Employment effects and the pension system - Evidence from a cohort based reform

Barbara Engels*, Johannes Geyer† and Peter Haan‡

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In this paper we exploit a cohort specific pension reform to estimate the causal employment effect of changes in the financial incentives to retire. In particular we analyze the effect of the introduction of pension deductions for early retirement on female employment. For the empirical analysis we use high-quality administrative data from the German Federal Pension Insurance (VSKT) and find positive and significant effects of the reform on employment.

Key Words: Pension reform, cohort based reform, labor supply .

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*HU Berlin and DIW Berlin

†HU Berlin and DIW Berlin

‡FU Berlin and DIW Berlin, phaan@diw.de

1. Introduction

In the last decades, many reforms have been introduced to ensure the solvency of the almost universal German Public Pension System against the backdrop of an ever-aging society. Germany faces one of the most incisive demographic changes.[1] The ever-aging population leads to a dramatic decrease of the ratio of workers and thus contributors to beneficiaries (system-dependency ratio), which puts the already financially precarious German pay-as-you-go (henceforth: PAYG) social-security system under severe pressure. German reunification and relatively high unemployment rates aggravated the financial problems of the pension system during the 1990s.

Most of the German workers retire before the statutory retirement age. Only one fifth of men born in 1935 retired at the statutory retirement age of 65 years. More than 23% retired at the minimum retirement age of 60. 40% of women born in 1935 retired at age 65, almost 30% retired at age 60 (Deutsche Rentenversicherung, 2014). The tendency towards early retirement particularly pressures the public-pension system as these workers have both less years of insurance contributions and a longer benefit period.

Pension reforms aim at improving the system-dependency ratio and the labor force participation of the elderly, i.e. increasing the actual retirement age.[2] However, it is difficult to econometrically evaluate the effect of these reforms, which are often direct or indirect pension benefit cuts, on actual retirement behavior. Given that benefits are a function of past earnings, estimates may suffer from endogeneity bias.

In this paper we apply an identification strategy which explicitly accounts for the endogeneity bias and allows to estimate the causal effect of a pension reform, namely the 1992 pension Reform in Germany, on employment. In particular similar to Mastrobuoni (2009) we use a Regression Kink Design to estimate the causal effect of the pension reform on the actual retirement age and labor supply by exploiting the kink in the schedule of pension benefits. This kink is related only due to variation between adjacent cohorts which are differently affected by the reform. The central advantage of this methodology is that similar to the regression discontinuity design clean identification is

[1] The severity of the demographic challenge is due to a quicker increase in life expectancy than elsewhere, partly due to a relatively low level still in the 1970s, and a more pronounced baby boom/baby bust transition (e.g., relative to the United States) to a very low fertility rate of 1.3 children per women (Berkel and Börsch-Supan, 2004).

[2] There is no indication that an increase in retirement age is likely to be prevented by deteriorating health. As Cutler and Sheiner (1998) report, age-specific rates of sickness have dropped faster than mortality rates.

possible without relying on potential spurious cross-sectional correlation; for a theoretical discussion and empirical applications on the labor supply effects of Unemployment Insurance, see Card *et al.* (2012), or Landais (2013). The empirical implementation is based on high-quality administrative data of the Research Data Center of the German Federal Pension Insurance (VSKT). We find significant and positive effects of the reform on the actual retirement age both for men and women.

The paper is structured as follows. First, we provide an overview of related previous studies. In Section 3 we describe the German pension reform of 1992. Then we describe the data in Section 4, descriptive statistics in Section 5 and the empirical model in Section 6. Section 7 provides preliminary estimation results and a very brief discussion.

2. Literature Review

This section will briefly summarize the literature related to the analysis. There are two fields of literature that need to be taken into account . First, papers related to the analysis of retirement behavior are presented. Second, research using the Regression Kink Design approach is summarized.

