

Reforms of an early retirement pathway in Germany and their labor market effects

1. Introduction

In most industrialized countries, population aging generates a need for policy reforms and adjustments in retirement systems (OECD 2017). Here, evidence based policy decisions demand reliable causal analyses. This study exploits two natural experiments with respect to early retirement rules. We offer causal evidence on the behavioral adjustments induced by retirement entry age reforms for German men. In particular, we investigate how shifts in retirement entry age affect labor force participation and program substitution.

The retirement entry age is central to the fiscal challenges facing retirement insurances. In most retirement systems, the rules for retirement entry are complex and allow for different types of adjustments. Often, there are regulations for specific groups of the workforce. As an example, the German retirement system uses different retirement entry regimes (so called "pathways" to retirement), e.g., for females, those with disabilities or severe handicaps, and those who are unemployed prior to retirement with different retirement entry ages. Many reforms modified these ages to respond to challenges associated with population aging. While the differentiation of pathways into retirement is relevant in most retirement systems (OECD 2017), the international literature rarely discusses this feature of institutional settings.

A large literature investigates the causal effects of a variety of specific retirement reforms. A first group of contributions considers structural parameters and separates wealth and accrual effects (e.g., Hanel 2010, 2012, Brown 2013, Atalay and Barrett 2015). A second group chooses a reduced form approach to determine causal reform effects on individual labor force status. Here, some analyses study reforms of the normal retirement age (NRA) (Mastrobuoni 2009, Hanel and Riphahn 2012, Lalive and Staubli 2015) which provides retirement benefits without actuarial deductions. Others consider modifications of the early retirement age (ERA)

(Cribb et al. 2016, Staubli and Zweimüller 2013, Geyer et al. 2020, Manoli and Weber 2018, Hernæs et al. 2016) at which retirement is possible only with reduced benefits.¹

We contribute to this literature in three important ways: First, we improve on a strategy to identify causal effects first introduced by Krueger and Pischke (1992) (for applications see Mastrobuoni 2009, Hanel and Riphahn 2012). The strategy identifies causal effects of cohort specific reforms by comparing the behavior of treated younger and non-treated older birth cohorts at given ages. The identifying assumption is that absent the reform the developments over the lifecycle would have been identical across cohorts. We use a weaker identifying assumption by additionally considering behavioral differences for affected (male) and non-affected (female) individuals of the same age and birth cohort. Our difference-in-difference-in-differences (DIDID) estimation accounts for general trends across cohorts as well as for specific trends across cohorts for the male and female subsamples. We show that in our case this yields slightly more conservative estimates than the traditional DID approach.

Second, we exploit two reforms of the NRA and ERA within the same retirement pathway. This generates insights beyond those available from using just one reform. Staubli and Zweimüller (2013, p. 20) point out that "a rise in the ERA is likely to be a more effective measure to increase LFP among older workers as opposed to a rise in the NRA." We offer a comparison of these responses.

Third, we study the response of male workers to reforms of retirement age regulations. This adds to a recent literature which looked at the effects of similar reforms for females: Geyer and Welteke (2021) apply a regression discontinuity approach to investigate German female workers' response to the abolition of an ERA. They differentiate active and passive substitution

¹ This research is also related to studies of the causal effect of changes in the attractiveness of unemployment insurance (UI) transfers (e.g., Inderbitzin et al. 2016, Riphahn and Schrader 2020, Kuhn et al. 2020). Inderbitzin et al. (2016) point out that more generous UI benefits can increase early retirement and modify the utilization of different pathways to retirement.

patterns and find that women mostly stay passive in their respective labor market status after a reform rather than actively moving to substitute states.² Engels et al. (2017) investigate women's response to an increase in the NRA in the case of Germany. They also do not find much active substitution, e.g., into disability retirement. Oguzoglu et al. (2020) study an increase of the eligibility age to the means-tested age pension for women in Australia with comparable results. Lalive et al. (2020) recently confirmed that the majority of Swiss females simply adjust their retirement choices to perceived norms of retirement instead of maximizing the payout of retirement benefits when they are confronted with an increase of the NRA.

We take advantage of large samples of potential retirees using administrative data from the German mandatory retirement insurance. We use the start of benefit receipt as a precise measure of retirement entry which allows us to separately identify reform effects on labor market exit and retirement entry behaviors. These data provide more reliable evidence than prior survey based studies (e.g., Krueger and Pischke 1992, Atalay and Barrett 2015, Giesecke 2018). The data also allow us to investigate a broad set of labor market responses and study program substitution. Besides causal reform effects on employment and unemployment, we identify the reforms' effects on alternative pathways into retirement. This is important because the reform objective - reducing the fiscal burden of aging populations - cannot be reached if individuals respond by simply shifting to different retirement programs.

In terms of identification, our study is most similar to Atalay and Barrett (2015) who investigate the effects of the 1993 Australian Age Pension reform. That reform progressively increased the ERA for women from 60 to 65 between 1995 and 2014. The authors study the effects on labor force participation and program substitution and find strong effects in both dimensions. They identify causal effects using difference-in-differences (DID) estimations on

² In our setting, a regression discontinuity approach is not convincing because the reforms were introduced stepwise and the reform intensity increased with the value of the running variable. In the setting studied by Geyer and Welteke (2021) a pathway to retirement was abolished abruptly at a given date of birth.

affected birth cohorts for men and women. In addition, they present their DID estimates separately by age following Mastrobuoni (2009), but without specifying a full DID model. In a review of the Atalay and Barrett (2015) analysis, Morris (2021) points out that after controlling for diverging time trends in the treatment and control groups the effect declines in size and turns insignificant. As Atalay and Barrett (2015), we identify the causal effect comparing males and females. However, we focus our analysis on treatment effects using a full DID model; thus, in our analysis identical time trends for male and female birth cohorts are not required as long as age-specific trends agree. Therefore our analysis is robust to the issues pointed out by Morris (2021). Also, while in the Australian pension program changes in labor force participation do not yield accrual effects on social security wealth and benefit receipt is means tested, we consider a more traditional retirement insurance with accrual and without means tests. Finally, we differ from Atalay and Barrett (2015) and also Mastrobuoni (2009) by using precise information on benefit receipt from administrative data instead of approximating the timing of retirement based on self-reported non-participation in the labor force. Similar to these prior studies and as suggested by the literature (e.g., Atalay et al. 2019, Courtney 2004), our measure of reform effects might be downward biased, if the reform generated spillover effects within couples.

In terms of institutions, our study is most similar to Engels et al. (2017) who investigate a reform of the retirement pathway for females in Germany. That reform consisted of a stepwise increase of the NRA from age 60 to 65 for the birth cohorts of 1940 and after in combination with the contemporaneous introduction of an ERA and related benefit deductions. Engels et al. (2017) study the direct effect of benefit discounts and consider a set of outcomes following Mastrobuoni (2009). They find sizeable employment and retirement responses to the introduction of benefit deductions. In contrast, we focus on reforms of the unemployment pathway to retirement which affected men: about 30 percent of the relevant cohorts used the pathway (DRV 2018). Our first reform, announced in 1996 and effective 1997, increased the

NRA stepwise from age 60 to 65 for the birth cohorts of 1937 and after and contemporaneously introduced an ERA with related benefit deductions. Our second reform, announced in 2004 and effective 2006, increased the ERA stepwise from age 60 to 63 for the birth cohorts 1946 and after. We differ from Engels et al. (2017) by first, considering reform effects on additional outcomes, second, by focusing on men instead of women, third by offering an additional control group in our identification strategy and finally, by comparing the effects of two separate reforms.

We find that both reforms increase the propensity to stay employed longer, postpone unemployment, and delay old-age retirement. After reform 1 (NRA), we observe an increased use of substitute pathways to enter retirement, i.e., disability retirement and retirement of the severely handicapped. Thus, our sample of men actively changed their labor force status in response to financial incentives. This differs from findings for women by Engels et al. (2017) and Geyer and Welteke (2021). While the direction of the reform effects is similar after both reforms, the magnitude of behavioral adjustments after reform 2 (ERA) appears to be larger. The results are robust but slightly larger when only a DID strategy is applied. The fiscal effects of both reforms are positive for social insurances and the taxpayer. This is consistent with the national and international literature. We find that individuals who have little time to adjust to the reform and who are caught by surprise delay retirement by more and adjust employment more strongly than those who have time to prepare for regulatory changes. The reform effects vary by pension wealth: in response to financial incentives the poorest prolong employment and postpone retirement by more than those with higher pension wealth.

In section 2, we describe the institutional features of the German retirement system and discuss our hypotheses and the underlying mechanisms of the expected reform effects. Section 3 outlines our data, sample, and variables, and provides first descriptive evidence. Additionally, we discuss the empirical method and potential challenges to the identification strategy. Results and robustness tests follow in sections 4 and 5, and section 6 concludes.

2. Institutional Background and Hypotheses

2.1 Retirement Insurance and Pathways to Retirement

The German retirement insurance operates on a pay as you go basis. It is funded mostly by mandatory contributions of employers and employees. Regulated at the federal level, it covers more than 80 percent of the population, excluding only civil servants and the self-employed. It offers old-age, disability, and survivor benefits. Given the limited relevance of private pensions in Germany, the mandatory retirement system provides the main source of income for most elderly households (Frommert 2010).³

Generally, benefit amounts depend on amounts and years of contribution. More specifically, the benefit formula considers the sum of annual 'earning points'. The earning points for one year represent the ratio of the individual's earnings and the mean earnings of all insured persons, i.e., the relative individual annual contribution. An individual who contributed to the retirement insurance over 45 years based on the annual average earnings would receive a gross benefit that amounts to about 48 percent of gross earnings (BMAS 2019). Benefit eligibility is regulated along pathways to retirement. Examples for such pathways are retirement "due to unemployment", "for women", "after long term employment", or "disability retirement". Pathways can be used with a normal retirement age (NRA) or an early retirement age (ERA). With the ERA, the minimum retirement entry age and subsequent benefit amounts are lower than with the NRA; specifically, each month of early benefit receipt prior to the NRA generates a permanent benefit cut by 0.3 percent (i.e., 3.6 percent for each full year).

We exploit two reforms of the entry age for the unemployment pathway into retirement. The unemployment pathway into retirement has been available for blue and white collar workers since 1957. The utilization of the pathway increased over successive birth cohorts. It was used by 10 percent of all retired men born in 1925, 24 percent of those born in 1935 and

³ For broader discussions of the German retirement system see, e.g., Seibold (2020), BMAS (2019), Geyer et al. (2020), Geyer and Welteke (2021), or Ye (2019).

30.8 percent of those born in 1940. For subsequent birth cohorts the shares declined, e.g., to 19.7 percent for the 1945 cohort (see DRV 2018, page 93).⁴

The pathway was used particularly by individuals with low reemployment probabilities, who had lost their jobs in the wake of structural changes in firms and industries and whose occupational experience was no longer demanded in regional labor markets (Mika and Krickl 2020). However, at the same time these individuals had accumulated substantial claims against the retirement insurance. Their past earnings and retirement benefits often exceeded those of the average retiree (DRV 2018).

The first reform increased the NRA stepwise from age 60 to 65 starting with individuals born in January 1937 and ending with those born in December 1941 (see column 1 of **Table 1** and **Figure A.1** in the Appendix). At the same time, early retirement with benefit deductions became newly available at age 60 for all cohorts. The second reform increased the ERA stepwise from age 60 to 63 starting with individuals born in January 1946 and ending with those born in December 1948.⁵ Both reforms contained regulations to protect the 'legitimate expectation' (*Vertrauensschutz*) of individuals.⁶

⁴ These figures describe the share of unemployment retirement out of all pathways to retirement. If the disability retirement (*Renten wegen verminderter Erwerbsfähigkeit*) pathway is disregarded the utilization of unemployment retirement amounts to 16.2, 35.4, 41.7, and 25.1 percent of all old age retirement pathways (*Renten wegen Alters*) for the birth cohorts 1925, 1935, 1940, and 1945, respectively. The latter shares for women are 1.2, 4.6, 3.4, and 4.7 percent (calculated based on Tables on pp. 90/91 in DRV 2018).

⁵ In addition to a minimum entry age, four requirements characterize the unemployment pathway: the individual must have 15 insurance years (*Wartezeit*), paid contributions in 8 out of the last 10 years, be unemployed at the time of retirement, and have been unemployed for at least 52 weeks after age 58 years and 6 months. The last two requirements were slightly relaxed after 2000. Individuals are considered to be unemployed if they are registered with the unemployment insurance. This requires to actively look for work. Between 1985 and 2008 this requirement was dropped for individuals aged 58 and above. Since 1996, the unemployment pathway is additionally available for individuals who were employed on partial retirement schemes (*Altersteilzeit*) which contrary to our first reform would increase the utilization of the pathway. As we cannot separate the effect of this extension from the reform effect on retirement, our estimated effects might be attenuated, i.e., biased toward zero.

⁶ Individuals born before 1942 with 45 insurance years or more and those born before Feb. 14, 1941 and unemployed on Feb. 14, 1996 were not affected by reform 1. Individuals who were unemployed on Jan. 1, 2004 were not affected by reform 2 (Steffen 2018).

Column 2 of **Table 1** depicts the retirement pathway for women (see also **Figure A.1**).⁷ Here, the reform for birth cohorts 1940 and after is very similar to the first reform of the unemployment pathway. In addition to these two pathways, the 'regular old-age' retirement pathway has traditionally been available at age 65 and does not offer an ERA; 'retirement after long-term employment' is available for individuals with 35 insurance years and offers an ERA of 63 and a NRA of 65. A special pathway is available for individuals with severe handicaps. Finally, the disability pathway used to provide retirement benefits independent of age (Hanel 2012). It is available until the 'regular old-age' retirement age is reached.⁸

As retirement insurance contributions paid in East Germany were in part treated differently from those paid in West Germany, we follow Ye (2019) and use only individuals who contributed in West Germany. In robustness tests, we include individuals with labor market experience in East Germany.

Since anticipation behavior can affect the estimation of treatment effects, it is important to consider reform announcements: in 1989, a reform law was passed which stipulated that starting in 2001 retirement entry ages should start to increase towards age 65 beginning with the 1941 birth cohort (Steffen 2018). However, in 1996 and 1997, reforms accelerated the increase in the retirement age and brought the starting date of these retirement entry age adjustments forward from 2001 to 1997. This newly affected individuals of the 1937 (instead of 1941) birth cohort (reform 1), who had little time for adjustment as they turned age 59 in 1996.

⁷ The pathway requires at least 15 insurance years and contributions for at least 10 years after age 40. For a description of additional pathways, please see **Table A.1** in the Appendix.

⁸ Since a 1999 reform, the NRA for disability benefits is 63 for retirement entries that occurred after 31.12.2000. For every month in which benefits are taken out before age 63, the benefit amount is reduced by 0.3 percent, but not by more than 10.8 percent. We account for this change by using a control variable that reflects the benefit discount connected to a potential disability retirement for a given calendar time and for each specific person. **Table A.2** in the Appendix describes the disability benefit discounts after 2000. The reform changed further elements of disability retirement, however, they are not relevant here.

The ERA had been available since 1997 for birth cohorts 1937 and after. In 2004, a law was passed which mandated that the minimum age for early retirement on the unemployment pathway increased starting in 2006 (reform 2) (Steffen 2018). As both reforms were passed into law very briefly before they became effective, we expect to observe short-term behavioral adjustments that are not yet attenuated through anticipatory behavior changes.

2.2 Related Institutions: Unemployment as a Bridge to Retirement

As we focus on retirement after unemployment, it is important to describe unemployment insurance (UI) rules. Historically, two types of unemployment benefits were provided: an insurance based payment (UB I) that covered about 60 percent of last net earnings and a means tested system which provided a more modest minimum income support (UB II). The duration of UB I benefit payment depends on the number of UI contribution years and the age of the unemployed individual and was reformed several times (see **Table A.3**).

Since the 1990s, it was common practice to use the long unemployment benefit duration as a bridge to retirement: retirement benefits after unemployment were available starting at age 60 without benefit deductions. So workers who were laid off starting e.g. at the age of 57 and 4 months, received unemployment insurance benefits for up to 32 months, and then entered retirement after unemployment. In our analysis, we follow Engels et al. (2017) and account for changes in the duration of unemployment benefit payout by controlling for the individual and age-specific maximum entitlement length.

2.3 Expected Reform Effects and Hypotheses

The first reform increased the NRA in a stepwise fashion and introduced an ERA. The second reform increased the ERA stepwise and thus disallowed retirement at early ages. The first reform implied a negative shock to individuals' social security wealth and the second reform restricted individuals' choice sets by making early retirement unavailable.

Under the first reform, it remained possible to retire starting at age 60. However, the reform introduced a benefit reduction after early retirement which increased over subsequent birth cohorts. To retire at age 60, the 1936 birth cohort did not suffer benefit reductions, cohort 1937 had to forgo up to 3.6 percent, and cohort 1942 and later lost 18 percent of their benefits.

