

Kemptoner, Daniel; Haan, Peter; Lüthen, Holger

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The increasing longevity gap by lifetime earnings and its distributional implications*

Peter Haan[†], Daniel Kemptner[‡] and Holger Lüthen[§]

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We use social security records to document the heterogeneity in life expectancy by lifetime earnings for West Germany and we analyze how this longevity gap has evolved over cohorts. In line with previous studies, we provide evidence that the earnings-related longevity gap is increasing over cohorts. We then propose a decomposition to disentangle the role of the increasing earnings inequality over cohorts and the effect of changes in the earnings gradient on life expectancy. Finally, we study the distributional implications of the increasing longevity gap for the pension system. First, we show how the heterogeneity in life expectancy affects the distribution and the inequality of social security wealth and we document how this has evolved between the cohorts. Second, we calculate internal rates of return of the pension system and compare the rates by lifetime earnings and between cohorts. Third, we extend the analysis by also accounting for survivor pensions and heterogeneous life expectancies of surviving spouses.

Keywords: mortality, lifetime inequality, pensions

JEL classification: H55, I14, J11

*Acknowledgments:

[†]DIW Berlin, FU Berlin & NETSPAR, phaen@diw.de

[‡]DIW Berlin, dkemptner@diw.de

[§]FU Berlin & DIW Berlin, hluethen@diw.de

1 Introduction

During the last decades most OECD countries have seen a strong increase in the inequality of earnings, consumption and wealth, see, e.g. Katz and Autor (1999), Krueger and Perri (2005) or Piketty and Saez (2007). Moreover, recent studies have confirmed the increase in inequality when studying lifetime earnings. For example Kopczuk, Saez, and Song (2010) for the US or Bönke, Corneo, and Lüthen (2015) for Germany use social security records and document that inequality of lifetime earnings has been increasing over time and between cohorts.

At the same time there exists striking evidence that life expectancy is highly correlated with different measures of income and wealth. Studies have documented that life expectancy is increasing with wages, income, wealth, or education see e.g. Cutler, Deaton, and Lleras-Muney (2006), Lleras-Muney (2005), or Chetty, Michael Stepner, and Cutler (2016). Consistent with the increase in earnings inequality, several studies provide evidence that the earnings-related longevity gap has been increasing over time Kiebele, Jasilionis, and Shkolnikov (2013), or Chetty, Michael Stepner, and Cutler (2016).

In this paper, we provide novel evidence about the increasing longevity gap in West Germany. In particular, we exploit social security records from the German Pension Insurance to document the heterogeneity in life expectancy by earnings over the full working life and we analyze how this longevity gap has evolved over a period of 24 years for cohorts born in 1926 through 1949. Further, in order to better understand the increase in the longevity gap, we use a decomposition to disentangle the role of the increasing earnings inequality and the effect of changes in the earnings gradient on life expectancy. Finally we study the implications of the increasing longevity gap on the distributional effects of the pension system. In particular, we analyze how the cohort-specific increase in the longevity gap affects the distribution of the social security wealth and of the internal rates of returns. In this analysis, we also consider survivor pensions and heterogeneous life expectancies of the surviving spouses.

For institutional reasons, the longevity gap for females is analyzed based on survivor pensions and their life expectancies must be computed conditional on outliving the spouse.¹ However, this also provides interesting insights because spousal income is a good proxy for the household income. Further, we cannot analyze East Germans because their pension entitlements are not a good proxy for their life time incomes.

¹Until 1967, it was legally allowed for women to leave the pension system at the time of their marriage and gain the monetary value of their collected earnings points. Until 1995, however, these women could reenter the pension system through retroactive payments. Up to 20% of the women for some of cohorts took up this option in a highly selective manner (see Appendix XXX).

Our paper extends the previous literature in several dimensions. First, we focus on a longer time period than previous studies and document the increase in the longevity gap by gender for the cohorts 1905 through 1949. Second, the decomposition analysis provides important insights why the longevity gap has been increasing. In particular, we show whether the increase in the longevity gap is explained by the increasing earnings inequality between the cohorts or whether the earnings gradient has changed. Third, we provide novel evidence about the role of the pension system. It has been previously documented that earnings-related heterogeneity in life expectancy can offset the distributional effects of a progressive pension system as implemented in the US or can lead to regressive effects in a proportional system (see, e.g. Gustman and Steinmeier (2001), Feldstein and Liebman (2002), or Breyer and Hupfeld (2010)). We extend these studies and show how the distributional effects of the pension system have changed over cohorts. In particular, we disentangle how cohort-specific pension reforms in the German pension system and the increasing gap in longevity have changed the distributional effects of the pension system. Further, we also compute the distributional effects of survivor pensions and heterogeneous life expectancies of surviving spouses.

The paper is organized as follows. In the next section we introduce the data from the German pension insurance which we use for our analysis and provide information about the institutions of the German pension insurance. Then we introduce the method we use to estimate cohort-specific mortality rates and how these depend on lifetime earnings. Based on this method we estimate the cohort-specific heterogeneity in life expectancies separately for men and women and we document how the earnings-related longevity gap has evolved over the cohorts. In the final section, we link these findings to the pension system and analyze the distributional implication of life expectancy for the pension system.

2 Data

In this section we describe the data from the German pension insurance which we use for our analysis. In addition we provide some institutional background about the German pension system and relevant pension reforms.

2.1 The German Pension Insurance Data

We use several administrative data sets from the German pension insurance. Due to its mandatory nature, the pension insurance records monthly information on working lives

and pension prospects of 80% of all West German men (Bönke, Corneo, and Lüthen (2015)).