2.1. The Analysis of Retirement Behavior

Many research has been conducted on the retirement behavior of workers in different countries. Most of it has borrowed from social security wealth as determinant of the timing of retirement.[3] Krueger and Meyer (2002) provide a comprehensive survey of studies that model retirement behavior.

Two main strands of research can be characterized according to the source of variation in benefits. One relies primarily on time-series variations in the legal context to identify the effect of changes in parameters of the social security system on labor supply. Most of the analyses of this strand find that a more generous social security system tends to reduce labor force participation and induce earlier retirement. However, the magnitude of the response to an increase in benefits varies considerably across studies.

The other strand of literature exploits cross-sectional variations in benefits (e.g. across families) to identify potential effects of the prevailing social security system. However, there is a fundamental problem of identification in cross-sectional studies, because it is difficult to untangle the impact of the social security system from the impact of other (individual) variables.

[3] Social Security benefits is, simplified, the international term for pension benefits.

Researchers that exploit a change in the social security law itself are, among many others, Hurd and Boskin, Krueger and Pischke and Burtless. Hurd and Boskin (1984) examine the effect of an increase in social security wealth between 1968 and 1972 on the retirement rate of older men in the US. Estimating logit models of whether men retire in a particular year as a function of social security wealth, they find that the increase in social security benefits can account for the entire 8.2 percentage point decrease in labor force participation.

Krueger and Pischke (1992) use a social security benefit notch which lowered benefits for the 1917 to 1921 cohorts to examine the effect of an unanticipated decline in social security wealth. They find that the decline did not significantly affect labor supply, although the increase in benefits from delaying retirement is significantly related to labor force participation. The social security wealth effect they find is less than one-sixth as large as the one Hurd and Boskin find. From a policy perspective, their findings indicate that reducing social security benefits does not slow down the trend to earlier retirement. A model of retirement behavior for changes in real social security benefits was proposed by Burtless (1986). He finds that unanticipated changes decreased the average retirement age in the long run by 0.17 years.

Gordon and Blinder (1980) estimate a maximum likelihood structural model of the reservation wage and the market wage to examine the determinants of the retirement decisions of white men exploiting cross-sectional variation. They find that the social security system has little or no effect on retirement decisions. According to them, the decision to retire is driven primarily by the effects of aging on market and reservation wages and by the incentives set up by private pension plans.

Baker and Benjamin exploit the fact that early retirement provisions in Canada were introduced sequentially (first in Quebec and three years later in the rest of Canada) to estimate a differences-in-differences effect of the policy change. They find that the change did not increase incidence of early retirement (Baker and Benjamin, 1999).

For Germany, most studies analyze the 1992 reform or its follow-ups. Since retirement reforms may take many years to be fully phased-in, appropriate post-reform data is often available only many years after the reform and literature has been increasing only lately.

There are two popular exceptions that analyze different pension reforms. Puhani and Tabbert (2011) apply a regression discontinuity design to estimate the effects of large cuts in pension on labor force participation oft mostly low-skilled repatriated ethnic German workers. Although permanent pension cuts amount to between 8 and 16%, they do not find a significant delay in retirement age. Hanel (2012) uses the exogenous variation in disability benefits in Germany in 2001 caused by a substantial change of the disability pension legislation to investigate behavioral responses to a benefits decrease of individuals whose earnings capacity is reduced. She estimates the probability of entering disability retirement considering forward-looking financial incentive measures as determinants. She finds that benefit levels have no effect on labor supply, but that implicit taxes on labor market income induce many people to retire early through disability retirement (however, the response to financial incentives is limited to those individuals in good health).

Studies analyzing the 1992 reform mostly employ variants of the option-value model developed by Stock and Wise (1990). They generally predict a postponement of retirement entry, but find estimates that vary both quantitatively and qualitatively.[4] Börsch-Supan (2000, 2001) estimate that the 1992 reform will increase the average retirement age by half a year, while actuarially fair adjustments would shift the retirement age by two years. Also studies about the link between benefit-generosity and retirement timing (e.g. Börsch-Supan and Schnabel (1998) and Liebman *et al.* (2009)) predict a postponement of retirement following the 1992 reform.