The literature offers different theoretical frameworks to derive hypotheses with respect to the reforms' effects. The first is based on an intertemporal consumption model. In this view, the reforms generated income and substitution effects: the income effect consists of the decline in 'pathway-specific pension wealth', e.g., at age 60. The newly introduced additional reduction in pension benefits that follows each month by which retirement takes place prior to the new normal retirement age increase the price of leisure. This generates the substitution effect in the choice of entering the unemployment pathway (for a more formal description, see, e.g., Hanel and Riphahn 2012). If leisure is a normal good, both effects reduce the demand for leisure and increase labor force attachment and incentives to postpone retirement entry. We therefore expect prolonged employment and unemployment. In particular, workers who would have used unemployment as a bridge into retirement before age 60 without the reform may postpone unemployment to later ages: their unemployment may decline before age 60 and increase afterwards. Also, we expect delayed retirement entry after the first reform. Since the reduction in pension benefits vary by cohort and by age, the income and substitution effects should differ across birth cohorts and for every cohort by age.

Alternative pathways of retirement, e.g., for those with severe handicaps, continued to offer retirement entry at age 60 without benefit deductions for the birth cohorts 1937-1939. In addition, disability retirement was available without any age restrictions at full benefits for the 1937 cohort. For the birth cohorts 1938 and after, disability retirement at full benefits was available until December 31, 1999. For subsequent entries, benefit discounts were introduced if the retiree had not yet reached age 63 (see **Table A.2**). Individuals may have used these alternative pathways as substitute exit routes out of the labor force.

The second reform abolished the option to use ERA on the unemployment pathway prior to age 63 in a stepwise fashion for birth cohorts 1946 and after. This reform may have no lifecycle income effects if prior benefit discounts after early retirement were actuarially fair. Nevertheless, behavioral adjustments will follow from changes to age-specific budget constraints: if the pathway to early retirement is unavailable other labor market options are more attractive as they provide an income. The effect of increasing ERA has been looked at for different countries before: see, e.g., Cribb et al. (2016) for the UK, Staubli and Zweimüller (2013) for Austria, Vestad (2013) studied the effect of a reduced ERA for Norway, and Geyer and Welteke (2021) and Geyer et al. (2020) studied different pathways in Germany. These studies generally find that such a reform (a) affects employment and unemployment, and (b) incentivizes program substitution.

A second framework to explain retirement behavior has recently been developed by Seibold (2020). He uses the example of 644 pension benefit continuities in Germany to establish convincing evidence that financial incentives alone cannot explain retirement patterns. Instead, he suggests that normal and early retirement ages become reference points for individual retirement decisions. Under this framework, the two reforms considered here shifted the reference points for retirement entry after unemployment which should then yield similar adjustment patterns.

Overall, we expect that after both reforms individuals stay in employment longer (H1). Because unemployment as a bridge to retirement becomes less attractive, after reform 1 (NRA), unemployment may decline prior to age 60 and increase at age 60 and after. In contrast, after reform 2 (ERA), unemployment may decline at age 60 and after because retirement without deductions was available only at age 65. In sum, we expect that unemployment is postponed to later ages (H2). We expect that both reforms contributed to a delay in the utilization of the unemployment pathway to retirement because it became either more expensive (reform 1) or

inaccessible (reform 2) (H3). Also, we expect that the demand for alternative pathways, such as disability retirement or retirement for the severely handicapped, increased (H4).

In addition, we compare the responses of two reforms. Staubli and Zweimüller (2013) suggest that responses to changes in the ERA are larger than responses to changes in the NRA: while individuals can ignore changes in the NRA by accepting reduced benefit payments upon retirement postponements of the ERA must be heeded. We compare the responses to reforms 1 and 2, which affect the same pathway but affect different birth cohorts.

3. Data and Methods

3.1 Data

We use administrative data offered by the German Pension Insurance. The *Versicherungskontenstichprobe* (VSKT) provides roughly a 1 percent random sample of persons aged 15-67 and covered by the German Statutory Pension Insurance. The data are available annually since 2002.⁹ Each wave provides information on demographic and pension relevant characteristics such as year and month of birth, nationality, information on monthly labor market status and earning points (Stegmann 2008, Himmelreicher and Stegmann 2008).

We use different samples for the two reforms. They consist of men and women born between 1935-1939 and 1945-1948. Due to special pension rules, we do not consider civil servants, self-employed, miners, and persons with pension entitlements according to the law on foreign pensions (*FRG*).¹⁰

⁹ For every new wave, the data drop the cohort turning 68 and add the cohort turning 15 in the observation year generating a panel data set. The first available VSKT 2002 data covers cohorts 1935-1972 and the last VSKT 2016 cohorts 1949-1986. Data for 2003 are not available. The Research Data Centre of the German Pension Insurance (FDZ-RV) created a version of the VSKT data for our project.

¹⁰ We also exclude individuals with missing information on the date of retirement entry. These individuals are not yet retired when the data is collected and their information may be misleading. They make up 0.2 (1.4) percent of the initial samples for reform 1 (2). For details, please see Stegmann (2016).

We analyze the reform effects by comparing the labor market behavior of treated and non-treated individuals. We compare the birth cohorts 1937-39 and 1946-48 who are affected by the reforms to the cohorts 1935-36 and 1945 who are not affected. In addition, we take advantage of the fact that females who are eligible for the female retirement pathway are basically not affected by the reform of the unemployment pathway.¹¹ Therefore, they constitute a control group in our analyses. The female retirement pathway provides a NRA of 60 for birth cohorts potentially affected by our first reform (1935-39) and an ERA of 60 for those birth cohorts potentially affected by our second reform (1945-48). Since the female birth cohorts 1940-44 were affected by the NRA reform for female retirement (see **Table 1**), we do not use these cohorts and thus limit our post-reform cohorts for reform 1 to 1937-39 and our pre-reform cohorts for reform 2 to 1945.¹² For reform 1 (NRA), we therefore consider individuals born 1935-1939 and for reform 2 (ERA) individuals born 1945-1948.

To obtain comparable subsamples, we follow Engels et al. (2017) and consider only those men and women in our sample who fulfill the eligibility criteria for the female retirement pathway when they are at age 55.¹³ These eligibility criteria demand a waiting period of 15 years and a compulsory contribution period of at least 10 years after reaching age 40. Clearly, we cannot condition on the eligibility criteria of the unemployment pathway since this involves the potentially endogenous response of anticipatory unemployment.

For every birth cohort, we use one wave of the VSKT to avoid duplicate observations.¹⁴ Based on the biographical information, we code monthly observations for each individual from

¹¹ Only two percent of female retirees of e.g. birth cohort 1939 used the unemployment pathway which compares to 30 percent of male retirees (DRV 2018, p. 93).

¹² We exclude cohorts 1949 and later because for them the ERA no longer differs by birth month which we use in our identification strategy (see section 3.2).

¹³ In our robustness checks, we test whether this restriction affects our results.

¹⁴ To handle mortality risks consistently and to avoid cohort-specific biases, for each cohort, we use that observation year and data wave in which individuals turn 65. Because some waves are not available, we use the VSKT 2002 and 2004 to gather the information for birth cohorts 1935-1939. As we use individual characteristics only prior to age 63 the date at which this information is gathered is innocuous.

age 60 plus 0 months to age 62 plus 11 months. As discussed above some individuals are not affected by the reform because of regulations to protect their 'legitimate expectation'. We code the treatment status of those individuals, about two percent of the sample, as not treated. Overall, we use 11,240 different individuals and 404,640 person-month observations for the first and 8,566 individuals and 308,376 person-month observations for the second reform.¹⁵

Our dependent variables characterize five different states. They describe for every age month whether an observation is in “employment”, “unemployment”, “old-age retirement”, “severely handicapped retirement”, or “disability retirement”. “Old-age retirement” combines retirement entries through all pathways except for “severely handicapped retirement”, or “disability retirement”.¹⁶

Table 2 describes our dependent variables. In the sample for reform 1, 21 percent of the full sample are in employment, about 4 percent in unemployment, 57 percent of the person-month observations of 60-62 years olds are already in old-age or severely handicapped retirement, and about 13 percent in disability retirement.¹⁷ The reform 2 sample has higher shares in employment and unemployment and a lower share in retirement.

Figures 1 and 2 depict cohort- and gender-specific employment, unemployment, and old-age retirement behavior by age for both reforms. **Figure 1.1** shows employment rates by age for men and women of cohorts 1935-39 (we dropped some birth cohorts to enhance clarity). After age 60, employment drops for men and women. However, males stay in employment longer than females. As expected, the treated male cohorts 1937 and 1939 have higher employment rates than the pre-reform cohort 1935 with little difference across cohorts for

¹⁵ We describe the impact of the sample selection steps on sample sizes in Appendix **Table A.4**.

¹⁶ These pathways are described in column A to D in **Table A.1**. Because we observe individuals under age 63 only, 'old-age retirement' comprises retirement due to unemployment (column A) and retirement for women (column B).

¹⁷ The remaining observations are in "other" states (training, marginal employment, non-commercial care) or disabled/long-term sick-leave. For a full description of variables see **Tables A.5-A.8**.

females. The developments for the non-affected cohorts are similar for males and females supporting our strategy to use females as a control group. **Figure 1.2** presents unemployment rates by cohort, gender, and age. While these rates are rather similar for females across birth cohorts, the male rates clearly reflect the reform incentives: the unemployment rate of post-reform cohorts exceeds that of pre-reform cohorts at almost all age months. The effect is most visible at the early ages. The male and female developments for the pre-reform cohorts are parallel. **Figure 1.3** depicts old-age retirement starting at age 60. Generally, males' retirement rates are lower than females'. While male cohorts affected by the reform have lower old-age retirement rates than the pre-reform cohorts this does not hold for females, matching expectations. As before, females and males in the cohort not affected by the reform (1935) have similar age patterns.

Figure 2 present the same outcomes with respect to reform 2, for cohorts 1945-1948 (cohort 1947 omitted to enhance clarity). **Figure 2.1** shows similar employment-age patterns for males and females pre-reform (i.e., birth cohort 1945). For the cohorts affected by the reform, we find substantial changes in employment rates for men, but not for women. The unemployment rates in **Figure 2.2** are unclear which is likely related to reforms of unemployment benefit duration in 2006 and 2008 for which we do not control here.¹⁸ However, the male pre-reform cohort stands out. Also, we find a drop in unemployment rates at the early ages and an increase in later ages for cohort 1948, as expected. Finally, **Figure 2.3** shows retirement rates and confirms cohort and gender differences: the retirement of the treated male cohorts declines stepwise by age and birth cohort which follows exactly the incentives generated by reform 2. As in **Figure 1.3**, we observe a similar age pattern for the male and female pre-reform cohort.

¹⁸ We do consider controls in our estimations, see section 2.2.

Figures 1 and 2 show that affected and non-affected male birth cohorts differ in their employment, unemployment, and retirement behavior in agreement with the expected reform effects. Female birth cohorts are suitable controls as they show similar pre-reform patterns.

3.2 Empirical Methods

We aim to identify the causal effect of two reforms on retirement behavior and labor force participation choices of older workers. We exploit the fact that both reforms affected specific birth cohorts at specific ages, e.g., reform 1 modified the NRA of individuals age 60 and born in 1937 or later and reform 2 modified the ERA of individuals age 60 and born in 1946 or later. Based on the combination of birth cohort and observation period, we can identify the causal reform effect if we assume that the reform is the only determinant of possible behavior changes across birth cohorts at a given age. This identification strategy is widely applied in the literature and requires that there are no changes in age-specific cohort trends absent the reform (e.g., Staubli and Zweimüller 2013, Mastrobuoni 2009, Hanel and Riphahn 2012).

We can go beyond this standard approach and allow for age-specific cohort trends. We additionally compare groups of men treated by the reform and women not treated by the reforms, both, at ages when the reform was effective or not, and for birth cohorts which were and were not affected. This DIDID setting is possible because the change in the unemployment pathway to retirement was not accompanied by a similar and simultaneous change in the retirement pathway for females and because the changes were implemented stepwise by cohort.

Under the requirements of the female retirement pathway, women continued to be able to retire at an NRA of 60 after our reform 1 (NRA) and similarly to use an ERA of 60 after our reform 2 (ERA) (see **Table 1**). Thus, we distinguish men who are affected by the reform (treatment group) from women who are not affected (control group) and compare their behavioral choices at ages which were affected and ages that were not affected by the reforms for birth cohorts affected (post-reform) and not affected (pre-reform) by the reforms. We

calculate the reform effect as the difference in changes between men and women across ages and cohorts. This identifies causal effects if the behavioral adjustments across cohort groups and genders would have been identical for different ages without the reform. This is a weaker identifying assumption than that required for a DID model: we can allow for changes in the labor market affecting men and women differently across birth cohorts as long as they are not age-specific.

The recent literature intensely discusses spillover effects in retirement choices of couples. There is substantial evidence showing coordination in spouses' retirement choices (e.g., Atalay et al. 2019, Hospido 2015). Clearly, such coordination behavior can modify the policy reforms' effects as changes of the retirement entry age for men affects the behavior of women and vice versa. If spillovers are neglected in the analysis of reform effects, the results can be biased downward (see Courtney 2004). Besides the direct reform effects of increasing retirement entry ages on the husbands' retirement, the reform could induce indirect reform effects by increasing the wives' retirement ages, as well. Since we compare male and female labor market outcomes and as our data do not allow us to control for the spouses' labor market choices our overall impact assessment of the reform may be biased downward.

Let *men* indicate whether the individual is male (*men*=1) or female and belongs to the control group (*men*=0). *C* contains month and year of birth fixed effects and *post* is equal to one for cohorts affected and equal to zero for cohorts not affected by the reform. *A* represents the individuals' monthly age in a given monthly observation *a*. Some ages are affected by the reform and others are not; *age* (valued 0 or 1) indicates whether an individual is affected by the reform in a given month. *X* are individual level control variables; we use measures of past earnings, health, tenure, and insurance group indicators (blue collar, white collar, other) as of age 55, i.e., prior to the observation window. Finally, to account for unemployment and disability benefit reforms (see sections 2.1 and 2.2), we also control for the maximum length of

(potential) unemployment benefit receipt and the month- and person-specific potential discount after disability retirement.¹⁹ We use the following linear regression model:

$$Y_{i,a} = \beta_0 + \beta_1 \text{men}_i + \beta_2 C_i + \beta_3 A_{ia} + \beta_4 C_i * A_{ia} + \beta_5 \text{men}_i * C_i \\ + \beta_6 \text{men}_i * A_{ia} + \gamma (\text{men}_i * \text{post}_i * \text{age}_{ia}) + X \theta + \varepsilon_{i,a} . \quad (1)$$

We estimate the parameters β , γ , and θ using least squares regression, where γ represents the causal effect of interest. ε is a random error. Please note that the triple interaction term is identical to using an indicator for being affected by the reform versus not (see, e.g., the specification by Staubli and Zweimüller 2013). We consider variations of this specification where we control for a post reform indicator instead of the detailed date of birth fixed effects, C .

In addition to the interaction model (1), we apply specifications that control for the reform intensity for given individuals (see Duggan et al. (2007) for a related approach). Appendix **Tables A.9** and **A.10** describe the number of months of benefit discounts after reform 1 (NRA) and the number of months by which an early retirement must be postponed after reform 2 (ERA). We use these indicators of reform intensity (I) that vary at the cohort, gender, and age level in a separate specification and estimate the following model for both reforms:²⁰

$$Y_{i,a} = \beta_0 + \beta_1 \text{men}_i + \beta_2 C_i + \beta_3 A_{ia} + \beta_4 C_i * A_{ia} + \beta_5 \text{men}_i * C_i \\ + \beta_6 \text{men}_i * A_{ia} + \gamma I_{ia} + X \theta + \varepsilon_{i,a} . \quad (2)$$

The estimate for γ yields the causal reform effect. As before, we apply alternative specifications which use a simple post reform indicator instead of monthly date of birth fixed effects, C . Generally, γ is identified by the reform which changed the incentives jointly by age and cohort. In the case of reform 1 (NRA), intensity represents the magnitude of the benefit discount that

¹⁹ For a description and descriptive statistics of all variables, see Appendix **Tables A.5-A.8**. We do not control for education because these variables mostly hold missing values and may not be reliable. Information about marital status and children is not generally available.

²⁰ The intensity is zero for females, for men of pre-reform cohorts, for men of post-reform cohorts at non-affected ages and for men with protected 'legitimate expectation' in the respective age month.

follows upon immediate retirement for reform 2 (ERA) it represents the waiting time to ERA. As we are not conditioning our sample on meeting the unemployment pathway criteria, our estimates represent intention to treat effects (ITT). We report robust standard errors that are clustered at the individual level.

4. Results and Robustness

4.1 Reform Effects

Table 3 shows the estimated causal effects of reform 1 (NRA) for the five labor force states of those aged 60-62. Columns 1-3 present the estimations based on the interaction model (equation 1) using different controls. The sign of the estimated reform effects agree with our expectations: we find increased employment and unemployment, reduced old-age retirement, and increased use of substitute pathways into retirement, i.e., disability and severely handicapped retirement.