The pension insurance records retirees time of death. In the first part of our analysis, we merge that information with data on the retiree stock. Both data sets stem from the data set SK90, which contains the universe of existing and decedent pensioners for calendar years 1992-2015. We select cohorts who are observed at age 65 or at some later ages (to assist in the estimation of age-related mortality). This leaves us with cohorts 1905-1949. The final data set includes 85 million surviving and 5 million decedent West German and 23.4 million existing and 1.2 million decedent East German men (see Appendix for table 3 that displays the number of observations of male retirees and decedents by cohorts and region). Those numbers are sufficient for an analysis of mortality of groups within the earnings distribution.

Figure 1: Observed mortality rates and survival probabilities of West German men for pooled cohorts by deciles of earnings point distribution at age 65

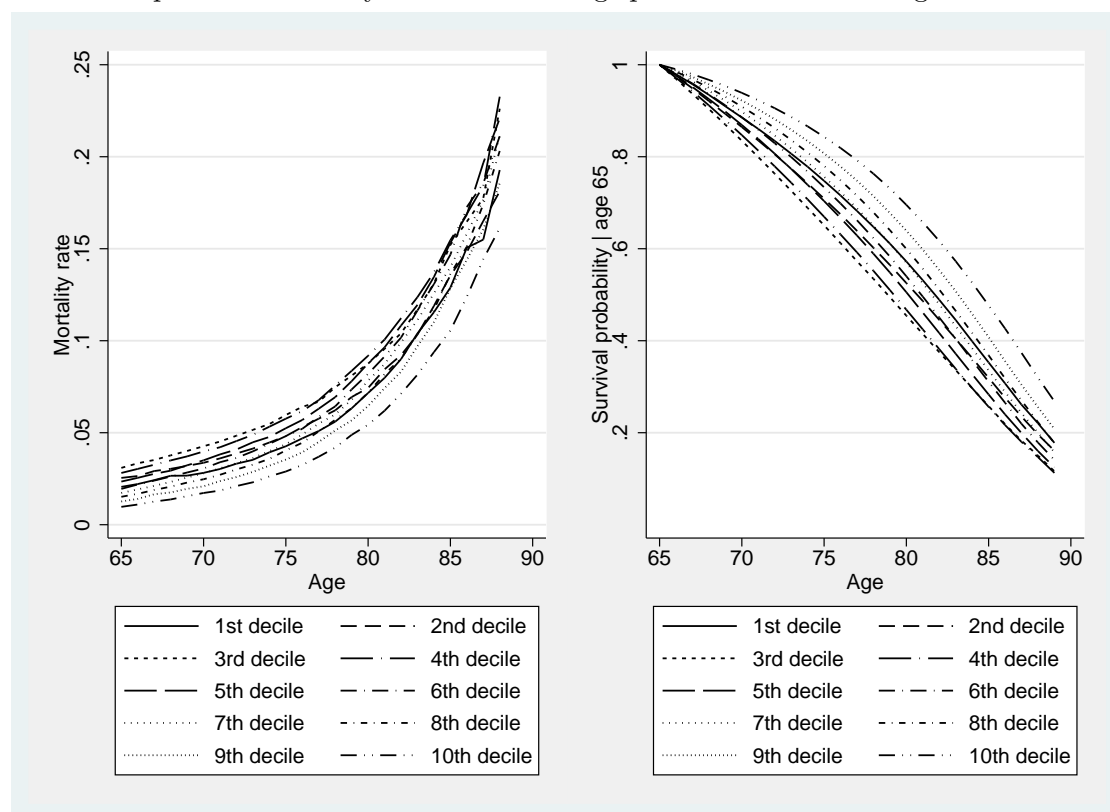


Figure 1 shows for pooled cohorts (1926-1949) the observed mortality rates and the probabilities of surviving until a certain age conditional on reaching age 65 by deciles of the earnings point distribution at age 65. Since our observation periods start with the period from December 1st, 1991, to November 30th, 1992, the first birth cohort where we observe the distribution at age 65 is the cohort from 1926. Hence, we directly observe both mortality rates and the distribution at age 65 for the pooled cohorts until age 88. Figure 1 documents substantial heterogeneity in mortality rates along the earnings point distribution. When computing conditional survival probabilities based on these mortality rates, this translates into a difference of about 12 percentage points in the probability of surviving until age 80 conditional on reaching age 65 between the decile with the lowest and the decile with the highest mortality rates.

We also want to consider how differential mortality affects the payouts of the pension system. Therefore, we calculate rates of return of pension contributions. This requires information on all contributions as well as pension prospects and their exact timing. We employ waves 2002-2011 of the Versicherungskontenstichprobe (VSKT), which includes complete monthly employment biographies for cohorts 1935 until 1983. To get an overlap with the results on differential mortality, we select cohorts 1935 to 1945. We follow Lüthen (2016) and exclude individuals with special pension arrangements like miners or self-employed as well as those with more than 25 years of missing information in the main employment phase between 30 and 60. This leaves us with about 3000 men (see Appendix A for further details on sample selection and numbers of observations).

2.2 Institutional background

The German statutory pension system is a pay-as-you-go system of Bismarckian variety. The great majority of employees is mandatorily insured and contributes a percentage of their gross earnings up to a contribution ceiling. For their contributions, the insureds acquire pension entitlements in form of earnings (or remuneration) points. The number of points is based on the ratio of individual wage to average wage. An individual earns exactly one point (per year) if its yearly wage corresponds to the average yearly wage. Employees accumulate earnings points over their working life until retirement. At retirement, the individual pension level is calculated on the basis of these accumulated earnings points (EP). Basically, the sum of earnings points EP minus a deduction that punishes people for early retirement then is multiplied with a pension value to calculate the monthly pension. This value is adjusted every calendar year. (see Lüthen (2016) for further details). The sum of EP mirror the length of the working life and the average position in the earnings distribution.