Hanel (2010) employs a proportional hazard model to a dataset from the Federal Pension insurance and finds the reform to cause an average postponement in employment exit of ten months for the entire population. Men postpone the claiming of pension benefits by 12 months following the reform. Women postpone it by more than 26 months. Berkel and Börsch-Supan (2004) estimate, based on the German Socio-Economic Panel (GSOEP) dataset, an increase in the average effective retirement age of 24 months for men and 7 months for women.

These studies typically assume that workers know their future benefits as a function of their retirement age and are able to compare future streams of benefits. These are strong assumptions, as shows empirical evidence. At least according to US studies, when asked, only half of the workers are able to provide an estimate of their expected Social Security benefits (cf. Bernheim and Levin (1989) and Gustman and Steinmeier (2001)). Lusardi and Mitchell (2005) provide evidence that financial illiteracy is widespread among older Americans. Against this backdrop, it is not reasonable to assume that workers know their future retirement benefits. However, people seem to respond to incentives when making their retirement decisions (Chan and Stevens (2008) call that "an important

[4]Note that the reform could have also other effects apart from a direct postponement of retirement. It could for example affect employment through the intensity of job search before retirement (Hairault *et al.*, 2010), resulting in an extended working period and higher contributions to the pension system. Also, the reform could influence the likelihood of retirement in the context of invalidity pensions (Riphahn, 1999).

empirical puzzle in the retirement literature").

It appears thus appealing to avoid the complex calculation of the actual benefits. Even if an exact calculation were possible, it is a strong assumption that the worker is aware of its potential pension benefits.

2.2. Regression Kink Design

The Regression Kink Design (RKD) has become an increasingly popular tool for causal inference in economics. Seminal papers are Nielsen *et al.* (2010) and Card *et al.* (2012). The concept of RKD was first introduced by Nielsen *et al.* (2010) in their study of financial aid effect on college enrollment. Following Nielsen *et al.*, Card *et al.* (2009) consider nonparametric identification of the average marginal effect of a continuous endogenous treatment variable in a generalized non-separable model when the treatment of interest is a known, deterministic but kinked function of an observed continuous assignment variable. They characterize a broad class of models for which a RKD provides valid inferences regarding the underlying marginal effects and show that, under suitable conditions, the RKD estimand identifies the treatment-on-the-treated parameter.

A key difference to Dong (2010) is that the RKD estimator depends on the derivative of the treatment variable, which would be infeasible when treatment is binary, while the estimator in Dong (2010) depends on the derivative of the expected value of a binary treatment, i.e. the treatment probability. Like Dong, Garmann (2014) uses a RKD based on a binary treatment variable to estimate the causal effect of coalition governments on fiscal policies in Germany, exploiting that there is a slope change in the probability of being in a coalition government at the 50% vote share of the strongest party.

Our study is strongly related to Mastrobuoni (2009). He estimates the effect of pension benefit cuts on retirement behavior by exploiting kinks in the US pension benefits schedule. The reform that he analyzes, an increase in the full-pension retirement age by two months per year for certain cohorts, is similar to the 1992 reform in Germany. Mastrobuoni's results, which are based on the determination of the cumulative distribution function (CDF) of retirement age, suggest that the mean retirement age of the cohorts affected by the reform increases by about half as much as the full-pension retirement age. Mastrobuoni actually applies a variant of the RKD, but since the concept of RKD was not elaborated at the time of the study, he neither establishes the corresponding estimator nor the identifying assumptions necessary for the RKD.

3. Institutional Background

3.1. The German Public-Pension System

The German pension system has been undergoing a reform process in the recent decades. It will slowly develop into a complex multi-pillar system. We provide some more details on the relevance of the pension system in Appendix A.