The results in columns 4-6 use precise measures of reform 1 intensity (equation 2) based on individuals' age and birth cohort (see **Table A.9**). The results are mostly statistically significant and confirm the patterns in columns 1-3. More specifically and based on column 6, they suggest that one year of postponed normal retirement increases the propensity to be employed in any given month by 0.8 percentage points (insignificantly) and the propensity to be unemployed by 1.6 percentage points; based on the pre-reform means (see last columns of **Table 2**) this amounts to increases in employment and unemployment by 2.6 and 27 percent, respectively. It reduces the propensity of old-age retirement by 8.6 percentage points, i.e., 28.9 percent, and yields large and significant increases in the propensity to use substitute retirement pathways in total by more than 4 percentage points per month, an increase by 16.0 percent.

We apply identical procedures to analyze the effects of reform 2 (ERA). **Table 4** shows the estimates. In columns 1-3, we find large and significant increases in the propensity to be employed and declines in the propensity to be unemployed. As expected, the propensity for old-age retirement declines. Surprisingly, we do not observe a significant increase in the use of

substitute retirement pathways. In the case of disability retirement, this may be connected to the 1999 reform and the connected benefit discounts (see section 2.1). The negative effect on severely handicapped retirement could be explained by an earlier reform of this pathway.²¹ The estimation results based on the intensity measure (columns 4-6) confirm these findings.

In columns 7 of **Tables 3** and **4**, we show the results of DID analyses where we omitted females as a control group. Here, the causal effect is identified by comparing men of given ages across birth cohorts, only. For both reforms, the findings are generally robust in terms of sign and significance of the estimates. However, the magnitude of the effects is generally larger when female control groups are disregarded (compare columns 6 and 7). Thus, using female control groups provides conservative estimates of effects which otherwise may have been overstated.

Finally, we compare the effect size of the two reforms. We argued based on Staubli and Zweimüller (2013) that the effect of reform 2 should exceed that of reform 1 because the former is more strict and renders, e.g., an early retirement at age 60 impossible instead of merely expensive. It may be misleading to simply compare coefficient estimates across reforms because the estimates represent ITT effects. They are estimated for the population of potential retirees that might consider the unemployment pathway and do not account for the share of individuals who will actually be unemployed and affected by the reform. Therefore, we adjust the estimated effects based on the observed share (p) of individuals in pre-reform cohorts that either used the NRA (prior to reform 1) or the ERA (prior to reform 2) of the unemployment

²¹ The reform increased the NRA of the severely handicapped retirement pathway from 60 to 63 (see **Table A.1**). However, additional regulations allowed all those individuals who were born prior to Nov. 16, 1950 - i.e. those treated by reform 2 - who were handicapped already in 2000, to retire at age 60. It is plausible that the share of individuals protected by this rule declines over time if younger individuals were less likely to be severely handicapped in 2000. This results in a mechanical drop in severely handicapped retirement entry which is driven by the reform of this pathway itself. Any substitution effects from our reform 2 would be too small to override this mechanism. The estimated significant negative effect thus most likely results from the temporal coincidence of the prior reform of severely handicapped retirement with our reform 2 (see **Tables 1** and **A.1**).

pathway. Out of all men born in 1935 or 1936 (1945) in our sample, 29.7 (16.3) percent used the unemployment pathway prior to age 63. The ratio of the ITT estimates over p yields estimates of the average treatment effect of the treated (ATT) (see Angrist and Pischke 2009) which is appropriate if p does not vary substantially over time. **Table 5** restates the estimation results of columns 6 of **Tables 3** and **4**. Columns 3 and 4 of **Table 5** present the ATT after dividing by p . As the ATT estimates scale the ITT estimates by factors 3.4 (column 3) and 6.1 (column 4) they show that the response of those actually affected by the reform are 3 and 6 times as large as the ITT estimates shown before. As an example, the propensity to be employed in a given month increases by 2.6 and 57 percentage points for those treated by a one year change in the NRA and ERA, respectively. The resulting estimates for employment (both positive) and unemployment (in absolute terms) are substantially larger for reform 2. The negative effects on old-age retirement are larger for reform 1 than for reform 2. Based on the sum of the effects on all three retirement pathways (old-age, severely handicapped, and disability retirement), reform 2 reduced the overall propensity to be in retirement by more than reform 1.

4.2 Threats to identification

We offer several tests to investigate whether our identifying assumption holds. In columns 2 and 5 of **Table 6**, we add linear time trend controls to the main estimation for both reforms separately for males and females. Generally, our main results (repeated in columns 1 and 4) are robust. In columns 3 and 6, we control for a richer specification of a linear trend; we add its interaction with the men indicator, post-reform cohort indicators, the interaction of men and post-reform indicator, and also with the interaction of men, post-reform, and affected age indicator. Again, the main results hold up. Therefore, time trends do not drive our main results.

In column 7 of **Table 6**, we show placebo results for reform 1 (NRA), where we consider the birth cohort 1935 as control and cohort 1936 as treated by reform 1. The results confirm that a non-existing reform had no significant effects which supports our setting.²²

4.3 Heterogeneities

We study effect heterogeneities along two dimensions. First, we distinguish the reform effects by year of birth, and separately estimate our models for the relevant birth cohorts. We expect that both reforms caught the oldest cohorts by surprise. Younger cohorts had more time to adjust after the reform laws were passed. The results for reform 1 (NRA) and 2 (ERA) in columns 2-4 of **Tables 7** and **8** show that the reform effect was indeed strongest for the oldest, most surprised cohorts.²³

Next, we study the heterogeneity of reform effects along the pension wealth distribution. We group individuals based on their earning points at age 55 representing individual pension wealth. As the reform introduced relative benefit deductions (e.g., by 3.6 percent), all retirees were affected identically in relative terms, independent of pension wealth. We consider three wealth tertiles of similar size (separately for males and females) and show the estimates in columns 5-7 of **Tables 7** and **8** for reforms 1 and 2. We expect that individuals with low pension wealth are most susceptible to potential benefit cuts whereas high wealth individuals may more easily forgo a small fraction of benefits to take advantage of early retirement. The same pattern would result if those with low pension wealth are more likely to actually use the unemployment pathway. The findings mostly agree with our expectations: after both reforms, those with the

²² We cannot offer the placebo test for reform 2 (ERA) because we use only one pre-reform cohort for reform 2 (see section 3.1).

²³ If the intensity effect is strongly nonlinear then the results across birth cohorts may not be reliable.

lowest pension wealth increased employment the most.²⁴ Also, they show the largest decline in old-age retirement entry after both reforms.

It is informative to compare the reforms: while reform 1 yielded the expected statistically significant employment and unemployment effects only for the oldest, most surprised cohort, after reform 2 the estimates for employment and unemployment are statistically significant for all cohorts. Similarly, the estimated employment and unemployment effects across pension wealth tertiles vary in sign and significance for reform 1 but are relatively large and statistically significant for reform 2. This confirms that reform 2 yielded stronger behavioral responses and affected the entire treatment group.

4.4 Robustness tests - sampling issues

In **Table 9**, we show the estimation results for both reforms for different samples. In columns 2 and 5 we add those male observations who would not have been eligible for female retirement at age 55. In column 3 and 6, we add those observations who had accumulated some employment spells in East Germany. In both cases, our main results (columns 1 and 4) hold up to these changes in the sample with only few exceptions.

In our specifications for reform 2, we account for the 2006 reform of the German unemployment insurance (UI) by controlling for the individual and age-specific maximum entitlement length (see section 2.2). Riphahn and Schrader (2019) and Dlugosz et al. (2014) show that the reform generated substantial anticipation behavior in terms of earlier unemployment entries. In order to evaluate whether this affects our results, we re-estimated the

²⁴ The significant negative employment effect of the middle pension wealth group is surprising. Apparently, they were more likely to shift into unemployment and particularly into health-related retirement pathways compared to the other wealth tertiles. It is possible that pension wealth in the middle group allows them to give up employment and to take the benefit discounts connected to these pathways. Also, their health may be worse than that of the high wealth group which permits the middle pension wealth group access to health-related pathways.

main specification after omitting observations from January-March of 2006. The results in column 7 of **Table 9** show that our findings are robust to this change.²⁵

4.5 Robustness tests - continuous long run outcome measures

For a different perspective and to investigate effects before retirement age, we consider summary measures of individual labor force states over time. Based on precise biographical information, we use the number of months an individual spent in our five states in three different age ranges (57-59, 60-62, and 57-62) as continuous dependent variables.²⁶ We apply a DID analysis to our data with one cross-sectional observation per person instead of monthly outcomes. Therefore, we cannot control for monthly age fixed effects and have to adjust the definition of some control variables (for details see **Tables A.11** and **A.12**).²⁷ However, for this analysis it is possible to illustrate the parallel paths which we depict in **Figures A.2-A.6**. The figures provide evidence that the common trends assumptions hold and we can claim to establish causal effects. For reform 2, we cannot show similar graphs because we have only one pre-reform birth cohort.

Table 10 shows estimates of the reform effect based on the specifications of column 6 in **Tables 3** and **4**. After reform 1, we observe an increase in the number of months spent in employment for all age groups. Unemployment declined substantially before age 60 and increased after age 60 with a large negative overall effect. We also find the expected decline in

²⁵ We also re-estimated our intensity models to determine whether the marginal effects from logit and probit estimations agree with our findings (results available upon request). The results hold up to the modified approach.

²⁶ 57-62 means that we count all months spent from age 57 years, 0 months until age 62, 11 months.

²⁷ As we use cross-sectional instead of panel observations, reform intensity no longer varies by age. Here, we define intensity as the person's benefit deduction after a retirement at age 60 which generates variation by date of birth. Similarly, controls for institutional reforms of unemployment and disability use age-specific average values and the eligibility for the protection of 'legitimate expectation' is considered for age 60. The models account only for year of birth fixed effects; we omit month of birth fixed effects and month of age to avoid collinearity (see Mastrobuoni 2009).

the number of months in old-age retirement. At the same time, the number of months spent in severely handicapped retirement and disability retirement increased significantly for all age groups. After reform 2, we observe increases in the number of months in employment, declines in unemployment for all age groups, reduced old-age retirement, *and* severely handicapped retirement. Among those aged below 60, we find modest but statistically significant substitution into disability retirement. Overall, the patterns are similar to those in response to reform 1.²⁸

5. Discussion

Based on reform 1 (NRA), we found that for those aged 60-62 postponing the normal retirement age by one year does not significantly affect employment. However, the monthly unemployment incidence in this age range increased by 1.6 percentage points which is a 27 percent effect relative to the pre-reform male sample mean of 5.83 (see column 6 of **Table 3** and last columns of **Table 2**). The old-age retirement rate declined by 8.6 points or 29 percent of the mean and the utilization of health related substitute retirement pathways jointly increased by 4.4 percentage points or 15.8 percent of the joint mean. While the point estimates are small, the overall effects are substantial and in most cases precisely estimated.

Based on reform 2 (ERA), we found that for individuals aged 60-62 shifting the early retirement age by one year increases the employment rate by 9.42 percentage points, about 21 percent relative to the pre-reform male sample mean. It reduces the unemployment rate by 5.14 points (48 percent), the old-age retirement rate by 2.5 points (15 percent), and increases the utilization of disability retirement by 0.87 percentage points (9.7 percent).

²⁸ In a robustness test, we account for the fact that individuals born in 1937 and 1938 (1946) had already reached age 59 and 58 in 1996 (2004) when the first (second) reform was passed. These individuals are used in the estimations, but were in fact unable to change their behavior at, e.g., age 57 in response to the reform. We re-estimated the models after omitting the relevant birth cohorts. The results confirm the robustness of our findings (available upon request).

We can compare these results to those provided by Engels et al. (2017) who investigated the reform of retirement for women in Germany which is very similar to our reform 1. For their sample in the 60-65 age range, they found that a shift in the NRA by one year would increase the employment rate by 3.6 percentage points ($3.6 * 1.0$), the unemployment rate by 3.24 percentage points ($3.6 * 0.9$) and the retirement rate would fall by 6.84 percentage points ($3.6 * 1.9$) (see their Table 3 columns II, V, VIII). While we obtain comparable effects for old-age retirement, their employment and unemployment effects are larger than ours. Unfortunately, the authors do not provide sample statistics. The difference in effect size may be related (i) to the fact that they can observe the two birth cohorts which face an increase in NRA up to age 65, i.e., the highest treatment intensity of up to 60 months of deductions²⁹ or (ii) to the fact that a larger population share uses the retirement pathway for women than for the unemployed.

Geyer and Welteke (2021) investigate a reform of the female retirement pathway that is similar to our reform 2: starting with birth cohorts 1952, the early retirement option for women at age 60 was abolished. Instead, women could use early retirement at age 63 via an alternative pathway. Using a regression discontinuity design, the authors find that female employment rates increased by 13.5 percentage points or 30 percent due to this reform. As their reform is three times as large as our reform 2 (we model a loss in ERA of only one year instead of three), our effect of a 9.4 percentage point increase in employment rates is relatively large. The difference may in part be due to the difference in identification strategies. Also, we investigate a male instead of a female treated sample; Dolls and Krolage (2019) also find larger responses among men than women.³⁰

²⁹ We have to exclude the two comparable birth cohorts (1940 and 1941) which are most affected by the reform from our analysis (see section 3.1).

³⁰ The Austrian reform studied by Staubli and Zweimüller (2013) is similar to our reform 2. They find that men and women increased employment by 9.75 and 11 percentage points and unemployment by 12.5 and 11.8 percentage points on average for an increase in ERA by two years for men and 3.25 years for women.

The results discussed in section 4.5 provide a different perspective and allow us to sign the reforms' overall fiscal effects. After reform 1, employment increases and unemployment declines between age 57 and 62. The retirement insurance benefits from a small net decline of about 2 months in the average number of months spent in retirement after the reform (plus 0.6 and 0.4 months in disability and severely handicapped retirement versus minus 3.7 months in old-age retirement). If in response to a change in NRA by one year, individuals on average stay in employment for longer and in unemployment and retirement for a shorter period, the fiscal effect is beneficial for the social insurances and the taxpayer. Engels et al. (2017) find larger effects: a shift in the NRA by 5 years generates an overall postponement of retirement by 15 months and a prolongation of employment by the same period (i.e. 3 months per year) with hardly any effects on unemployment. However, as mentioned above, they observe two more birth cohorts which are confronted with large treatment intensities at ages 60-62 of up to 60 months of deductions. Overall, the results of the two studies are comparable and suggest that the reform succeeded in reducing the burden of demographic aging borne by the retirement insurance.

The overall effects of reform 2 show similar patterns. Between age 57 and 62, we observe about 6.6 additional months in employment and 4.7 months less in unemployment due to a shift in the ERA by one year. In total, individuals spend about 1.5 months less in retirement. So, again the fiscal reform effect is positive.

Comparing the two reforms' effects with respect to the number of months in employment and unemployment at different age intervals confirms that the effects of reform 2 are typically larger: a shift in the NRA by one year yields smaller employment responses than a shift in the ERA by one year (see first panel of **Table 10**). Similarly, except for age group 57-59, the unemployment response is larger after reform 2.

6. Conclusions

This study adds to the literature on causal effects of shifting retirement entry ages. We exploit two separate reforms of one old-age retirement pathway in Germany. The unemployment pathway offers privileged retirement options for the unemployed. The first reform consisted of a stepwise increase of the normal retirement age (NRA) with full benefits, from age 60 to 65 for the birth cohorts of 1937 and after in combination with the contemporaneous introduction of an early retirement age (ERA) with benefit deductions. The second reform increased the ERA stepwise from age 60 to 63 for the birth cohorts 1946 and after. The first reform (NRA) introduced benefit deductions and made retirement at a given age prior to the NRA more costly. The second reform (ERA) made early retirement prior to age 63 impossible.

We use administrative data covering a large sample of retirees. We test four hypotheses: we expect that both reforms increase the propensity to stay employed longer (H1), to postpone unemployment from before to after age 60 (H2), to delay retirement (H3), and to use substitute pathways to enter retirement, i.e., disability retirement and retirement of the severely handicapped (H4). In addition, we compare the behavioral adjustments after reforms 1 and 2.

Our findings confirm hypotheses H1-3 for both reforms. H4, i.e., active program substitution, is supported for reform 1, only. Several sets of results show similar patterns in the response to reforms 1 and 2. The magnitude of responses to reform 2 appears to exceed that of the responses to reform 1. Overall, both reforms reduced the fiscal burden for the retirement insurance as the total utilization of retirement benefits declined by about 1.5 and 2 months per person. The findings agree with the prior national and international literature. Heterogeneity tests indicate that individuals most surprised by the reforms and with little time to adjust delay retirement by more and adjust employment more strongly. We find stronger increases in employment and declines in old-age retirement among individuals with the lowest retirement wealth. Our estimates are robust to various tests, changes of the sample and specifications. The results of a placebo test confirm the approach.

Our study stands out in the literature by using rich data, by evaluating two reforms, by looking at a large variety of outcomes, and by applying an identification strategy that compares responses across birth cohorts, age, and for affected and non-affected individuals (difference-in-difference-in-differences estimation). Specifically, we take advantage of the facts that (i) female older workers do not have to rely on the unemployment pathway and are therefore not treated by the reform, and that (ii) the treatment intensity for men varies by month of birth and by age. We show in a robustness test that our results hold up if the female control group is omitted altogether.