We exploit this link between collected EP and earnings level and use the sum of EP as a proxy for lifetime earnings. The high earnings are capped, which concerns about 7% of all earnings of West German men per year (Bönke, Corneo, and Lüthen (2015)). Since earnings ranks and levels are highly correlated in the years individuals earn above the ceiling, those individuals are very likely to have multiple censored spells, which effectively cap their lifetime earnings to a strong extend in our data (Bönke, Corneo, and Lüthen (2015)). We attempt to solve this issue by grouping individuals in deciles. The highest decile then contains all individuals with multiple censored spells, as they still collect the highest number of EP in total.

3 Heterogeneity in life expectancies

In this section, we first discuss the methodology that we use in order to extract the information on the survival probabilities and life expectancies from our data. We proceed with a presentation of life expectancies at the statutory pension age 65 by cohort groups and earnings point deciles. In a decomposition analysis, we show to what extend changes in the intra-cohort heterogeneity of life expectancies can be attributed to the rise in inequality of individuals' earnings biographies.

3.1 Method

We aim at estimating the life expectancy at age 65 using conditional age-specific mortality rates between age 65 and age 99. Since we do not observe the birth cohorts in our data for full relevant age range, we need to extrapolate for older cohorts from observations at higher ages to the unobserved rates at lower ages, and for younger cohorts from the observed rates at lower ages to the unobserved rates at higher ages. This is done using an appropriately specified econometric probability model.

We estimate conditional mortality probabilities based on a logistic probability model. In line with the structure of our data, we regress a variable that indicates death (i.e. discontinuation of a pension) within the 12 months following the reporting date (December to November of the following year) on a age variable that indicates age on November 30th. We assume that the mortality rate is a function of a 4th order polynomial of the age variable. This functional form assumption is strongly supported by the comparison with a non-parametric specification (see figure XXX in the Appendix). The parametric assumptions allow us to also account for cohort groups, earnings point deciles, and their

interactions in the probability model:

$$\text{Prob}(\text{death}_{itcd}) = \Lambda \left(\beta_0 + \sum_{p=1}^4 \beta_p t^p + \eta_c + \mu_d + \nu_{cd} \right) \quad (1)$$

where $\Lambda(\cdot)$ is the logistic distribution function and individual i is in cohort group c and in earnings point decile d . The variable/subscript t indicates the individual's age on November 30th. Cohorts are grouped into fifteen 3-year birth cohort groups (1905 – 07, 1908 – 10, 1911 – 13, ..., 1947 – 49). The deciles refer to the cut-off points of the earnings point distribution at age 65 of the respective cohort-group (see figure 8 in the Appendix). It is very important to keep these cut-off points fixed within cohort-groups instead of making them age-specific. Otherwise, we would run in a severe selection problem that are due to differential mortality by decile groups. For the cohort groups older than the one from 1927-1929, we do not observe the earnings point distribution at age 65 in our data. Therefore, we use the cut-off points of the cohort group from 1927-1929 for these older cohorts. Of course, this changes the interpretation of the decile groups for these cohorts because they become earnings point groups that do not refer to exactly ten per cent of the distribution at age 65. In our analysis, we therefore focus on the cohort groups from 1927-1929 onwards. However, we still need to include the older cohorts in the estimation in order to properly identify the age polynomial.

The model is estimated by the method of maximum likelihood. Based on the model and the parameter estimates (see Appendix XXX), we predict conditional mortality rates for a grid of age \times cohort group \times earnings point decile. The age grid is running from age 65 to age 99. We assume that individuals die with probability 1 in the year they turn 100. Using the implied conditional survival probabilities, we can compute life expectancies at age 65 by cohort groups and earnings point deciles. We can also use the conditional survival probabilities directly in order to compute pension wealth at age 65 by cohort groups and earnings point deciles as well as the respective internal rates of return of the pension system.

3.2 Cohort-specific life expectancy by earnings point deciles

We present the life expectancies at the legal retirement age of 65. The estimations are based on the methodology discussed in the previous subsection. This analysis not only allows us to study the within-cohort heterogeneity in life expectancies, but also shows the pronounced cohort trends of this heterogeneity. We start with the analysis of West German men and then we continue with the analysis of the women.