Old-Age Pensions

The German retirement system distinguishes five types of old-age pensions. In the 1990s, one of them corresponded to the statutory retirement at age 65, which has been elevated in 2007 to 67, and four corresponded to early retirement. Early retirement was possible for recipients of women and unemployment old-age pensions, two pension types that have been abated in the meantime and are only available for individuals born before 1952, and for recipients of disability old-age pensions. The minimum retirement age is 60 years for these groups. Insured persons with a history of long service were also allowed to retire early at age 63. To be eligible for early retirement, insured persons have to fulfill conditions that vary with the pension type.[5]

The old-age pension for women requires a minimum age of 60, 120 months of compulsory contributions after the 40^{th} birthday and the fulfillment of a 15 year waiting period.[6]

The unemployment old-age pension is open to people aged 60 and older that fulfill a 15 year waiting period. It requires at least 52 weeks of unemployment after the age of 58.5. It is also open to applicants retiring through the law about part-time work for employees over 55. This law allows early retirement without unemployment for employees that work only have of their original working hours for at least 24 months after turning 55 (see §237 SGB VI (Bundesministerium der Justiz (BMJ), 2012)). Many people choose the path of unemployment into retirement. Of all men that retired 2004 in Germany, only about one fourth was employed in the year before retirement. More than one fourth was unemployed and about 15% were in part-time employment (own calculations based on the "Entries into Retirement" 2004 sample of the German Federal Insurance, see Section

[5] Normal old-age retirement is open to all insured persons aged 65 and older that fulfill a waiting period of five years. Waiting periods of five, ten and 15 years consist of contribution periods, periods of wage-replacement benefits (unemployment, sick-pay) and periods of child-raising.

[6] Periods of compulsory contributions consist of contribution periods, periods of wage-replacement benefits like unemployment and sick-pay and periods of child-raising (§55 SGB VI (Bundesministerium der Justiz (BMJ), 2012)).

4). Many people left their companies prior to retirement according to the "59 ruling" (before called "57 ruling", depending on the period of time that unemployment benefits are paid, which used to be longer before). Unemployment compensation is often used as an unofficial pre-retirement income support scheme. Before workers can enter the public pension system at the age of 60, they are paid a combination of severance pay by their employer and unemployment benefits (Wübbeke, 2005). Recipients of unemployment benefits hence show a tendency to retire early.

Note that the choice of normal or early retirement schemes may not be voluntary due to the entitlement criteria and labor market restrictions.[7]

3.2. The 1992 Pension Reform

Until the 1992 pension reform, old-age pension benefits were the product of the employee's relative earnings position over the life-cycle ("earnings points"), the years of service life, the adjustment factor for the pension type and the current pension value. The relative-earnings position is computed in each year. Years of service life are determined as the sum of active contribution years, years of contribution on behalf of the employee and years that are counted as service years even though no own contribution was made, for example child-raising.

If an individual was eligible for one of the four early retirement pension types described above, she could claim the pension benefits before the normal retirement age of 65 without facing any penalties for early retirement. The adjustment of benefits to retirement age was only implicit via years of contributions. Because benefits are proportional to the number of contribution years, a worker that withdraws earlier from the labor market receives lower benefits. For example, with a constant income profile and 40 years of service, each year of earlier retirement decreased pension benefits by 2.5% (1/40). At the same time, while the pension claim dropped only by the share of the earnings points earned in the last contribution year in the sum of all earnings points, the sum of payments paid by the insurance increased by the share of this year in the sum of all retirement years (for example 1/20 for 20 retirement years). Because there were no penalties for retirement prior to age 65, there was a strong incentive to retire at the earliest possible point in time, which implied a huge financial burden to the insurance. As already mentioned, only 20% of men and 40% of women born in 1935 retired at the statutory retirement age.