Our results confirm that treated men respond to retirement incentives and after the reform 1 of NRA actively utilize substitute pathways into retirement if those become relatively more attractive. This finding differs from the conclusions of Geyer and Welteke (2021) who find that treated women use 'passive program substitution' in response to reforms of their ERA and remain in their labor market status rather than pursuing alternative retirement pathways. Possibly, male and female retirement behaviors differ in response to their relative role and sequence in spousal retirement choices. Alternatively, only reforms to the NRA call forth active substitution behaviors whereas reforms of an ERA do not.

Regulatory changes may have potentially unintended distributional effects as those with the lowest retirement wealth adjust their labor market status more strongly than those who are economically better off. So, while financial incentives appear to be effective in deterring early retirement, the welfare effects of the policy and their heterogeneity across different population groups deserve additional attention.

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Table 1 Age at retirement by pathway and birth cohort

Birth Cohort	1		2	
	Retirement due to unemployment		Retirement for women	
	NRA (Yr.)	ERA (Yr.)	NRA (Yr.)	ERA (Yr.)
1934	60 (1994)	n.a.	60 (1994)	n.a.
1935	60 (1995)	n.a.	60 (1995)	n.a.
1936	60 (1996)	n.a.	60 (1996)	n.a.
1937	rising to 61 (1998)	60 (1997)	60 (1997)	n.a.
1938	rising to 62 (2000)	60 (1998)	60 (1998)	n.a.
1939	rising to 63 (2002)	60 (1999)	60 (1999)	n.a.
1940	rising to 64 (2004)	60 (2000)	rising to 61 (2001)	60 (2000)
1941	rising to 65 (2006)	60 (2001)	rising to 62 (2003)	60 (2001)
1942	65 (2007)	60 (2002)	rising to 63 (2005)	60 (2002)
1943	65 (2008)	60 (2003)	rising to 64 (2007)	60 (2003)
1944	65 (2009)	60 (2004)	rising to 65 (2009)	60 (2004)
1945	65 (2010)	60 (2005)	65 (2010)	60 (2005)
1946	65 (2011)	rising to 61 (2007)	65 (2011)	60 (2006)
1947	65 (2012)	rising to 62 (2009)	65 (2012)	60 (2007)
1948	65 (2013)	rising to 63 (2011)	65 (2013)	60 (2008)
1949	65 (2014)	63 (2012)	65 (2014)	60 (2009)
1950	65 (2015)	63 (2013)	65 (2015)	60 (2010)
1951	65 (2016)	63 (2014)	65 (2016)	60 (2011)
1952	retirement pathway terminated		retirement pathway terminated	

Notes: For a more complete description see **Table A.1**. The entry "rising to" means that the retirement age increased by one month for each month of birth in the relevant birth cohort: in column 1 individuals born, e.g., in January of 1937 had a NRA of 60 and 1 month, those born in February of 1937 had a NRA of 60 and 2 months and so on, reaching an NRA of 61 years for those born in December of 1937.

Source: SGB VI, BMAS (2017), Steffen (2018), and own calculations.

Table 2 Descriptive statistics of dependent variables

	Reform 1 - Analysis Sample			Reform 2 - Analysis Sample			Pre-reform Means for Men	
	All	Men	Women	All	Men	Women	Reform 1 Men	Reform 2 Men
States (mean)								
Employment (0/1)	0.2099	0.3123	0.0917	0.3977	0.5047	0.3289	0.3064	0.4526
Unemployment (0/1)	0.0414	0.0684	0.1450	0.0889	0.0841	0.0766	0.0583	0.1070
Old-age retirement (0/1)	0.4899	0.2463	0.7085	0.2458	0.1397	0.3428	0.2972	0.1628
Severely handicapped retirement (0/1)	0.0818	0.1354	0.0295	0.1092	0.1143	0.0948	0.1258	0.1259
Disability retirement (0/1)	0.1344	0.1657	0.1338	0.0913	0.0820	0.0995	0.1528	0.0895
Observations	404,640	161,376	186,228	308,376	142,380	148,536	84,636	42,660
Number individuals	11,240	4,749	5,173	8,566	3,955	4,126	2,351	1,185
Average age	61.46	61.44	61.46	61.46	61.46	61.46	61.46	61.46
Birth cohorts	1935-39			1946-49			1935-36	1945

	Reform 1 - Analysis Sample			Reform 2 - Analysis Sample			Pre-reform Means	
	All	Men	Women	All	Men	Women	Reform 1 Men	Reform 2 Men
States (mean)								
Employment (0/1)	0.2099	0.3123	0.0917	0.3977	0.5047	0.3289	0.3064	0.4526
Unemployment (0/1)	0.0414	0.0684	0.1450	0.0889	0.0841	0.0766	0.0583	0.1070
Old-age retirement (0/1)	0.4899	0.2463	0.7085	0.2458	0.1397	0.3428	0.2972	0.1628
Severely handicapped retirement	0.0818	0.1354	0.0295	0.1092	0.1143	0.0948	0.1258	0.1259
Disability retirement (0/1)	0.1344	0.1657	0.1338	0.0913	0.0820	0.0995	0.1528	0.0895
Observations	404,640	161,376	186,228	308,376	142,380	148,536	84,636	42,660
Number individuals	11,240	4,749	5,173	8,566	3,955	4,126	2,351	1,185
Average age	61.46	61.44	61.46	61.46	61.46	61.46	61.46	61.46
Birth cohorts	1935-39			1946-49			1935-36	1945

Notes: All observations are in the age range 60-62. Old-age retirement combines retirement after all pathways except for severely handicapped retirement and disability retirement; given our age restrictions this comprises only the two pathways of retirement due to unemployment and retirement for women (see **Table A.1**). **Tables A.5-A.8** describe all variables and provide further descriptive statistics. The number of observations in the columns entitled 'All' exceed the sum of male and female observations because sampling restrictions with respect to the protection of 'legitimate expectations' are not yet imposed in the columns 'All' (see sections 2.1 and 3.1 in the text). The affected observations are dropped from the male subsamples described in the columns entitled 'Men'.

Source: SUFVSKT2002_FAU_Schrader-SUFVSKT2013_FAU_Schrader, own calculations.

Figure 1.1 Reform 1 (NRA) - Employment rate by age, cohort, and gender

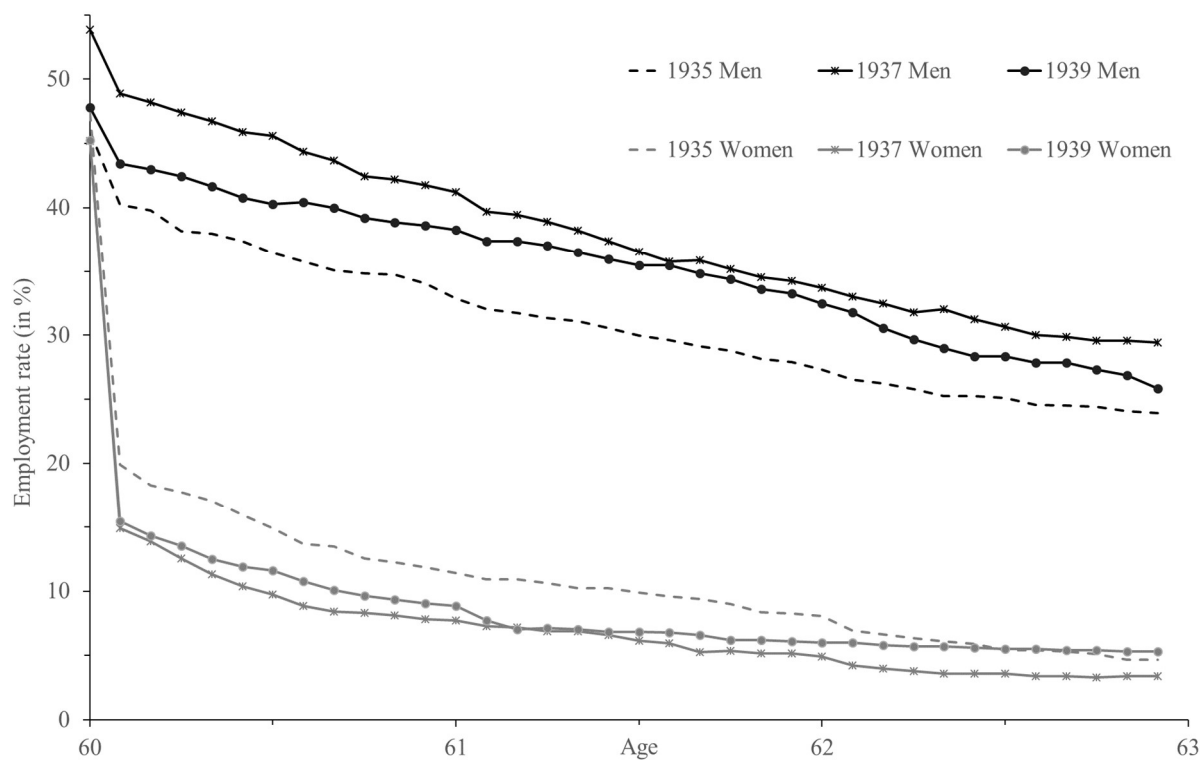


Figure 1.2 Reform 1 (NRA) - Unemployment rate by age, cohort, and gender

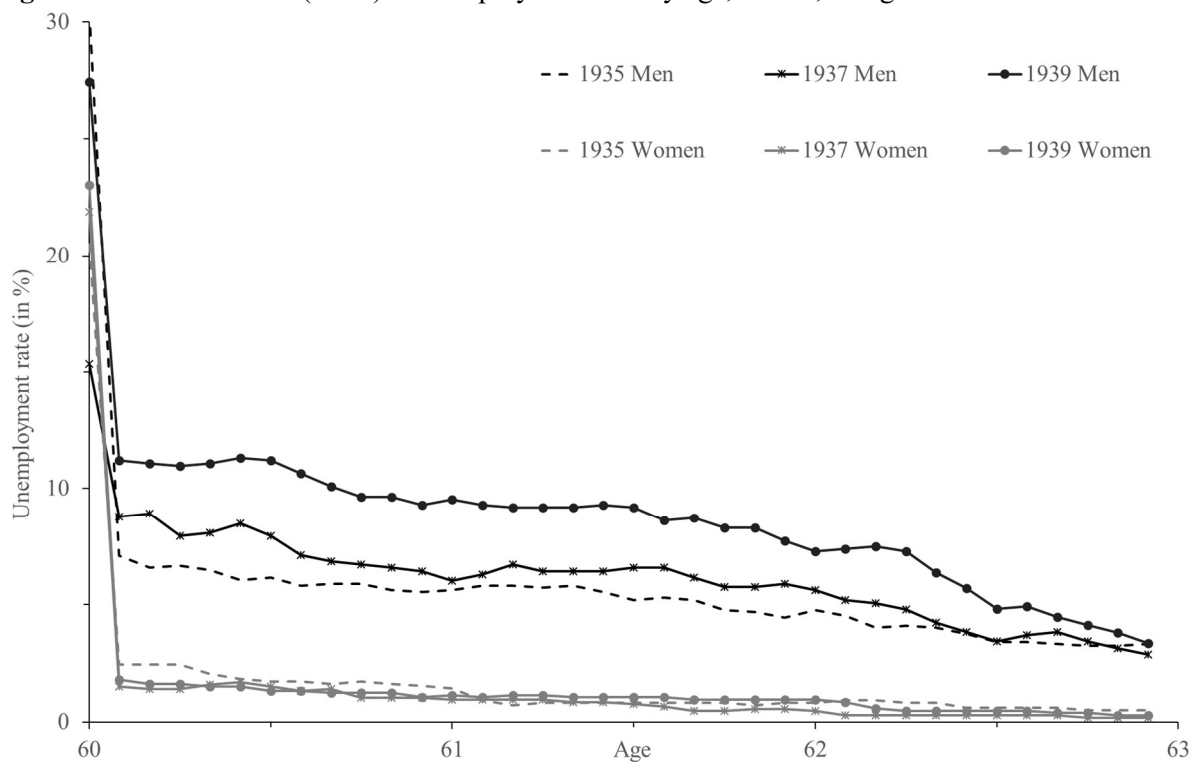
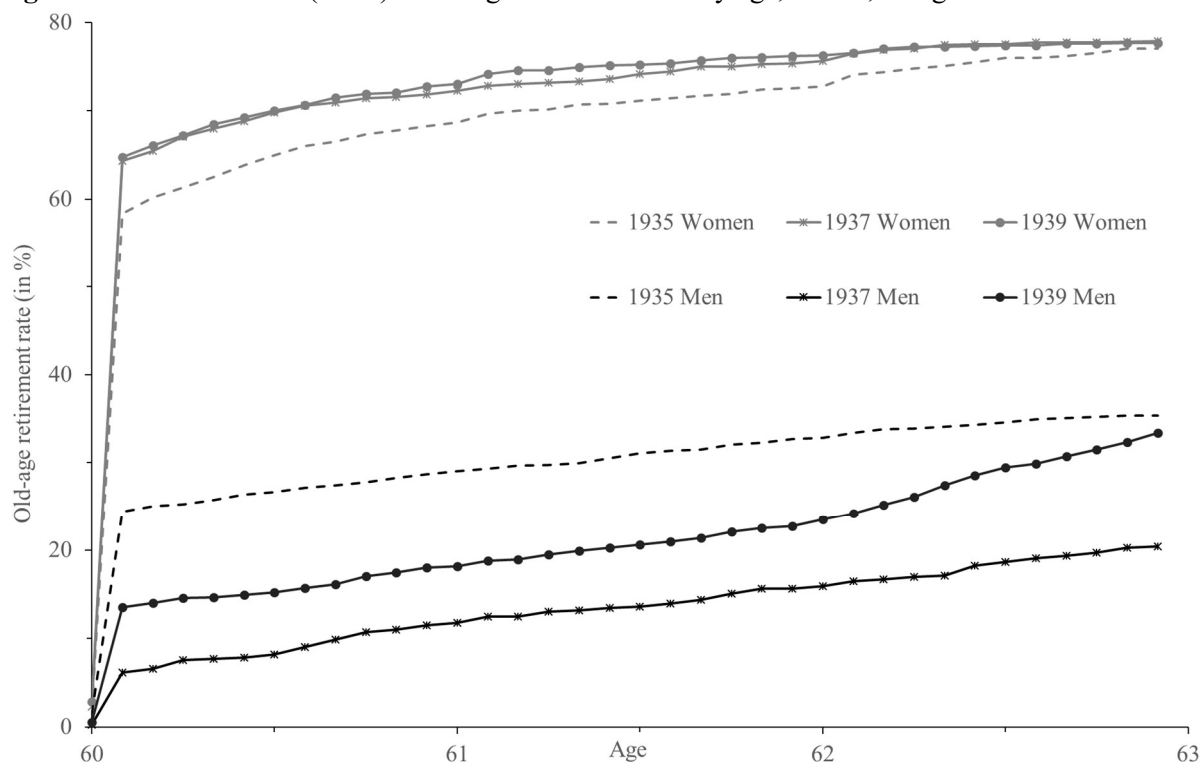


Figure 1.3 Reform 1 (NRA) – Old-age retirement rate by age, cohort, and gender



Notes: The NRA for birth cohorts 1935 was 60; the NRA for birth cohorts 1937 (1939) increased in monthly steps from 60 to 61 (62 to 63) for those born from January through December. The ERA did not exist for birth cohort 1935; for birth cohorts 1937 and after it was at 60. For the figures, we deleted male, post-reform cohort observations who due to protection of legitimate expectation (measured as of age 60) were not treated by the reforms. We show the gender-specific number of individuals of a given birth cohort and age in employment relative to the number of all individuals in that gender, age, and birth cohort cell in our sample.

Source: SUFVSKT2002_FAU_Schrader-SUFVSKT2013_FAU_Schrader, own calculations.