3.2.1 Males

Figure 2: Life expectancies of West German men at age 65

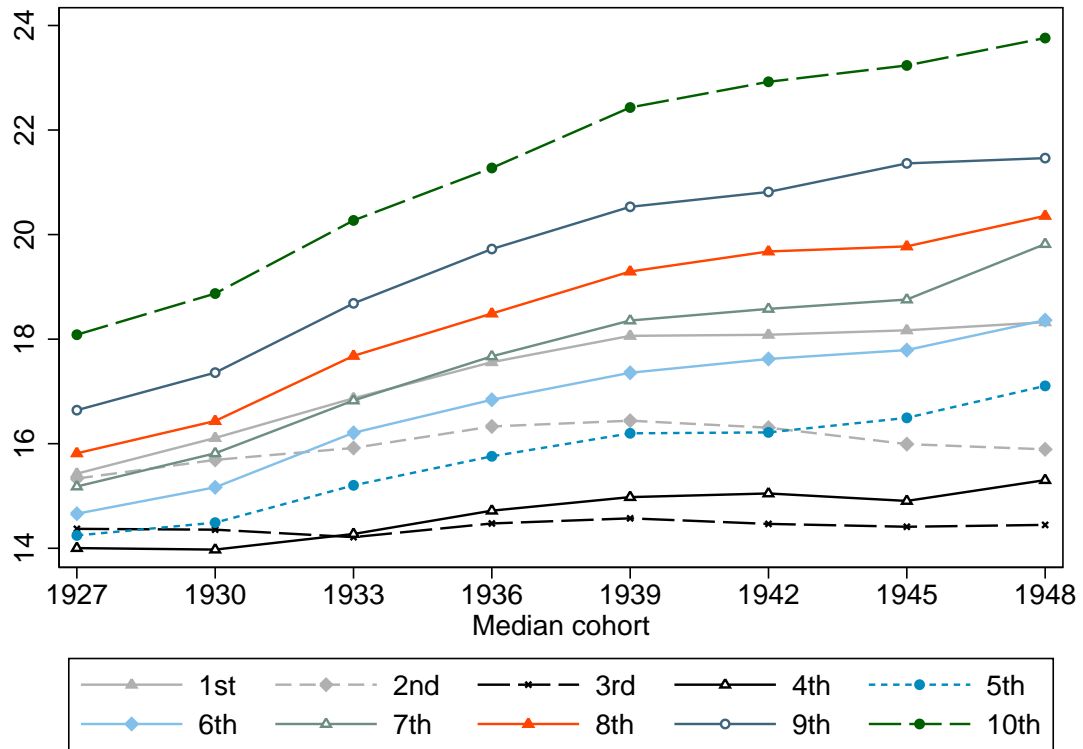


Figure 2 shows life expectancies for West German men. While we find comparatively little heterogeneity by decile groups for the oldest cohorts born between 1905 and 1907 (about two years between the decile with the lowest and the decile with the highest life expectancy), this changes dramatically over time. For the cohorts born between 1947 and 1949, we find a difference of almost ten years. Hence, the rise in average life expectancies over cohorts is mainly driven by the upper decile groups.

This not only suggests that the conditions of life must have changed quite differentially for individuals in the different deciles, it also points to substantial distributional effects through the longevity insurance provided by the pension system (see second part of the paper). The first two decile groups deviate from the otherwise monotonous relationship between the position in the earnings point distribution and the life expectancy. This

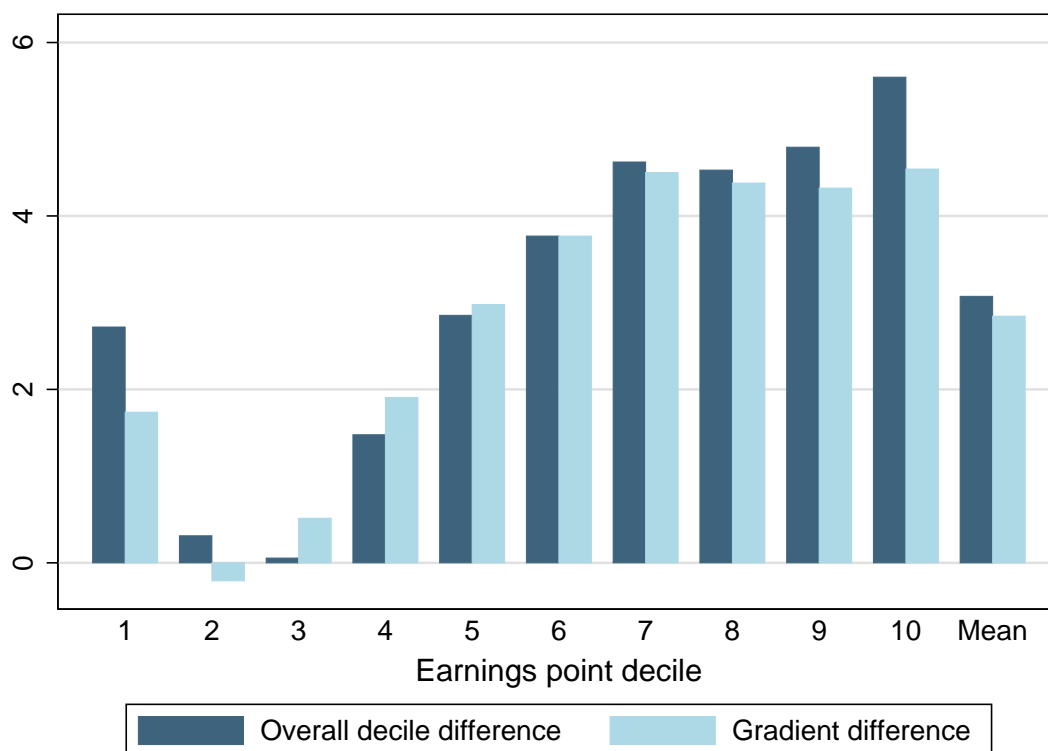
is due to many of these individuals receiving higher lifetime earnings than reflected by their earnings points because they stopped contributing to the system at some point in time and became e.g. self-employed.

3.2.2 Females

[TO BE COMPLETED UNTIL THE CONFERENCE]

3.3 Decomposition

Figure 3: Difference in life expectancies between 1948 and 1927 cohort group



Annotation: The cohort 1948 is an average of cohorts 1947-1949. The cohort 1927 is an average of cohorts 1926-1928. The “gradient change” denotes the change in life expectancies when assuming that the earnings point distribution at age 65 of the 1926 cohort applies to the 1948 cohort.

In this subsection, we investigate whether the increase in the longevity gap can be explained by an increase in inequality of lifetime income or whether this is rather due to

a change in the lifetime income gradient. With an increase in the gradient, we mean that being at a certain position in the distribution exerts a stronger effect on life expectancy and, therefore, leads to an increase in the longevity gap conditional on the distribution. We address this question by computing life expectancies for the last cohort group in our data (1947-1949) under the assumption that the distribution of earnings points has remained constant since the first cohort group where we observe the earnings point distribution at age 65 (1926-1928). The remaining inequality in life expectancies can be attributed to an increase in the income gradient.