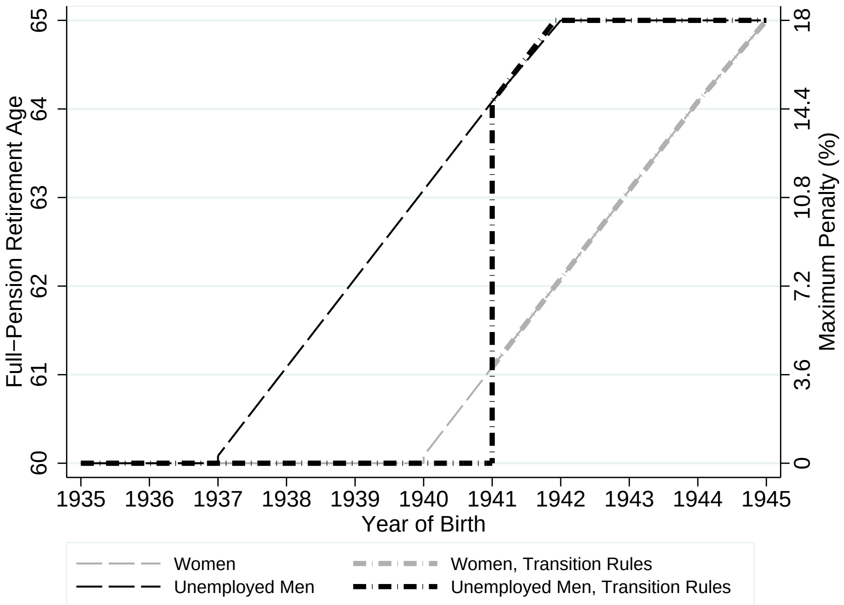
With the pension reform of 1992, the legislator introduced permanent pension deduc-

[7] For brief discussion of the importance of public pensions in Germany, see Appendix A.

tions for early retirement before the statutory retirement age. The minimum retirement age remained the same, as did the statutory retirement age. The normal or full-pension retirement age shifted gradually from the minimum retirement age of 60 toward the statutory retirement age of 65, depending on the month and year of birth of the individual.[8]

Figure 1 shows the policy implications of the reform graphically.

Figure 1: Policy Schedules of the 1992 Pension Reform



Full-pension retirement age (in years) and maximum early retirement penalty (in percent) according to the 1992 pension reform. The cohort year markers are set to January.

3.3. Calculation of Pension Benefits

Since the 1992 reform, benefits have not only been the product of the employee's relative earnings position, the years of service life, the adjustment factor for the pension type and the average pension, but also of the adjustment factor for the difference of the actual

[8]The 1992 reform also introduced other changes, which we assume do not have a significant impact on the retirement behavior of the cohorts we are interested in. For example, the 1992 reform abolished the indexation of pensions to gross wages in favor of net wages, which was a move away from the destabilizing feedback loop in which pensions increased when taxes and contributions increased. Also, the number of earnings points received for periods of child-raising was increased for children born 1992 and later. As the cohorts considered in my analysis are cohorts 1935 to 1945, which supposedly do not accumulate child-raising periods after 1992, this aspect of the reform is not taken into consideration.

retirement age to the normal retirement age (access factor). The individual annual pension benefits are determined according to §64 SGB VI (Bundesministerium der Justiz (BMJ), 2012) by

$$p_{i,t} = \underbrace{a_i \times T_i \times E_i}_{\text{personal pension base}} \times m_t \times V_t, \tag{1}$$

where the access factor a_i contains the pension deductions for retirement before the FPRA introduced by the 1992 reform. It is larger than 1.0 for retirement after the full-pension retirement age of 65 and less than 1.0 for retirement before 65. m_t depicts the number of months the pension is received in the respective year. V_t denotes the current pension value per benefit point (e.g. 25.31 Euro in 2002, 27.47 Euro in 2012; West Germany). The pension value is determined by various factors such as the average wage, the contribution rate, the demographic development (based on 2004 legislation) and the so-called *Riester-Faktor* (based on 2002 legislation).[9] T_i depicts the pension type. It is 1 for old-age pensions. E_i represents the sum of the earnings points collected over life time. An earnings point is based on individual pension contributions[10] divided by the average social security earnings in the respective year. One year with average contributions results in one earning point. Above or below average contributions affect the number of earning points proportionally.