Figure 2.1 Reform 2 (ERA) – Employment rate by age, cohort, and gender

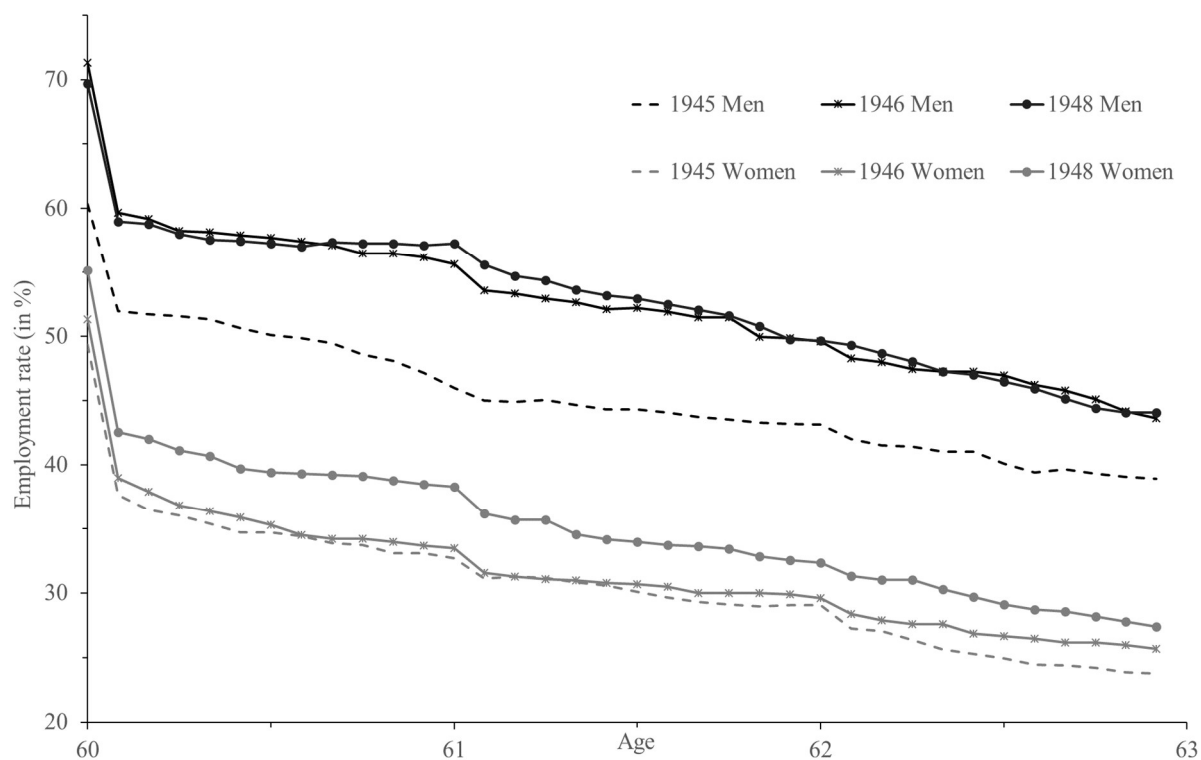


Figure 2.2 Reform 2 (ERA) - Unemployment rate by age, cohort, and gender

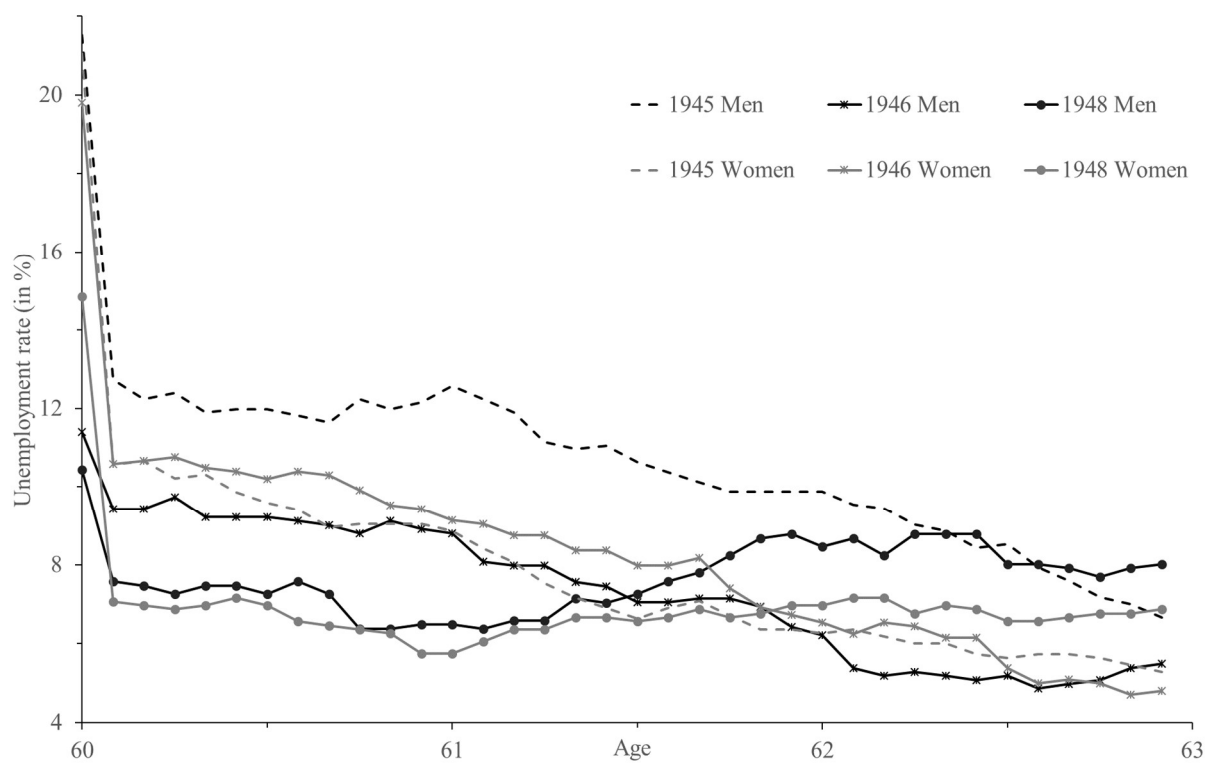
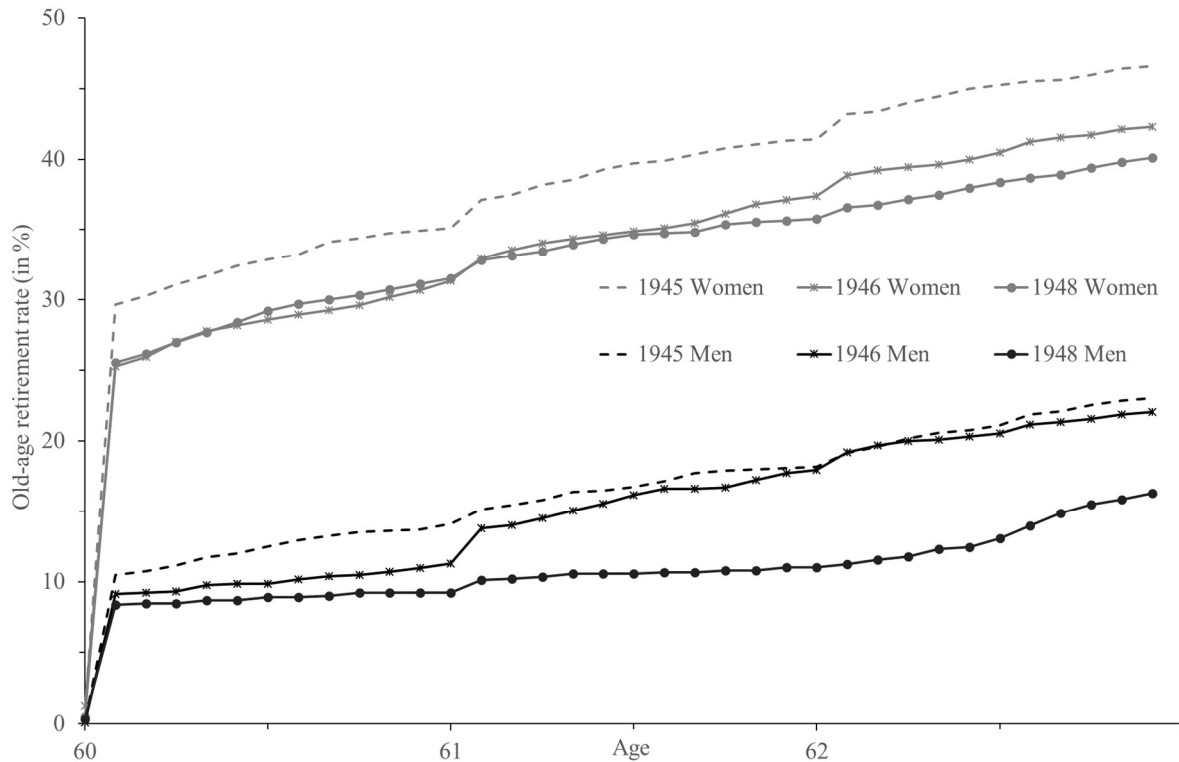


Figure 2.3 Reform 2 (ERA) – Old-age retirement rate by age, cohort, and gender



Notes: The ERA for birth cohort 1945 was 60; the ERA for birth cohorts 1946 (1948) increased in monthly steps from 60 to 61 (62 to 63) for those born from January through December. The NRA was 65 for all birth cohorts. For the figures, we deleted male, post-reform cohort observations who due to protection of legitimate expectation (measured as of age 60) were not treated by the reforms. We show the gender-specific number of individuals of a given birth cohort and age in employment relative to the number of all individuals in that gender, age, and birth cohort cell in our sample.

Source: SUFVSKT2002_FAU_Schrader-SUFVSKT2013_FAU_Schrader, own calculations.

Table 3 Reform 1 (NRA) - Treatment and treatment intensity effects for the labor force states

Dependent variable	Men x post-reform x age			Intensity			Intensity-DID
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
States							
Employment	0.0232** (0.0115)	0.0130 (0.0118)	0.0140 (0.0113)	0.0158* (0.0084)	0.0073 (0.0086)	0.0076 (0.0082)	-0.0031 (0.0092)
Unemployment	0.0300*** (0.0061)	0.0270*** (0.0060)	0.0259*** (0.0059)	0.0183*** (0.0045)	0.0163*** (0.0044)	0.0158*** (0.0044)	0.0141*** (0.0048)
Old-age retirement	-0.1680*** (0.0113)	-0.1754*** (0.0117)	-0.1577*** (0.0119)	-0.0888*** (0.0074)	-0.0967*** (0.0082)	-0.0863*** (0.0083)	-0.0955*** (0.0092)
Severely handicapped retirement	0.0283*** (0.0088)	0.0238*** (0.0086)	0.0230*** (0.0084)	0.0164*** (0.0060)	0.0112* (0.0059)	0.0106* (0.0058)	0.0204*** (0.0065)
Disability retirement	0.0594*** (0.0083)	0.0775*** (0.0079)	0.0647*** (0.0077)	0.0238*** (0.0060)	0.0412*** (0.0055)	0.0341*** (0.0054)	0.0436*** (0.0058)
Controls:							
Age fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Post-reform effects	Yes	No	No	Yes	No	No	No
Birth fixed effects	No	Yes	Yes	No	Yes	Yes	Yes
Individual characteristics	No	No	Yes	No	No	Yes	Yes
Institutions	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	404,640	404,640	404,640	404,640	404,640	404,640	218,412

Notes: The table shows OLS estimates of the coefficient on “men x post-reform x age” in columns (1)-(3) and on intensity in column (4)-(7). In addition to reported controls, all specifications except for column (7) include an indicator for men. Columns (1) and (4) use interactions of "post-reform" and age fixed effects. Columns (2), (3), and (5)-(7) additionally control for interaction effects of age with birth fixed effects and columns (2), (3), (5), and (6) also for interaction effects of age effects and men and birth effects and men. Column (7) shows the results of difference-in-differences estimation without females as a control group. **Table A.5** describes all controls. Individual level-clustered standard errors (SE) in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

Source: SUFVSKT2002_FAU_Schrader-SUFVSKT2013_FAU_Schrader, own calculations.

Table 4 Reform 2 (ERA) - Treatment and treatment intensity effects for the labor force states

Dependent variable	Men x post-reform x age			Intensity			Intensity-DID
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
States							
Employment	0.1322*** (0.0120)	0.1817*** (0.0102)	0.1594*** (0.0099)	0.0904*** (0.0083)	0.1092*** (0.0081)	0.0942*** (0.0077)	0.1226*** (0.0089)
Unemployment	-0.0517*** (0.0075)	-0.0740*** (0.0091)	-0.0620*** (0.0084)	-0.0258*** (0.0046)	-0.0597*** (0.0067)	-0.0514*** (0.0063)	-0.0647*** (0.0075)
Old-age retirement	-0.0640*** (0.0091)	-0.0592*** (0.0097)	-0.0758*** (0.0096)	-0.0489*** (0.0056)	-0.0140** (0.0070)	-0.0250*** (0.0069)	-0.0403*** (0.0080)
Severely handicapped retirement	-0.0151* (0.0082)	-0.0305*** (0.0080)	-0.0229*** (0.0077)	-0.0187*** (0.0050)	-0.0192*** (0.0058)	-0.0145*** (0.0056)	-0.0123* (0.0069)
Disability retirement	-0.0069 (0.0071)	-0.0092 (0.0068)	0.0081 (0.0067)	-0.0008 (0.0049)	-0.0027 (0.0053)	0.0087* (0.0052)	0.0077 (0.0061)
Controls:							
Age fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Post-reform effects	Yes	No	No	Yes	No	No	No
Birth fixed effects	No	Yes	Yes	No	Yes	Yes	Yes
Individual characteristics	No	No	Yes	No	No	Yes	Yes
Institutions	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	308,376	308,376	308,376	308,376	308,376	308,376	159,840

Notes: The table shows OLS estimates of the coefficient on “men x post-reform x age” in columns (1)-(3) and on intensity in columns (4)-(7). In addition to reported controls, all specifications except for column (7) include an indicator for men. Columns (1) and (4) use interactions of "post-reform" and age fixed effects. Columns (2), (3) and (5)-(7) additionally control for interaction effects of age with birth fixed effects and columns (2), (3), (5), and (6) also control for interaction effects of age effects and men and birth effects and men. Column (7) shows the results of difference-in-differences estimation without females as a control group. **Table A.6** describes all controls. Individual level-clustered SE in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

Source: SUFVSKT2002_FAU_Schrader-SUFVSKT2013_FAU_Schrader, own calculations.

Table 5 Reform 1 (NRA) and 2 (ERA) - Comparison of the treatment intensity effects

Dependent variable	Intensity			
	ITT		ATT (=ITT/p)	
	Reform 1	Reform 2	Reform 1	Reform 2
	(1)	(2)	(3)	(4)
States				
Employment	0.0076 (0.0081)	0.0942 (0.0077)	0.0256	0.5779
Unemployment	0.0158 (0.0044)	-0.0514 (0.0063)	0.0532	-0.3153
Old-age retirement	-0.0863 (0.0082)	-0.0250 (0.0069)	-0.2906	-0.1534
Severely handicapped retirement	0.0106 (0.0058)	-0.0145 (0.0056)	0.0357	-0.0890
Disability retirement	0.0341 (0.0054)	0.0087 (0.0052)	0.1148	0.0534
Controls:				
Age fixed effects	Yes	Yes	Yes	Yes
Birth fixed effects	Yes	Yes	Yes	Yes
Individual characteristics	Yes	Yes	Yes	Yes
Institutions	Yes	Yes	Yes	Yes
Observations	404,640	308,376	404,640	308,376

Notes: The table shows OLS estimates of the coefficient on intensity. In addition to reported controls, all specifications include an indicator for men and control for interaction effects of age and birth fixed effects and for interaction effects of age effects and men and birth effects and men. All controls for reform 1 (NRA) are described in **Table A.5** and for reform 2 (ERA) in **Table A.6**. In column (3) we use $p = 0.297$ as the share of all men born in 1935 or 1936 in our sample who used the unemployment pathway prior to age 63; in column (4) we use $p = 0.163$ as the share of all men born in 1945 who used the unemployment pathway prior to age 63.

Source: SUFVSKT2002_FAU_Schrader-SUFVSKT2013_FAU_Schrader, own calculations.

Table 6 Reforms 1 and 2 - Treatment intensity effects with controls for time trends and placebo estimation

Dependent variable	Intensity						Men x post-reform x age
	Reform 1			Reform 2			Reform 1
	Basic estimation	Time trend men	Time trend men & post & age	Basic estimation	Time trend men	Time trend men & post & age	Reform 1936*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
States							
Employment	0.0076 (0.0082)	0.0019 (0.0088)	0.0004 (0.0096)	0.0942*** (0.0077)	0.1074*** (0.0091)	0.1210*** (0.0102)	0.0110 (0.0204)
Unemployment	0.0158*** (0.0044)	0.0136*** (0.0046)	0.0129*** (0.0048)	-0.0514*** (0.0063)	-0.0564*** (0.0071)	-0.0615*** (0.0081)	0.0068 (0.0065)
Old-age retirement	-0.0863*** (0.0083)	-0.0890*** (0.0088)	-0.0941*** (0.0097)	-0.0250*** (0.0069)	-0.0393*** (0.0082)	-0.0459*** (0.0093)	-0.0114 (0.0254)
Severely handicapped retirement	0.0106* (0.0058)	0.0163*** (0.0062)	0.0176*** (0.0068)	-0.0145*** (0.0056)	-0.0112* (0.0066)	-0.0132* (0.0075)	-0.0089 (0.0147)
Disability retirement	0.0341*** (0.0054)	0.0374*** (0.0058)	0.0392*** (0.0064)	0.0087* (0.0052)	0.0110* (0.0062)	0.0129* (0.0071)	-0.0236 (0.0200)
Controls:							
Age fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Institutions	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time trend	No	Yes	Yes	No	Yes	Yes	No
Time trend x men	No	Yes	Yes	No	Yes	Yes	No
Time trend x post-reform	No	No	Yes	No	No	Yes	No
Time trend x men x post-reform	No	No	Yes	No	No	Yes	No
Time trend x men x post-reform x age	No	No	Yes	No	No	Yes	No
Observations	404,640	404,640	404,640	308,376	308,376	308,376	155,448

Notes: The table shows OLS estimates of the coefficient on intensity in columns (1)-(6) and on “men x post-reform x age” in column (7). In addition to reported controls, all specifications include an indicator for men and all control for interaction effects of age and birth fixed effects and for interaction effects of age effects and men and birth effects and men. For a description of all controls see **Table A.5** and **A.6**. Individual level-clustered SE in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

* Placebo reform is set so that cohort 1935 is pre-reform and cohort 1936 is only post-reform cohort.