Table 1: Shares and re-weighting matrix for computation of life expectancies at age 65 for 1948 cohort group when assuming 1927 distribution

Deciles based on distribution of 1948 cohort group										
	1	2	3	4	5	6	7	8	9	10
Shares	0.0615	0.0989	0.1003	0.1133	0.1164	0.1185	0.1203	0.1161	0.1002	0.0544
Weights										
1	0.615	0.385	0	0	0	0	0	0	0	0
2	0	0.604	0.396	0	0	0	0	0	0	0
3	0	0	0.607	0.393	0	0	0	0	0	0
4	0	0	0	0.74	0.26	0	0	0	0	0
5	0	0	0	0	0.904	0.096	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0.089	0.911	0	0	0
8	0	0	0	0	0	0	0.292	0.708	0	0
9	0	0	0	0	0	0	0	0.453	0.547	0
10	0	0	0	0	0	0	0	0	0.455	0.544

Annotation: Cohort 1927 is an average of cohorts 1926-1928 and cohort 1948 is an average of cohorts 1947-1949. In the re-weighting matrix, the rows contain the weights in order to compute life expectancies by deciles for the 1948 group when assuming the 1927 distribution at age 65. For example, the life expectancy for the lowest decile, then, is computed as 0.615 times the original life expectancy of the lowest decile plus 0.385 times the original life expectancy of the second lowest decile, and so on.

This is done by assuming that the cut-off points of the deciles and the estimated parameters from the cohort group 1947-1949 apply to the 1926-1928 group (see figure 8 in the Appendix for cut-off values). As a consequence, the shares in the decile groups are no longer 10 per cent for the earnings point distribution at age 65 (see table 1). The “new” shares are used in a re-weighting procedure, where we recover life expectancies by deciles by computing them as a weighted average of the original estimated life expectancies by deciles that have been estimated for the 1947-1949 group.

For example, if we had only 5% of the observations in the highest decile group and more than 5% in the second highest decile group when assuming the age 65 distribution from the 1926-1928 group, we would compute the new life expectancy for the highest decile as 0.5 times the original life expectancy in the highest decile plus 0.5 times the original life expectancy in the second highest decile, and so on. As a consequence, the re-weighted life expectancy in the highest decile would come out lower than the original one from the 1947-1949 group and the difference between the two life expectancies could be attributed to the change in the distribution between the cohort groups.

Figure 3 shows that the differences between the original and re-weighted life expectancies of the 1948 cohort group and the life expectancy of the 1927 cohort group are similar, but differ in particular for the first and the tenth decile. The difference between the respective differences in life expectancies can be attributed to changes in the inequality of lifetime income. However, the increase in the longevity gap can mainly be attributed to a change in the mortality gradient. This means that the increase in life expectancy for the upper decile groups is mainly driven by how inequality impacts on life expectancy (e.g. individuals in the upper decile groups may have changed health-related behavior and stopped smoking more often than individuals in the lower deciles).

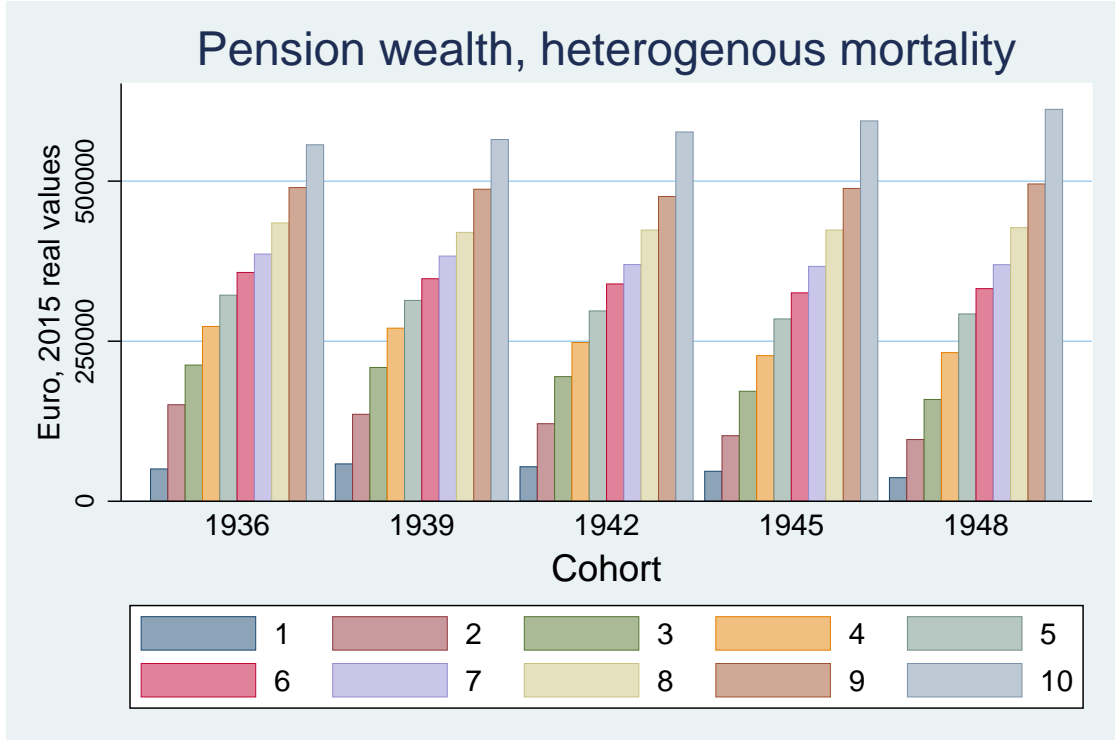
4 Implication of life expectancy for the pension system

In this section, we study the implications of the increasing longevity gap on the distributional effects of the pension system. In particular, we analyze how the cohort-specific increase in the longevity gap affects the distribution of the social security wealth and of the internal rates of returns. We also consider survivor pensions and heterogeneous life expectancies of the surviving spouses. For the reasons discussed above, this analysis can only be implemented for West German men.