In this analysis, we focus only on the access factor a. According to the 1992 reform, each month of early retirement will lead to a 0.3% decrease in pension benefits over the entire benefit period up to a particular maximum depending on eligibility age and pension type. The access factor a of the pension equation (1) is hence 0.003 less than 1.0 for every month of early retirement. This corresponds to a 3.6% annual decrease in benefits in addition to the effect of the fewer contribution years. A woman born in February 1940 that retires at age 60 has to face a deduction of two months times 0.3%, hence 0.6%. After the reform is fully implemented, the maximum deduction amounts to 18% for retirement at age 60 instead of at the full-pension retirement age 65. An overview of the rules applying after the reform can be found in Table 1.

To furthermore incentivize retirement beyond the statutory retirement age, the reform also introduced a reward for the postponement of retirement entry. Each month of retirement postponement past 65 is rewarded with a 0.5% increase in benefits. This

[9]The *Riester-Faktor* lowers the pension value growth to limit the future contribution rate growth.

[10]An earnings point might stem from own financial contributions based on periods of labor, but also from periods of child-raising, education and invalidity as well as compensation points following divorce (transfer points). The transfer points share of total earnings points is less than 10% for men and less than 35% for women (own estimation using the data of this study).

Table 1: Old-Age Pension Types After 1992 Reform

Pension Type	Cohort First Affected	Minimum Ret. Age	Full Pension Age	Maximum Deduction	Waiting Period
Regular (SGB VI §235)	–	65	65	–	5
Women (SGB VI §237a)	1940	60	65	18%	15
Unemployed (SGB VI §237)	1937	60	65	18%	15

Old-age pension types after the 1992 reform and its modifications are fully phased in. The waiting period contains the minimum number of years of service. These are years of active contributions plus years of contribution on behalf of the employee and years that are counted as service years even when no contribution was made at all, e.g. years of unemployment, child-raising, and military service. Own calculations based on Bundesministerium der Justiz (BMJ) (2012).

corresponds to a 6% annual increase in benefits in addition to the effect of the additional contribution years. However, despite this incentive, almost all individuals retire latest at age 65, hence we will not consider the rewards further.

4. Data

4.1. German Federal Pension Insurance Data

To investigate the retirement entries following the step-wise introduction of deductions for early retirement, we use high-quality administrative data of the Research Data Center of the German Federal Pension Insurance (FDZ-RV). The dataset that we analyze is based on the anonymized[11] Scientific Use File (SUF) of the Insurance Account Sample (*Versicherungskontenstichprobe*, VSKT) of the Federal Pension Register.[12]

The VSKT is a panel that has been first drawn in 1983. To remain a random sample

[11]For general rules of de-facto anonymization in the FDZ-RV, see Stegmann *et al.* (2005).

[12]An alternative dataset offered by FDZ-RV is the Outflow Sample of entries into retirement (*Versicherungsrentenzugang*, RTZN). The RTZN sample has the advantage that it contains a variable indicating if protection of confidence rules are applied. Also, the exact type of old-age pension is indicated. However, these variables are only available for cohorts 1960 and later. Furthermore, the sample does not cover all possible entry years of all cohorts including those not affected by the reform, such that a comparative analysis is not viable. The sample starts in year 2003, when most of the individuals are already retired. Also, as the sample contains only retirement entries in the reference year, it does not give information on the point of retirement of the entire cohort. Thus, inter-cohort effects cannot be compared.

of all insured persons also after 1983, new insured persons have to be drawn in proportionately. The used dataset SUFVSKT is a process-produced stratified random 25% sample of the VSKT and a 5% sample of all mandatorily insured individuals of the German Federal Pension Insurance whose account is not closed at the point of time of the evaluation. Those individuals have at least one entry in their social security record and are aged between 30 and 67 in the samle reference year. SUFVSKT waves of reference years 2002 through 2012 form the basis of our study.[13] Earlier waves are not available, as is wave 2003. Each wave contains the biographies of the individuals up to the reference year. Panel mortality is negligible (Fachinger and Himmelreicher, 2006).