Source: SUFVSKT2002_FAU_Schrader-SUFVSKT2013_FAU_Schrader, own calculations.

Table 7 Reform 1 (NRA) - Heterogeneity of treatment intensity effects

	Intensity						
	Basic estimation	Cohort 1937	Cohort 1938	Cohort 1939	Low pension wealth at 55	Middle pension wealth at 55	High pension wealth at 55
Dependent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
States							
Employment	0.0076 (0.0082)	0.2172*** (0.0396)	0.0426*** (0.0146)	-0.0080 (0.0097)	0.0697*** (0.0130)	-0.0367*** (0.0139)	-0.0017 (0.0149)
Unemployment	0.0158*** (0.0044)	-0.0505** (0.0244)	0.0090 (0.0087)	0.0197*** (0.0052)	0.0073 (0.0084)	0.0164** (0.0070)	0.0222*** (0.0075)
Old-age retirement	-0.0863*** (0.0083)	-0.3461*** (0.0316)	-0.1328*** (0.0140)	-0.0653*** (0.0098)	-0.1324*** (0.0145)	-0.0611*** (0.0145)	-0.0687*** (0.0138)
Severely handicapped retirement	0.0106* (0.0058)	0.0263 (0.0200)	-0.0001 (0.0098)	0.0140** (0.0069)	-0.0036 (0.0095)	0.0241** (0.0111)	0.0068 (0.0088)
Disability retirement	0.0341*** (0.0054)	0.1541*** (0.0274)	0.0658*** (0.0103)	0.0230*** (0.0062)	0.0323*** (0.0116)	0.0436*** (0.0093)	0.0274*** (0.0070)
Controls:							
Age fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Institutions	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	404,640	237,096	239,292	239,148	133,560	133,560	137,520

Notes: The table shows OLS estimates of the coefficient on intensity. All specifications are as in column (6) of **Table 3**. All controls are described in **Table A.5**. Individual level-clustered SE in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

Source: SUFVSKT2002_FAU_Schrader-SUFVSKT2013_FAU_Schrader, own calculations.

Table 8 Reform 2 (ERA) - Heterogeneity of treatment intensity effects

	Intensity						
	Basic estimation	Cohort 1946	Cohort 1947	Cohort 1948	Low pension wealth at 55	Middle pension wealth at 55	High pension wealth at 55
Dependent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
States							
Employment	0.0942*** (0.0077)	0.2382*** (0.0337)	0.1341*** (0.0146)	0.0770*** (0.0095)	0.1647*** (0.0216)	0.0837*** (0.0124)	0.0786*** (0.0125)
Unemployment	-0.0514*** (0.0063)	-0.0896*** (0.0268)	-0.0620*** (0.0120)	-0.0462*** (0.0078)	-0.1500*** (0.0216)	-0.0447*** (0.0098)	-0.0138** (0.0065)
Old-age retirement	-0.0145*** (0.0056)	-0.0584*** (0.0216)	-0.0159 (0.0098)	-0.0123* (0.0071)	-0.0227 (0.0149)	-0.0117 (0.0092)	-0.0173** (0.0088)
Severely handicapped retirement	-0.0250*** (0.0069)	-0.0886*** (0.0259)	-0.0576*** (0.0130)	-0.0144* (0.0086)	-0.0170 (0.0110)	-0.0289*** (0.0105)	-0.0332*** (0.0127)
Disability retirement	0.0087* (0.0052)	-0.0021 (0.0183)	0.0122 (0.0080)	0.0082 (0.0067)	0.0357* (0.0191)	0.0078 (0.0092)	0.0056 (0.0048)
Controls:							
Age fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Institutions	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	308,376	161,352	156,348	156,348	101,772	101,808	104,796

Notes: The table shows OLS estimates of the coefficient on intensity. All specifications are as in column (6) of **Table 4**. All controls are described in **Table A.6**. Individual level-clustered SE in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

Source: SUFVSKT2002_FAU_Schrader-SUFVSKT2013_FAU_Schrader, own calculations.

Table 9 Reforms 1 and 2 - Treatment intensity effects when adding non-eligible men and those with East German spells and when omitting observations in January-March 2006

Dependent variable	Intensity						
	Reform 1			Reform 2			
	Basic estimation	With non-eligible men	With times in East Germany	Basic estimation	With non-eligible men	With times in East Germany	Without Jan-Mar 2006
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
States							
Employment	0.0076 (0.0082)	-0.0048 (0.0060)	0.0111 (0.0068)	0.0942*** (0.0077)	0.0625*** (0.0058)	0.0946*** (0.0067)	0.0947*** (0.0078)
Unemployment	0.0158*** (0.0044)	-0.0034 (0.0034)	0.0154*** (0.0039)	-0.0514*** (0.0063)	-0.0575*** (0.0054)	-0.0619*** (0.0058)	-0.0511*** (0.0063)
Old-age retirement	-0.0863*** (0.0083)	-0.0626*** (0.0063)	-0.0928*** (0.0071)	-0.0250*** (0.0069)	-0.0081 (0.0052)	-0.0227*** (0.0062)	-0.0256*** (0.0070)
Severely handicapped retirement	0.0106* (0.0058)	0.0088** (0.0042)	0.0098** (0.0046)	-0.0145*** (0.0056)	-0.0051 (0.0041)	-0.0138*** (0.0051)	-0.0143** (0.0056)
Disability retirement	0.0341*** (0.0054)	0.0371*** (0.0041)	0.0383*** (0.0046)	0.0087* (0.0052)	0.0140*** (0.0040)	0.0118*** (0.0045)	0.0088* (0.0052)
Controls:							
Age fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Institutions	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	404,640	533,952	606,096	308,376	401,616	413,172	300,581

Notes: The table shows OLS estimates of the coefficient on intensity. All specifications are as in column (6) of **Tables 3 and 4**. Specification in column (2) and (5) include an indicator for eligibility and specification in column (3) and (6) an indicator for times in East Germany. For a description of all controls for reforms 1 and 2 see **Table A.5** and **A.6**, respectively. Columns (2) and (5) add observations on men to the baseline sample who failed to meet the eligibility requirements of female retirement. Columns (3) and (6) add those observations on men and women to the baseline sample who at some point earned pension points in East Germany. Column (7) omits observations from January 1 to March 31 2006. Individual level-clustered SE in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

Source: SUFVSKT2002_FAU_Schrader-SUFVSKT2013_FAU_Schrader, own calculations.

Table 10 Reform 1 (NRA) and 2 (ERA) -
Treatment intensity effects for the number of months in labor force status

Dependent variable	Intensity	
	Reform 1	Reform 2
	(1)	(2)
Months in employment		
Age 57-59	2.7454*** (0.2374)	3.8989*** (0.2878)
Age 60-62	1.6730*** (0.2189)	2.5683*** (0.2885)
Age 57-62	4.4215*** (0.4127)	6.6862*** (0.5256)
Months in unemployment		
Age 57-59	-4.2429*** (0.2099)	-3.9444*** (0.2444)
Age 60-62	0.4058*** (0.0926)	-0.8941*** (0.1707)
Age 57-62	-3.8466*** (0.2284)	-4.8133*** (0.3405)
Months in old-age retirement		
Age 60-62	-3.7387*** (0.2331)	-1.4853*** (0.2535)
Months in severely handicapped retirement		
Age 60-62	0.4376*** (0.1685)	-0.4729** (0.2058)
Months in disability retirement		
Age 57-59	0.9290*** (0.1402)	0.4262*** (0.1192)
Age 60-62	0.6740*** (0.1708)	0.0793 (0.1851)
Age 57-62	1.6032*** (0.2841)	0.4656* (0.2642)
Controls:		
Birth fixed effects	Yes	Yes
Individual characteristics	Yes	Yes
Institutions	Yes	Yes
Observations	11,240	8,566

Notes: The table shows OLS estimates of the coefficient on intensity in column (1) and (2). In addition to reported controls, all specifications include an indicator for men. All controls are described in **Table A.10**. Individual level-clustered SE in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

Source: SUFVSKT2002_FAU_Schrader-SUFVSKT2013_FAU_Schrader, own calculations.

Appendix Tables

Table A.1 Age at retirement by pathway and birth cohort

Birth Cohort	A		B		C		D		E		F	
	Retirement due to unemployment		Retirement for women		Ret. after long term employment		Regular old age retirement		Severely handicapped retirement		Disability retirement	
	NRA (Yr.)	ERA (Yr.)	NRA (Yr.)	ERA (Yr.)	NRA (Yr.)	ERA (Yr.)	NRA (Yr.)	ERA (Yr.)	NRA (Yr.)	ERA (Yr.)	NRA (Yr.)	ERA (Yr.)
1934	60 (1994)	n.a.	60 (1994)	n.a.	63 (1997)	n.a.	65 (1999)	n.a.	60 (1994)	n.a.	^ disability age	n.a.
1935	60 (1995)	n.a.	60 (1995)	n.a.	63 (1998)	n.a.	65 (2000)	n.a.	60 (1995)	n.a.	^ disability age	n.a.
1936	60 (1996)	n.a.	60 (1996)	n.a.	63 (1999)	n.a.	65 (2001)	n.a.	60 (1996)	n.a.	^ disability age	n.a.
1937	rising to 61 (1998)	60 (1997)	60 (1997)	n.a.	rising to 64 (2001)	63 (2000)	65 (2002)	n.a.	60 (1997)	n.a.	^ disability age	n.a.
1938	rising to 62 (2000)	60 (1998)	60 (1998)	n.a.	rising to 65 (2003)	63 (2001)	65 (2003)	n.a.	60 (1998)	n.a.	63 (2001)	< 63
1939	rising to 63 (2002)	60 (1999)	60 (1999)	n.a.	65 (2004)	63 (2002)	65 (2004)	n.a.	60 (1999)	n.a.	63 (2002)	< 63
1940	rising to 64 (2004)	60 (2000)	rising to 61 (2001)	60 (2000)	65 (2005)	63 (2003)	65 (2005)	n.a.	* rising to 61 (2001)	60 (2000)	63 (2003)	< 63
1941	rising to 65 (2006)	60 (2001)	rising to 62 (2003)	60 (2001)	65 (2006)	63 (2004)	65 (2006)	n.a.	* rising to 62 (2003)	60 (2001)	63 (2004)	< 63
1942	65 (2007)	60 (2002)	rising to 63 (2005)	60 (2002)	65 (2007)	63 (2005)	65 (2007)	n.a.	* rising to 63 (2005)	60 (2002)	63 (2005)	< 63
1943	65 (2008)	60 (2003)	rising to 64 (2007)	60 (2003)	65 (2008)	63 (2006)	65 (2008)	n.a.	* 63 (2006)	60 (2003)	63 (2006)	< 63
1944	65 (2009)	60 (2004)	rising to 65 (2009)	60 (2004)	65 (2009)	63 (2007)	65 (2009)	n.a.	* 63 (2007)	60 (2004)	63 (2007)	< 63
1945	65 (2010)	60 (2005)	65 (2010)	60 (2005)	65 (2010)	63 (2008)	65 (2010)	n.a.	* 63 (2008)	60 (2005)	63 (2008)	< 63
1946	65 (2011)	rising to 61 (2007)	65 (2011)	60 (2006)	65 (2011)	63 (2009)	65 (2011)	n.a.	* 63 (2009)	60 (2006)	63 (2009)	< 63
1947	65 (2012)	rising to 62 (2009)	65 (2012)	60 (2007)	65 (2012)	63 (2010)	rising to 65 1 m.	n.a.	* 63 (2010)	60 (2007)	63 (2010)	< 63
1948	65 (2013)	rising to 63 (2011)	65 (2013)	60 (2008)	65 (2013)	63 (2011)	rising to 65 2 m.	n.a.	* 63 (2011)	60 (2008)	63 (2011)	< 63
1949	65 (2014)	63 (2012)	65 (2014)	60 (2009)	rising to 65 3 m.	63 (2012)	rising to 65 3 m.	n.a.	* 63 (2012)	60 (2009)	rising to 63 7 m.	rising to < 63 7 m.
1950	65 (2015)	63 (2013)	65 (2015)	60 (2010)	rising to 65 4 m.	63 (2013)	rising to 65 4 m.	n.a.	* 63 (2013)	60 (2010)	rising to 63 8 m.	rising to < 63 8 m.
1951	65 (2016)	63 (2014)	65 (2016)	60 (2011)	rising to 65 5 m.	63 (2014)	rising to 65 5 m.	n.a.	63 (2014)	60 (2011)	rising to 63 9 m.	rising to < 63 9 m.
1952	retirement pathway terminated		retirement pathway terminated		rising to 65 6 m.	63 (2015)	rising to 65 6 m.	n.a.	rising to 63 1 m.	rising to 60 1 m.	rising to 63 10 m.	rising to < 63 10 m.
1953					rising to 65 7 m.	63 (2016)	rising to 65 7 m.	n.a.	rising to 63 2 m.	rising to 60 2 m.	rising to 63 11 m.	rising to < 63 11 m.
1954					rising to 65 8 m.	63 (2017)	rising to 65 8 m.	n.a.	rising to 63 3 m.	rising to 60 3 m.	rising to 64 (2008)	rising to < 64 0 m.
1955					rising to 65 9 m.	63 (2018)	rising to 65 9 m.	n.a.	rising to 63 4 m.	rising to 60 4 m.	rising to 64 4 m.	rising to < 64 4 m.
1956					rising to 65 10 m.	63 (2019)	rising to 65 10 m.	n.a.	rising to 63 5 m.	rising to 60 5 m.	rising to 64 6 m.	rising to < 64 6 m.
1957					rising to 65 11 m.	63 (2020)	rising to 65 11 m.	n.a.	rising to 63 6 m.	rising to 60 6 m.	rising to 64 8 m.	rising to < 64 8 m.
1958					rising to 66 (2024)	63 (2021)	rising to 66 (2024)	n.a.	rising to 63 7 m.	rising to 60 7 m.	rising to 64 10 m.	rising to < 64 10 m.
1959					rising to 66 2 m.	63 (2022)	rising to 66 2 m.	n.a.	rising to 63 8 m.	rising to 60 8 m.	rising to 65 (2024)	rising to < 65 0 m.
1960					rising to 66 4 m.	63 (2023)	rising to 66 4 m.	n.a.	rising to 63 9 m.	rising to 60 9 m.	65 (2025)	< 65 0 m.
1961					rising to 66 6 m.	63 (2024)	rising to 66 6 m.	n.a.	rising to 63 10 m.	rising to 60 10 m.	65 (2026)	< 65 0 m.
1962					rising to 66 8 m.	63 (2025)	rising to 66 8 m.	n.a.	rising to 63 11 m.	rising to 60 11 m.	65 (2027)	< 65 0 m.
1963					rising to 66 10 m.	63 (2026)	rising to 66 10 m.	n.a.	rising to 64 (2027)	rising to 61 (2024)	65 (2028)	< 65 0 m.
1964					rising to 67 (2031)	63 (2027)	rising to 67 (2031)	n.a.	rising to 64 1 m.	rising to 61 1 m.	65 (2029)	< 65 0 m.

Notes: * Individuals born before Nov. 17, 1950 and who were severely handicapped on Nov. 16, 2000 can retire at age 60 without deductions.

< 63: Disability retirement prior to age 63 was charged with benefit discounts of up to 10.8 % if retirement entry occurred after 2001.

^ Until 31.12.2000, the "old" disability retirement enabled eligible persons to enter the retirement independently of the age without deductions after the person became disabled.

Source: SGB VI, BMAS (2017), Steffen (2018), and own calculations.