4.1 Inequality of Social Security Wealth

This section shows some details about the average pension wealth across deciles and cohorts. This analysis is conditional on individuals reaching age 65. The pension wealth is constructed by calculating the pension from age 65 up until age 99 while regarding the decile-specific mortality rate. All pensions are 2015 real values, with pension received after 2016 are assumed to stay constant in 2016 real values. Figure 4 displays the distribution of pension wealth by decile over five different cohort groups. Pension wealth differs greatly by decile, ranging from nearly 0 for the lowest groups up to more than 600,000 for the highest decile of the youngest cohort. Further, it becomes apparent that

Figure 4: Average pension wealth at age 65 by decile over cohorts



Annotation: Real 2015 values. All five median cohorts are grouped into 3-cohort groups, i.e. cohort 1936 is an average of cohorts 1935-1937.

pension wealth increases greatly across cohorts. [TO DO: Show the role of increasing life expectancy vs. developments in the pension system].

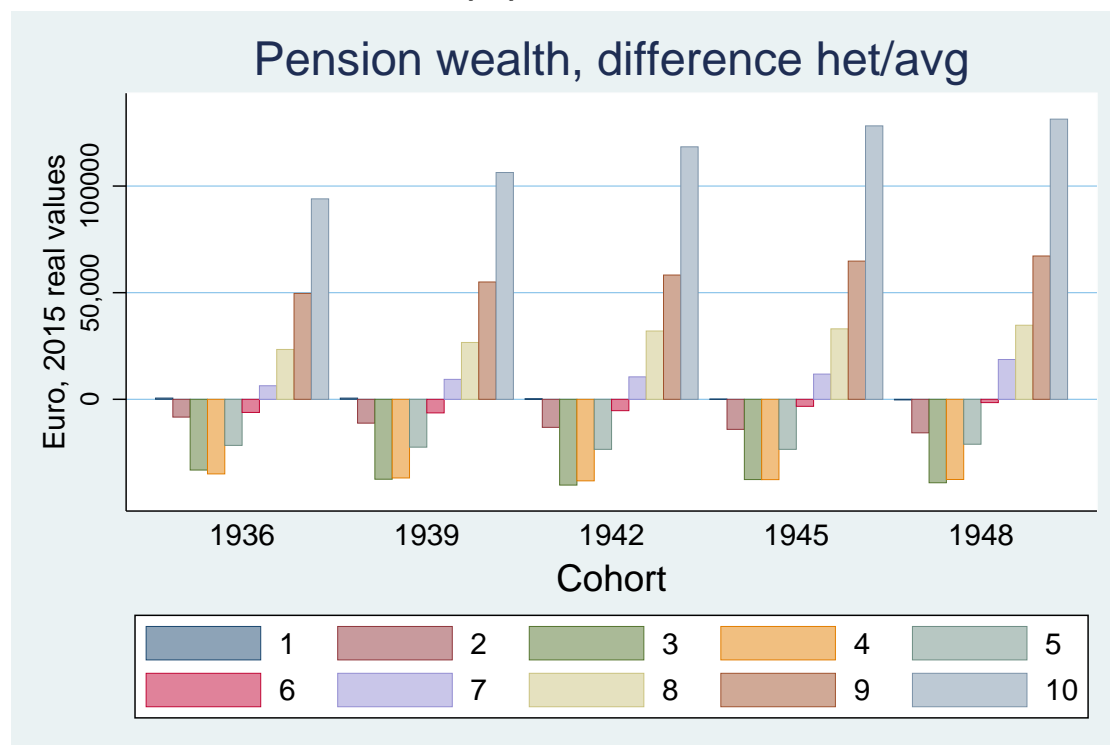
Table 2 shows that the distribution also becomes more unequal and grew from a Gini of 0.283 to a Gini of 0.339. This growth in pension wealth inequality is largely driven by the increase in differential mortality. The differences between the two values of pension wealth, one with and one without differential mortality, are displayed in Figure 5. These values are shown to be increasing over cohorts. Heterogeneous life expectancies raise the pension wealth of the four upper decile groups and lower it for the third to sixth decile group. The highest decile group gains more than 100,000 EUR for the cohorts 1938 onwards and the gain is still more than 50,000 EUR for the second highest decile group. Hence, the heterogeneous life expectancies exert a strong regressive effect. However, a full assessment of the distributional effects of the pension system under heterogeneous life expectancies needs to account also for retirement behavior. This is done in the next

Table 2: Ginis of pension wealth at age 65 with and without differential mortality over cohorts

Cohort	1936	1939	1942	1945	1948
Gini under					
differential mortality	0.283	0.281	0.302	0.320	0.339
average mortality	0.241	0.231	0.246	0.261	0.276

Annotation: Real values. All eight median cohorts are grouped into 3-cohort groups, i.e. cohort 1936 is an average of cohorts 1935-1937. Gini is multiplied by 100.

Figure 5: Difference between pension wealth at age 65 with and without differential mortality by decile over cohorts

