percent level. Standard errors in parentheses. SSC VI denotes Social Security Code Book VI. Database is CIB 2005.