Table A.2 Benefit reductions after disability retirement by month of age and retirement

Birth cohort	Deductions for a retirement entry with age...																							
	61+0	61+1	61+2	61+3	61+4	61+5	61+6	61+7	61+8	61+9	61+10	61+11	62+0	62+1	62+2	62+3	62+4	62+5	62+6	62+7	62+8	62+9	62+10	62+11
1.1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3
3.1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0.3
4.1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.9	0.6	0.6	0.3
5.1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0.9	0.6	0.6	0.3
6.1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5	1.2	0.9	0.6	0.6	0.3
7.1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.8	1.5	1.2	0.9	0.6	0.6	0.3
8.1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.1	1.8	1.5	1.2	0.9	0.6	0.6	0.3
9.1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.4	2.1	1.8	1.5	1.2	0.9	0.6	0.6	0.3
10.1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.7	2.4	2.1	1.8	1.5	1.2	0.9	0.6	0.6	0.3
11.1938	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2.7	2.4	2.1	1.8	1.5	1.2	0.9	0.6	0.6	0.3
12.1938	0	0	0	0	0	0	0	0	0	0	0	0	3.3	3	2.7	2.4	2.1	1.8	1.5	1.2	0.9	0.6	0.6	0.3
1.1939	0	0	0	0	0	0	0	0	0	0	0	3.6	3.3	3	2.7	2.4	2.1	1.8	1.5	1.2	0.9	0.6	0.6	0.3
2.1939	0	0	0	0	0	0	0	0	0	0	3.9	3.6	3.3	3	2.7	2.4	2.1	1.8	1.5	1.2	0.9	0.6	0.6	0.3
3.1939	0	0	0	0	0	0	0	0	0	4.2	3.9	3.6	3.3	3	2.7	2.4	2.1	1.8	1.5	1.2	0.9	0.6	0.6	0.3
4.1939	0	0	0	0	0	0	0	0	4.5	4.2	3.9	3.6	3.3	3	2.7	2.4	2.1	1.8	1.5	1.2	0.9	0.6	0.6	0.3
5.1939	0	0	0	0	0	0	0	4.8	4.5	4.2	3.9	3.6	3.3	3	2.7	2.4	2.1	1.8	1.5	1.2	0.9	0.6	0.6	0.3
6.1939	0	0	0	0	0	0	5.1	4.8	4.5	4.2	3.9	3.6	3.3	3	2.7	2.4	2.1	1.8	1.5	1.2	0.9	0.6	0.6	0.3
7.1939	0	0	0	0	0	5.4	5.1	4.8	4.5	4.2	3.9	3.6	3.3	3	2.7	2.4	2.1	1.8	1.5	1.2	0.9	0.6	0.6	0.3
8.1939	0	0	0	0	5.7	5.4	5.1	4.8	4.5	4.2	3.9	3.6	3.3	3	2.7	2.4	2.1	1.8	1.5	1.2	0.9	0.6	0.6	0.3
9.1939	0	0	0	6	5.7	5.4	5.1	4.8	4.5	4.2	3.9	3.6	3.3	3	2.7	2.4	2.1	1.8	1.5	1.2	0.9	0.6	0.6	0.3
10.1939	0	0	6.3	6	5.7	5.4	5.1	4.8	4.5	4.2	3.9	3.6	3.3	3	2.7	2.4	2.1	1.8	1.5	1.2	0.9	0.6	0.6	0.3
11.1939	0	6.6	6.3	6	5.7	5.4	5.1	4.8	4.5	4.2	3.9	3.6	3.3	3	2.7	2.4	2.1	1.8	1.5	1.2	0.9	0.6	0.6	0.3
12.1939	0	6.9	6.6	6.3	6	5.7	5.4	5.1	4.8	4.5	4.2	3.9	3.6	3.3	3	2.7	2.4	2.1	1.8	1.5	1.2	0.9	0.6	0.3

Source: Steffen (2018), own calculations.

Table A.3 Duration of unemployment benefit receipt (in months) by age

Age	July 1987-Jan.2006	Feb. 2006-Dec. 2007	since Jan. 2008
< 45	12	12	12
45-46	18	12	12
47-49	22	12	12
50-51	22	12	15
52-54	26	12	15
55-56	26	18	18
57	32	18	18
> 57	32	18	24

Notes: Column 1 describes the age cutoffs. The cut in benefit durations as of February 2006 affected those unemployed since February 1, 2006. The prolongation of unemployment benefit durations as of January 2008 affected those entering unemployment on or after January 1, 2008 and aged 50 or 58 at that time, or those still receiving unemployment benefits from a prior entry to unemployment on January 1, 2008 and aged at least 50 or 58 at that time.

Source: Riphahn and Schrader (2020).

Table A.4 Sample Selection Steps

Steps of sample selection	Reform 1						Reform 2					
	Men		Women		Men & Women		Men		Women		Men & Women	
	Succes- sive steps	Separate steps	Succes- sive steps	Separate steps	Succes- sive steps	Separate steps	Succes- sive steps	Separate steps	Succes- sive steps	Separate steps	Succes- sive steps	Separate steps
Number of individuals in starting data	16,227		24,154		40,381		12,923		16,573		29,496	
Individuals not eligible for female retirement pathway	6,269	6,269	13,351	13,351	19,620	19,620	5,427	5,427	9,339	9,339	14,766	14,766
Individuals with pension entitlements according to the law on foreign pensions	375	449	803	1,166	1,178	1,615	247	283	308	463	555	746
Self-employed individuals	204	394	115	209	319	603	137	336	110	235	247	571
Miners	1,261	1,614	1,088	1,539	2,349	3,153	1,217	1,479	834	1,111	2,051	2,590
Individuals with missing information on the date of retirement entry	44	2,170	35	2,753	79	4,923	233	2,486	167	2,851	400	5,337
Individuals with pension contributions in East Germany	2,007	2,613	3,589	5,309	5,596	7,922	1,222	2,207	1,689	3,029	2,911	5,236
Number of individuals in final sample	6,067		5,173		11,240		4,440		4,126		8,566	
Number of observations in final sample	218,412		186,228		404,640		159,840		148,536		308,376	

Source: SUFVSKT2002_FAU_Schrader-SUFVSKT2013_FAU_Schrader, own calculations.

Table A.5 Reform 1 (NRA) – List of variables

Variable	Description
Dependent variables	
Employment (0/1)	Employed with age 60-62 (monthly status)
Unemployment (0/1)	Unemployed with age 60-62 (monthly status)
Old-age retirement (0/1)	Retired (old-age without severely handicapped) with age 60-62 (monthly status)
Severely handicapped retirement (0/1)	Retired (severely handicapped) with age 60-62 (monthly status)
Disability retirement (0/1)	Retired (disability) with age 60-62 (monthly status)
Independent variables	
Reform indicators	
Men (0/1)	Men (ref. = women)
<i>Age fixed effects</i>	
Age1-Age36 (0/1)	Monthly age from 60 years+0 months to 62 years and 11 months (ref. = 60 + 0)
Men x Age60 - Men x Age62 (0/1)	Men times age from 60 years to 62 years (ref. = women of same age)
<i>Post-reform effects</i>	
Post-reform (0/1)	Individuals born in 1937-39 (ref. = 1935-36)
Men x post-reform (0/1)	Men times individuals born in 1937-39 (ref. = women born in 1935-39, and men born in 1935-36)
Post-reform x Age60 - Post-reform x Age62 (0/1)	Individuals born in 1937-39 times age from 60 years to 62 years (ref. = individuals born in 1935-36 of same age)
<i>Birth fixed effects</i>	
Birth1-Birth60 (0/1)	Month and year of birth from January 1935 to December 1939 (ref. = January 1935)
Men x Birth1935 - Men x Birth1939 (0/1)	Men times year of birth from 1935 to 1939 (ref. = men born in 1935)
Birth1935 x Age60 - Birth1939 x Age62 (0/1)	Year of birth from 1935 to 1939 times age from 60 years to 62 years (ref. = 1935 times age 60, 61 or 62)
<i>Treatment effect indicators</i>	
Men x post-reform x age (0/1)	Men times individuals born in 1937-39 times individuals in affected age (ref. = women born in 1935-39, men born in 1935-36, and men born in 1937-39 in non-affected age (Table A.8) or with protected 'legitimate expectations')
Intensity	Increase of NRA/deductions for early retirement for men born in 1937-39 measured in years (monthly status, ref. = women born in 1935-39, men born in 1935-36, and men born in 1937-39 with zero deductions (Table A.8) or protected 'legitimate expectations')
Individual characteristics	
Past earnings	Earning points (pension calculation) until age 55
Months poor health	Months in disability/sickness until age 55
Months tenure	Months of last employment until age 55
Blue collar, White collar, and other (0/1)	Insurance group at age 55 (ref. = White collar)
Institutions	
Deductions disability retirement	(Potential) deductions of the pension benefit for disability retirement in percent (monthly status)
Time trend	
Time trend	Linear time trend for month of observation from January 1995 to November 2002
Time trend x men	Linear time trend times men
Time trend x post-reform	Linear time trend times individuals born in 1937-39
Time trend x men x post-reform	Linear time trend times men times individuals born in 1937-39
Time trend x men x post-reform x age	Linear time trend times men times individuals born in 1937-39 times individuals in affected age

Table A.6 Reform 2 (ERA) – List of variables

Variable	Description
Dependent variables	
Employment (0/1)	Employed with age 60-62 (monthly status)
Unemployment (0/1)	Unemployed with age 60-62 (monthly status)
Old-age retirement (0/1)	Retired (old-age without severely handicapped) with age 60-62 (monthly status)
Severely handicapped retirement (0/1)	Retired (severely handicapped) with age 60-62 (monthly status)
Disability retirement (0/1)	Retired (disability) with age 60-62 (monthly status)
Independent variables	
Reform indicators	
Men (0/1)	Men (ref. = women)
<i>Age fixed effects</i>	
Age1-Age36 (0/1)	Monthly age from 60 years+0 months to 62 years and 11 months (ref. = 60 + 0)
Men x Age60 - Men x Age62 (0/1)	Men times age from 60 years to 62 years (ref. = women of same age)
<i>Post-reform effects</i>	
Post-reform (0/1)	Individuals born in 1946-48 (ref. = 1945)
Men x post-reform (0/1)	Men times individuals born in 1946-48 (ref. = women born in 1946-48, and men born in 1945)
Post-reform x Age60 - Post-reform x Age62 (0/1)	Individuals born in 1946-48 times age from 60 years to 62 years (ref. = individuals born in 1945 of same age)
<i>Birth fixed effects</i>	
Birth1-Birth48 (0/1)	Month and year of birth from January 1945 to December 1948 (ref. = January 1945)
Men x Birth1945 - Men x Birth1948 (0/1)	Men times year of birth from 1945 to 1948 (ref. = men born in 1945)
Birth1945 x Age60 - Birth1948 x Age62 (0/1)	Year of birth from 1945 to 1948 times age from 60 years to 62 years (ref. = 1945 times age 60/61/62)
<i>Treatment effect indicators</i>	
Men x post-reform x age (0/1)	Men times individuals born in 1946-48 times individuals in affected age (ref. = women born in 1945-48, men born in 1945, and men born in 1946-48 in non-affected age (Table A.9) or with protected 'legitimate expectations')
Intensity	Increase of ERA for men born in 1946-48 measured in years (monthly status, ref. = women born in 1945-48, men born in 1945, and men born in 1946-48 with zero increase (Table A.9) or protected 'legitimate expectations')
Individual characteristics	
Past earnings	Earning points (pension calculation) until age 55
Months poor health	Months in disability/sickness until age 55
Months tenure	Months of last employment until age 55
Blue collar, White collar, and other (0/1)	Insurance group at age 55 (ref. = White collar)
Institutions	
UB months	Maximum length of (potential) unemployment benefit (UB) receipt (monthly)
Time trend	
Time trend	Linear time trend for month of observation from January 2005 to November 2011
Time trend x men	Linear time trend times men
Time trend x post-reform	Linear time trend times individuals born in 1946-48
Time trend x men x post-reform	Linear time trend times men times individuals born in 1946-48
Time trend x men x post-reform x age	Linear time trend times men times individuals born in 1946-48 times individuals in affected age

Table A.7 Reform 1 (NRA) – Descriptive statistics of variables as listed in **Table A.5**

	Mean	SD	Min	Max	N
Dependent variables					
Employment (0/1)	0.2099	0.4072	0	1	404,640
Unemployment (0/1)	0.0414	0.1993	0	1	404,640
Old-age retirement (0/1)	0.4899	0.4999	0	1	404,640
Severely handicapped retirement (0/1)	0.0818	0.2741	0	1	404,640
Disability retirement (0/1)	0.1344	0.3410	0	1	404,640
Independent variables					
Reform indicators					
Men (0/1)	0.5398	0.4984	0	1	404,640
<i>Age fixed effects</i>					
Age1-Age36 (discrete)	61.4583	0.8657	60	62.9167	404,640
Men x Age60 - Men x Age62 (discrete)	32.9259	30.4093	0	62	404,640
<i>Post-reform effects</i>					
Post-reform (0/1)	0.6158	0.4864	0	1	404,640
Men x post-reform (0/1)	0.3306	0.4704	0	1	404,640
Post-reform x Age60 - Post-reform x Age62 (0/1)	37.5660	29.6772	0	62	404,640
<i>Birth fixed effects</i>					
Birth1-Birth60 (discrete)	30.9578	17.3235	1	60	404,640
Men x Birth1935 -Men x Birth1939 (discrete)	1,045.5552	965.4549	0	1939	404,640
Birth1935 x Age60 - Birth1939 x Age62 (discrete)	118,160	1,583.9335	116,100	120,218	404,640
<i>Treatment effect indicators</i>					
Men x post-reform x age (0/1)	0.1045	0.3059	0	1	404,640
Intensity	0.1145	0.4089	0	3	404,640
Individual characteristics					
Past earnings	32.7003	12.4666	3.6847	63.5557	404,640
Months poor health	4.5265	7.7551	0	83	404,640
Months tenure at age 55	197.6244	144.3428	1	495	404,640
Insurance group (categorical)	1.4617	0.5451	0	2	404,640
Institutions					
Deductions disability retirement	0.3296	1.0373	0.0000	6.9000	404,640
Time trend					
Time trend	48.4578	20.1995	1	95	404,640
Time trend x men	26.1470	28.3638	0	95	404,640
Time trend x post-reform	36.9736	31.3990	0	95	404,640
Time trend x men x post-reform	19.8930	29.5409	0	95	404,640
Time trend x men x post-reform x age	10.3204	23.4979	0	95	404,640

Source: SUFVSKT2002_FAU_Schrader-SUFVSKT2013_FAU_Schrader, own calculations.

Table A.8 Reform 2 (ERA) – Descriptive statistics of variables as listed in **Table A.6**

	Mean	SD	Min	Max	N
Dependent variables					
Employment (0/1)	0.3977	0.4894	0	1	308,376
Unemployment (0/1)	0.0889	0.2846	0	1	308,376
Old-age retirement (0/1)	0.2458	0.4306	0	1	308,376
Severely handicapped retirement (0/1)	0.1092	0.3118	0	1	308,376
Disability retirement (0/1)	0.0913	0.2881	0	1	308,376
Independent variables					
Reform indicators					
Men (0/1)	0.5183	0.4997	0	1	308,376
<i>Age fixed effects</i>					
Age1-Age36 (discrete)	61.4583	0.8657	60	62.9167	308,376
Men x Age60 - Men x Age62 (discrete)	31.6180	30.4852	0	62	308,376
<i>Post-reform effects</i>					
Post-reform (0/1)	0.7314	0.4432	0	1	308,376
Men x post-reform (0/1)	0.3800	0.4854	0	1	308,376
Post-reform x Age60 - Post-reform x Age62 (0/1)	44.6142	27.0468	0	62	308,376
<i>Birth fixed effects</i>					
Birth1-Birth60 (discrete)	23.6623	13.9459	1	48	308,376
Men x Birth1945 -Men x Birth1948 (discrete)	1,008.8981	972.5709	0	1948	308,376
Birth1945 x Age60 - Birth1948 x Age62 (discrete)	118,733	1,590.7455	116,700	120,776	308,376
<i>Treatment effect indicators</i>					
Men x post-reform x age (0/1)	0.1630	0.3694	0	1	308,376
Intensity	0.1700	0.4809	0	3	308,376
Individual characteristics					
Past earnings	24.4363	18.1024	0	61.9806	308,376
Months poor health	5.6866	9.8769	0	116	308,376
Months tenure at age 55	186.8324	143.9480	1	494	308,376
Insurance group (categorical)	1.4512	0.5559	0	2	308,376
Institutions					
UB months	22.4116	3.7076	18.0000	32.0000	308,376
Time trend					
Time trend	41.1623	17.3898	1	83	308,376
Time trend x men	21.3221	24.0672	0	83	308,376
Time trend x post-reform	34.8498	24.5308	0	83	308,376
Time trend x men x post-reform	18.0749	24.7864	0	83	308,376
Time trend x men x post-reform x age	9.0400	19.7282	0	83	308,376

Source: SUFVSKT2002_FAU_Schrader-SUFVSKT2013_FAU_Schrader, own calculations.

Table A.9 Intensity of reform 1 (NRA) by retirement age and date of birth

Retirement age		Year and months of birth																																					
		1937												1938												1939													
Year	Months	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12		
60	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
60	1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35		
60	2	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34		
60	3	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33		
60	4	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32		
60	5	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
60	6	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
60	7	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29		
60	8	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28		
60	9	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27		
60	10	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26		
60	11	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25		
61	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
61	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
61	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22		
61	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
61	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
61	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
61	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17			
61	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18		
61	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16			
61	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
61	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14			
61	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13			
62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12			
62	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11			
62	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10		
62	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	
62	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	
62	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	
62	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7
62	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	
62	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	
62	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	
62	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3
62	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	

Notes: The cells show the number of months for which an individual has to accept benefit discounts depending on retirement age and date of birth. As an example, individuals born in December of 1937 have to accept 12 months of discount (0.3 % each, totaling 3.6%) if they retire as soon as they reach age 60 (0 months).

Source: SGB VI Anlage 19, own calculations.