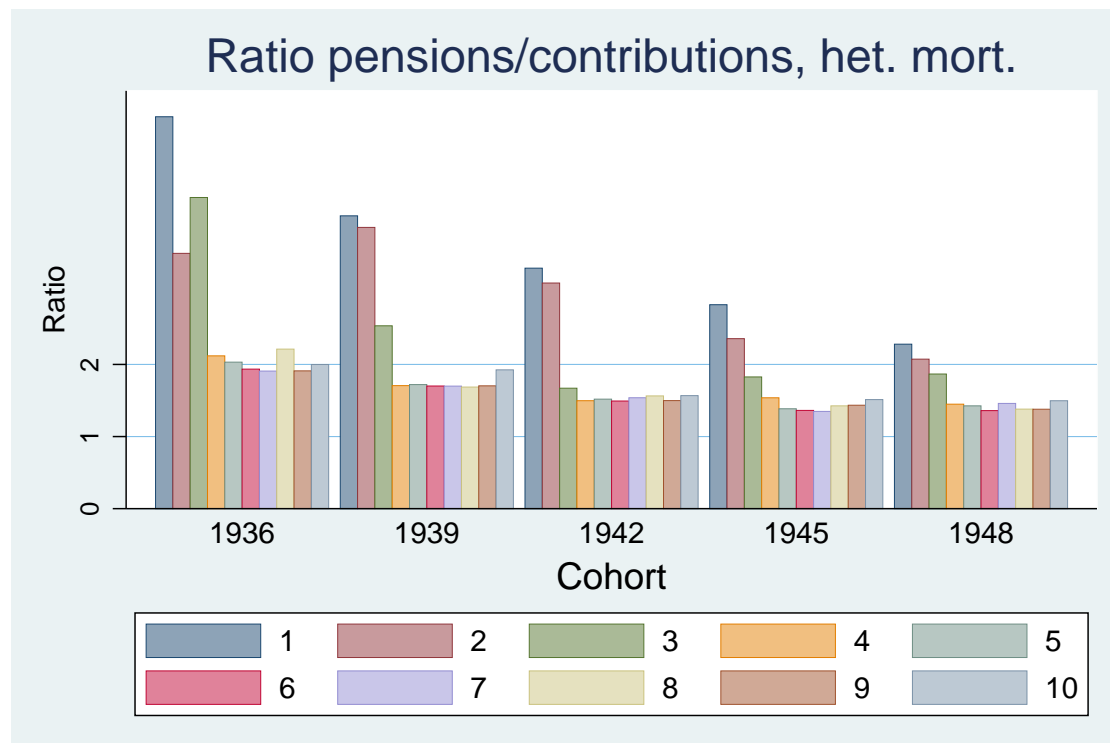


Annotation: Real 2015 values. All five median cohorts are grouped into 3-cohort groups, i.e. cohort 1936 is an average of cohorts 1935-1937.

subsection where we compute rates of return that increase with life expectancy and decrease with retirement age.

4.2 Distribution of internal rates of returns

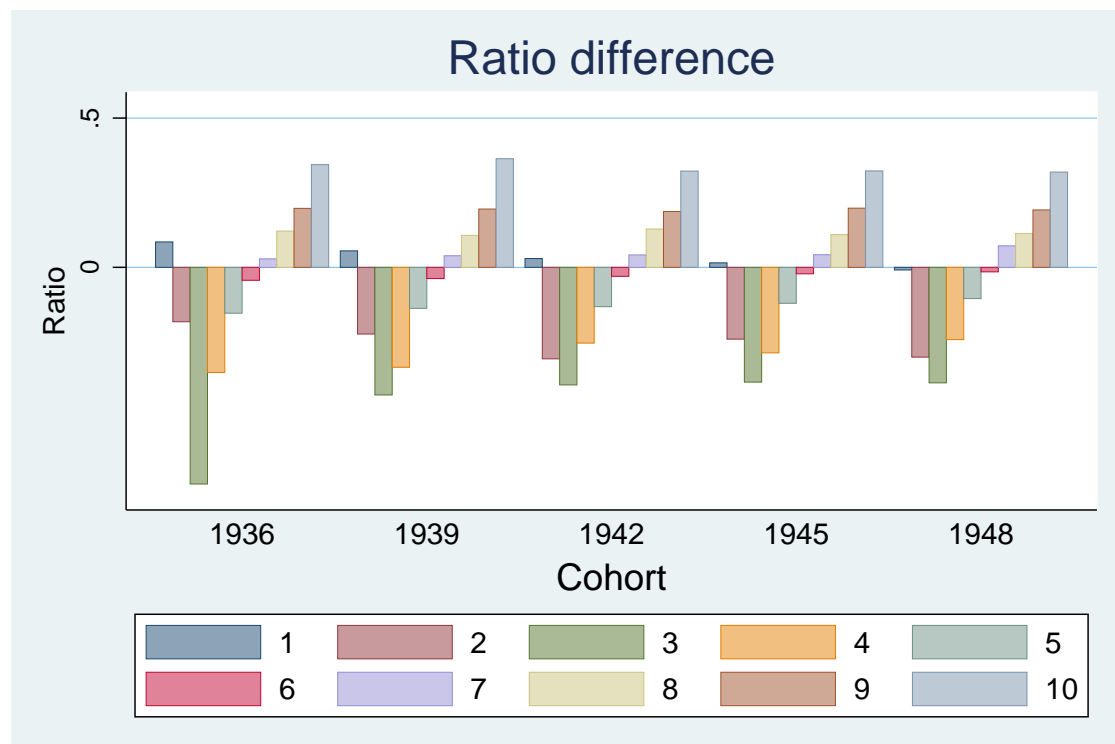
Figure 6: Difference between pension benefits and contributions divided by contributions (returns) by decile over cohorts



Annotation: Real 2015 values. All five median cohorts are grouped into 3-cohort groups, i.e. cohort 1936 is an average of cohorts 1935-1937.

Figure 6 displays differences between pension benefits and contributions divided by contributions. This shows that the overall distributional effect of the pension system is not regressive. However, the pension system is becoming less progressive over cohorts. Figure 7 shows the regressive effect how the increase in differential mortality induces a regressive distributional effect of the pension system. The fact that the overall effect of the pension system is still not regressive is due to the lower decile groups benefiting more from the early retirement option.

Figure 7: Difference between returns with and without differential mortality by decile over cohorts



Annotation: Real 2015 values. All five median cohorts are grouped into 3-cohort groups, i.e. cohort 1936 is an average of cohorts 1935-1937.

5 Conclusion

In this paper we provide novel evidence about the increasing longevity gap. In particular, we exploit social security records from the German Pension Insurance to document the heterogeneity in life expectancy by earnings over the full working life and we analyze how the longevity gap has evolved between the cohorts 1905 and 1949. Further, in order to better understand the increase in the longevity gap we use a decomposition to disentangle the role of the increasing earnings inequality and the effect of changes in the earnings gradient on life expectancy. Finally we study the implications of the increasing longevity gap on the distributional effects of the pension system. In particular, we analyze how the cohort-specific increase in the longevity gap affects the distribution of the social security wealth and of the internal rates of returns.

For men, we observe a cohort trend of rising life expectancies for all but the decile group with the lowest life expectancy. However, this trend is markedly stronger for individuals in the higher earnings point deciles. Between the cohorts from 1903 and 1949, the rise in life expectancy for the highest decile amounts to about eight years. For the cohorts born between 1947 and 1949, we find a difference of almost ten years between the decile with the highest and the decile with the lowest life expectancy.

Taking into account differential mortality rates in the computation of pension wealth, the distribution becomes substantially more unequal. A comparison of pension wealth under differential mortality with a hypothetical scenario of homogenous mortality rates shows how the increase in differential mortality induces a regressive distributional effect of the pension system. However, a full assessment of the distributional effects of the pension system under heterogeneous life expectancies reveals that the overall distributional effect of the pension system is not regressive. This is due to the lower decile groups benefiting more from the early retirement option. Still, the increasing longevity gap makes the pension system less progressive over cohorts such that the German pension system may become a regressive system in the near future.

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Appendix

Figure 8: Cut-off values of deciles of earnings point distribution at age 65 over cohorts

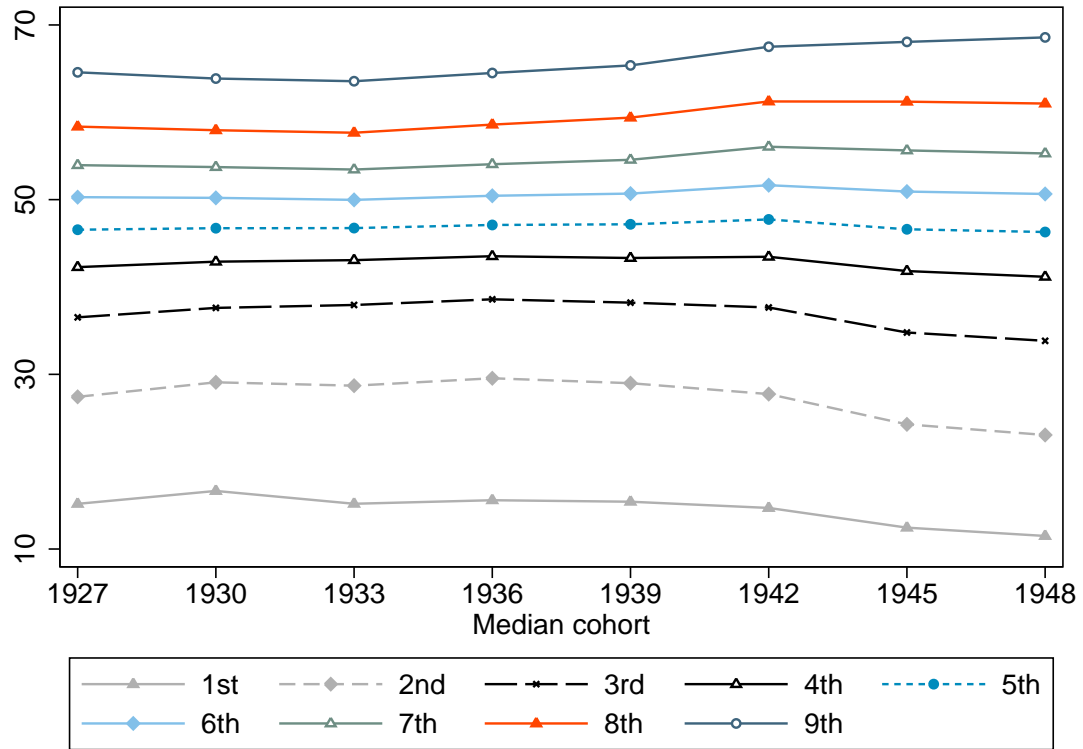


Table 3: Observations of male retirees and decedents by cohorts

Cohort	Existing	Decedent	Total
1905	133,770	34,864	168,634
1906	172,138	41,154	213,292
1907	227,772	51,289	279,061
1908	285,605	59,331	344,936
1909	358,907	69,996	428,903
1910	433,735	78,404	512,139
1911	513,939	87,683	601,622
1912	646,549	102,235	748,784
1913	757,320	111,214	868,534
1914	840,762	116,322	957,084
1915	753,298	97,716	851,014
1916	658,436	79,499	737,935
1917	679,590	76,799	756,389
1918	773,323	81,988	855,311
1919	1,311,056	129,242	1,440,298
1920	1,867,231	171,991	2,039,222
1921	2,103,742	181,574	2,285,316
1922	2,228,879	178,319	2,407,198
1923	2,266,022	167,811	2,433,833
1924	2,431,348	166,737	2,598,085
1925	2,965,084	187,300	3,152,384
1926	3,225,013	188,719	3,413,732
1927	3,445,036	193,247	3,638,283
1928	3,728,576	202,539	3,931,115
1929	3,622,772	186,398	3,809,170
1930	3,581,029	172,260	3,753,289
1931	3,311,835	149,063	3,460,898
1932	3,141,907	132,091	3,273,998
1933	3,027,808	119,400	3,147,208
1934	3,615,941	133,719	3,749,660
1935	3,713,939	127,446	3,841,385
1936	3,627,577	115,404	3,742,981
1937	3,518,759	104,308	3,623,067
1938	3,506,705	97,547	3,604,252
1939	3,466,680	92,012	3,558,692
1940	3,202,694	81,423	3,284,117
1941	2,716,833	65,119	2,781,952
1942	1,957,010	44,625	2,001,635
1943	1,755,573	38,564	1,794,137
1944	1,467,799	31,228	1,499,027
1945	894,633	18,361	912,994
1946	867,558	17,017	884,575
1947	707,864	13,069	720,933
1948	496,604	8,851	505,455
1949	256,161	4,256	260,417
Total	85,264,812	4,608,134	89,872,946