Table A.10 Intensity of reform 2 (ERA) by retirement age and date of birth

		Year and months of birth																																											
Retirement age		1946												1947												1948																			
Year	Months	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12								
60	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36								
60	1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35								
60	2	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34								
60	3	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33								
60	4	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32								
60	5	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31								
60	6	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30								
60	7	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29								
60	8	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28								
60	9	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27								
60	10	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26								
60	11	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25								
61	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24								
61	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23								
61	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22								
61	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21								
61	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20								
61	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19								
61	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18								
61	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17								
61	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
61	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15								
61	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14								
61	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13								
62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11	12								
62	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10	11								
62	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10							
62	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9						
62	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8						
62	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7					
62	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6	7				
62	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	6			
62	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5		
62	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4		
62	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	
62	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		

Notes: The cells show the number of months by which the first option for early retirement at a given age has been postponed after reform 2 (ERA) depending on retirement age and date of birth. As an example, individuals born in December of 1946 who wanted to retire exactly up reaching age 60 have to wait 12 months after the reform until early retirement becomes available to them for the first time.

Source: SGB VI Anlage 19, own calculations.

Table A.11 Reform 1 (NRA) and 2 (ERA) – List of variables for cross section estimations (section5)

Variable	Description
Dependent variables	
Months in...	Number of months considered in three different age ranges (57-
...employment	...employment
...unemployment	...unemployment
...old-age retirement	...old-age retirement
...severely handicapped retirement	...severely handicapped retirement
...disability retirement	...disability retirement
Independent variables	
Reform indicators - Reform 1	
Men (0/1)	Men (ref. = women)
<i>Birth fixed effects</i>	
Cohort1-Cohort5 (0/1)	Year of birth from 1935 to 1939 (ref. = 1935)
<i>Treatment effect indicators</i>	
Intensity	Increase of NRA/deductions for early retirement for men born in
Reform indicators - Reform 2	
Men (0/1)	Men (ref. = women)
<i>Birth fixed effects</i>	
Cohort1-Cohort4 (0/1)	Year of birth from 1945 to 1948 (ref. = 1945)
<i>Treatment effect indicators</i>	
Intensity	Increase of ERA for men born in 1946-48 measured in years
Institutions - Reform 1	
Deductions disability retirement	(Potential) deductions of the pension benefit for disability retirement in percent (mean for respective age range)
Institutions - Reform 2	
UB months	Maximum length of (potential) unemployment benefit (UB) receipt (mean for respective age range)
Individual characteristics	
Past earnings	Earning points (pension calculation) until age 55
Months poor health	Months in disability/sickness until age 55
Months tenure	Months of last employment until age 55
Blue collar, White collar, and other (0/1)	Insurance group at age 55 (ref. = White collar)

Table A.12 Reform 1 (NRA) and 2 (ERA) – Descriptive statistics of variables in **Table A.11**

	Sample reform 1		Sample reform 2	
	Mean	SD	Mean	SD
Dependent variables				
Months in employment				
Age 57-59	20.2392	15.7508	22.6653	16.1399
Age 60-62	7.5568	13.2244	14.3165	16.3012
Age 57-62	27.796	25.5315	36.9818	29.6036
Months in unemployment				
Age 57-59	8.4468	13.0634	5.9608	11.5827
Age 60-62	1.492	4.5235	3.2008	8.2374
Age 57-62	9.9388	13.825	9.1616	16.379
Months in old-age retirement				
Age 60-62	17.6355	16.7271	8.8503	14.254
Months in severely handicapped retirement				
Age 60-62	2.946	9.3273	3.9295	10.4985
Months in disability retirement				
Age 57-59	3.5988	9.7044	1.7996	7.3062
Age 60-62	4.8373	11.8516	3.2881	9.9548
Age 57-62	8.4361	19.9409	5.0877	15.6595
Independent variables				
Reform indicators				
Men (0/1)	0.5398	0.4984	0.5183	0.4997
<i>Post-reform effects</i>				
Post-reform (0/1)	0.6158	0.4864	0.7314	0.4433
<i>Birth fixed effects</i>				
Cohort1-Cohort5/Cohort1-Cohort4 (discrete)	3.0454	1.4110	2.4465	1.1231
<i>Treatment effect indicators</i>				
Men x post-reform (0/1)	0.2168	0.4121	0.3234	0.4678
Intensity	0.3456	0.7700	0.4890	0.8605
Individual characteristics				
Past earnings	32.7003	12.4672	24.4363	18.1034
Months poor health	4.5265	7.7554	5.6866	9.8775
Months tenure at age 55	197.6244	144.3490	186.8324	143.9562
Insurance group (categorical)	1.4617	0.5451	1.4512	0.5559
Institutions				
Ref. 1: Deductions disability retirement/ Ref. 2: UB months	0.3296	0.6029	22.4116	1.2432

Notes: The sample of reform 1 (NRA) consists of 11,240 observations and the sample of reform 2 (ERA) of 8,566 observations. The "Insurance group" variable is equal to "1" for blue collar workers, to "2" for white collar workers, and to "0" for others. Statistics of "Deductions disability retirement" and "UB months" relate to the observations in age range 60-62.

Source: SUFVSKT2002_FAU_Schrader-SUFVSKT2013_FAU_Schrader, own calculations.

Figure A.1 ERA und NRA by birth month and year and retirement pathway

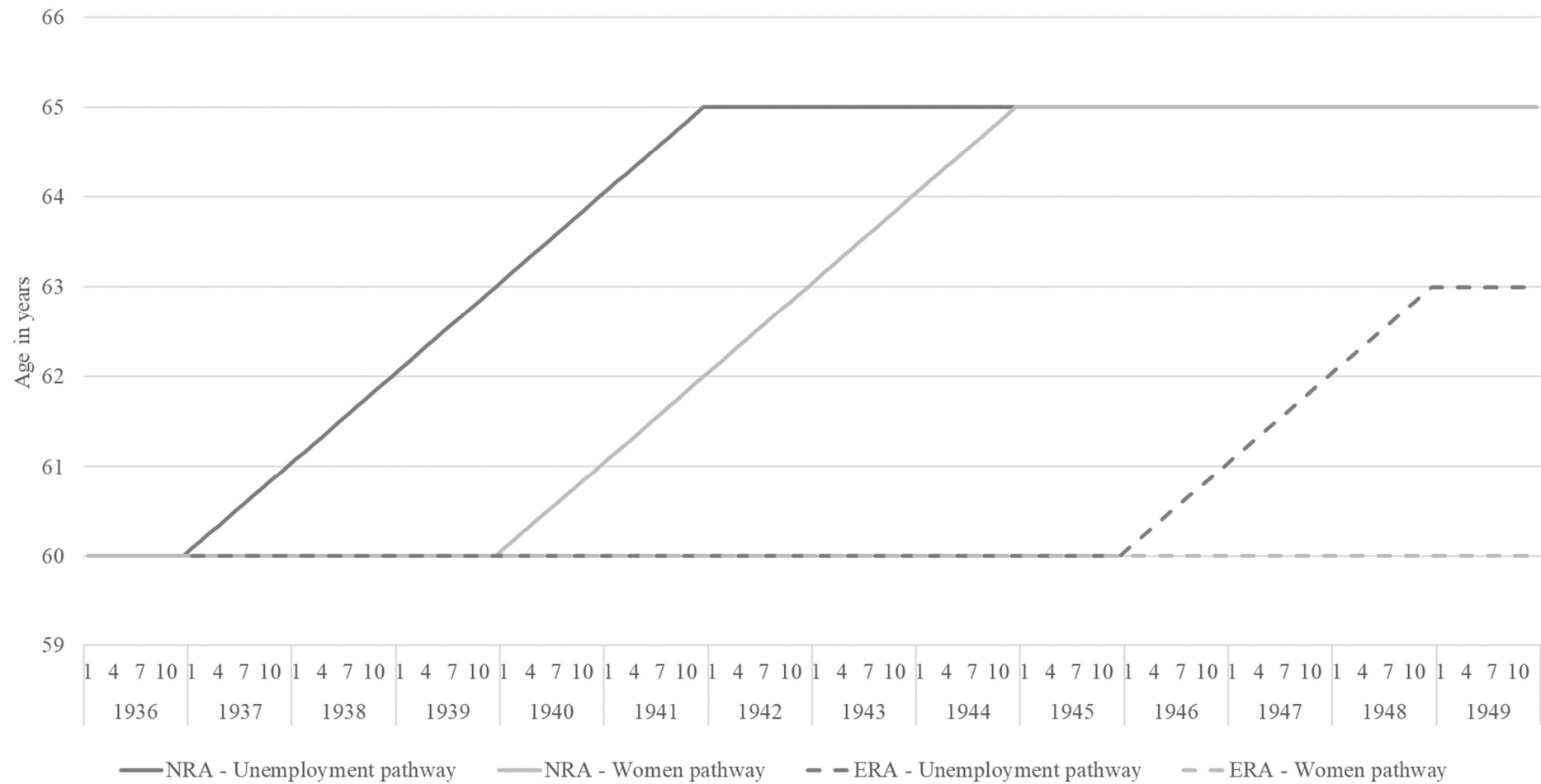


Figure A.2 Mean number of months in employment by birth cohort and gender (age 57-62)

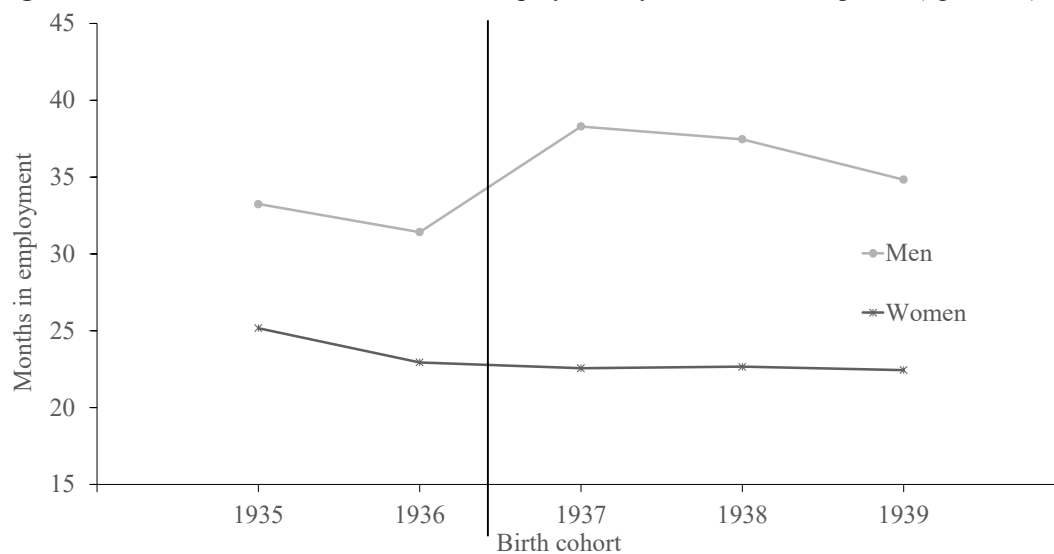


Figure A.3 Mean number of months in unemployment by birth cohort and gender (age 57-62)



Figure A.4 Mean number of months in old age retirement by birth cohort and gender (age 60-62)

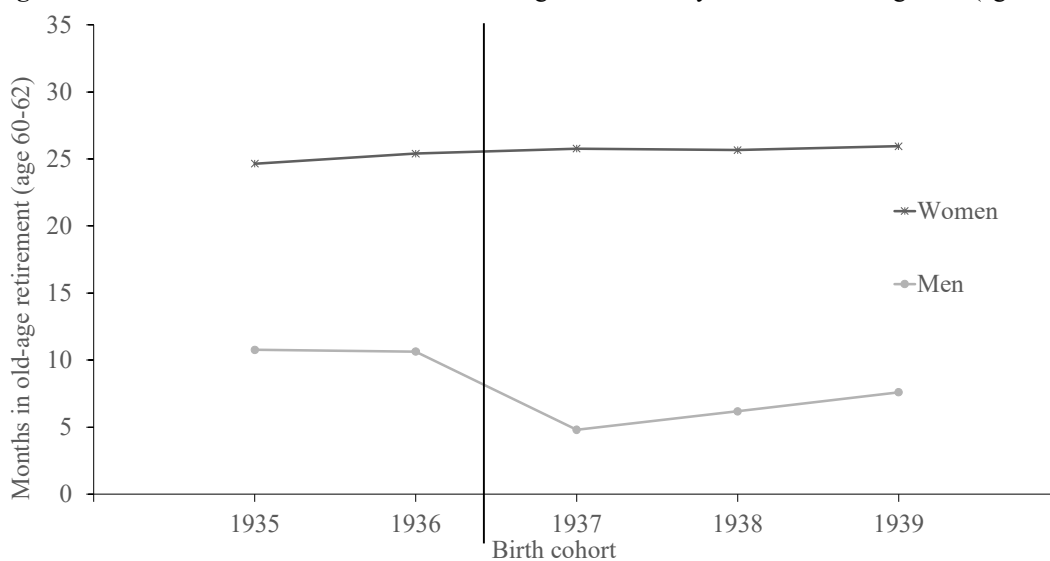


Figure A.5 Mean number of months in sev. handicapped retirement by birth cohort and gender (age 60-62)

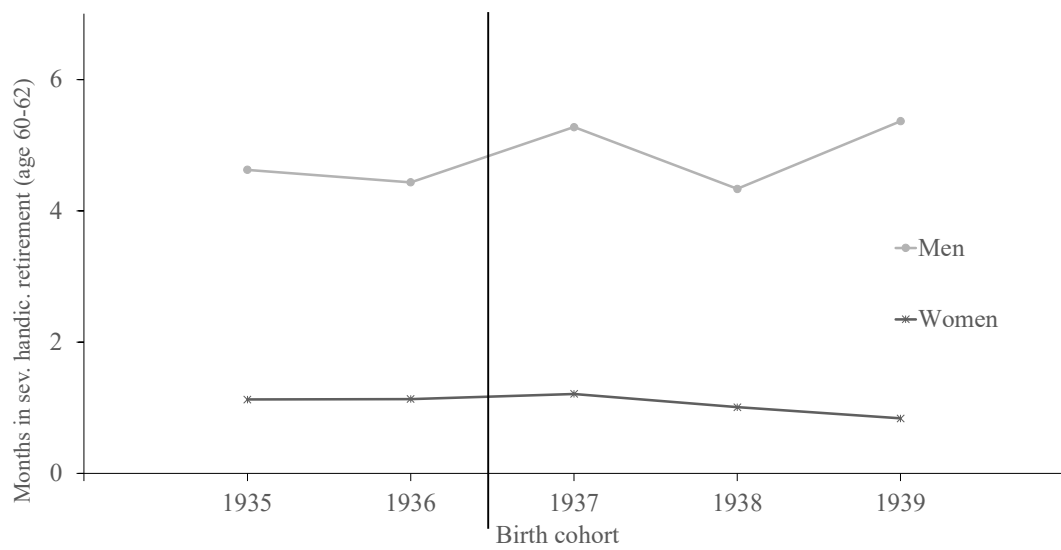
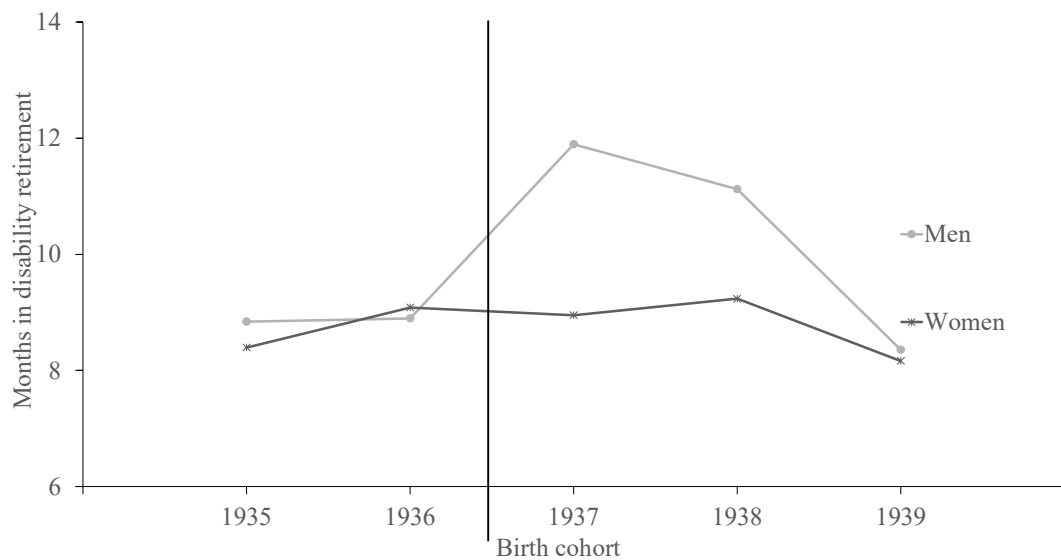


Figure A.6 Mean number of months in disability retirement by birth cohort and gender (age 57-62)



Source: SUFVSKT2002_FAU_Schrader-SUFVSKT2013_FAU_Schrader, own calculations.