Data on the occupation of an insured person is not very rich in the VSKT. The registered occupation is always the last occupation, hence it is impossible to analyze life-time careers. The last occupation may not be very representative of the occupation the individual had over her life course. Also, there are many missing values on the occupation variable, which can be due to the fact that an individual has been unemployed or passively insured (e.g. if working in household). Due to these limitations it is not possible to draw reliable conclusions on the retirement entry behavior based on occupations, which is unfortunate, since it has been shown that occupation has a significant influence on retirement timing.[14]

Another disadvantage of the VSKT data is that it is not possible to relate to the partner of the individual, although the household context might play a significant role for the timing of retirement, because spousal influence is supposedly existent (cf. Drobnic (2002)). Growing empirical evidence suggests that the decision to retire is a joint one between retirees and their spouses (Henkens, 1999; Smith and Moen, 1998; Gustman and Steinmeier, 2004). To nevertheless be able to include socioeconomic factors into the model, similar to Hanel (2010) we make use of information provided by the German Socio-Economic Panel (SOEP).[15] In particular obtain indicators for the trends and levels of some socioeconomic variables like education and marital status that might influence the retirement behavior.

[13]A detailed description of the data can be found in Himmelreicher and Stegmann (2008).

[14]In particular, especially men in highly qualified occupations like professors and managers show a high retirement age, while employees with less qualified (manual) occupations retire considerably earlier (Stegmann, 2006).

[15]Wagner *et al.* (2007) provide an overview of SOEP, see also `http://www.diw.de/soep`.

4.2. Sample

The sample covers cohorts 1935 to 1945. Since the personal identification number is not constant over time due to anonymity preservation, and therefore cannot be used to track individuals over different waves, only certain cohorts are taken from each wave in order to avoid duplicate observations.[16] Cohorts 1935 and 1936 stem from the 2002 wave, cohort 1937 stems from the 2004 wave, cohort 1938 from the 2005 wave, and so on. Cohort 1945 is taken from the 2012 wave. We use the biographical information to expand the sample overs the years 1995 to 2010.

We exclude individuals which are not retired, as well as people with distinctive pension systems like miners, civil servants and self-employed persons, people with pensions according to the Foreign Pension Law (*Fremdrentengesetz*), and people with partial pensions. The SUF is limited to German citizens living in Germany. The sample selection process is completed by restricting the dataset to individuals that are eligible for early retirement according to the criteria presented below.

4.2.1. Pension Eligibility Criteria

Given the information in the dataset, it is difficult to determine unambiguously eligibility for unemployment and women old-age pensions.[17] For this analysis, we define two samples in order to test the robustness of our results. We distinguish strict and soft eligibility criteria.

The strict definition reduces the probability that an individual is declared eligible though not being eligible. The soft definition reduces the probability that a person is declared non-eligible though being eligible.[18]

Unemployment Old-Age Pensions To be eligible for unemployment old-age pensions according to the legal definition, individuals have to be at least 60 years old, have at least 15 insurance years, have contributed to the insurance for more than eight out of the last ten years, and have to have been unemployed for at least 12 months after the

[16] This procedure is possible since one of the stratification criteria is year of birth, and consequently every birth cohort is a random subsample. Other attempts to avoid duplicates such as different forms of matching have proven to be highly prone to error.

[17] Furthermore, it is impossible to determine the eventually chosen pension type.

[18] The men's strict definition does not consider the substantial share of individuals who retire through the law about part-time work for employees over 55. The women's strict definition tends to understate the contribution period since it ignores that many women engage in unpaid caregiving in the years prior to retirement, which often does not appear in the data because it is not recorded automatically.

age of 58.5. Unemployment pension schemes are also available for individuals retiring through the law about part-time work for employees over 55.[19]

The soft eligibility criteria established for this analysis demand that the individuals fulfill the waiting period of 15 insurance years and that they have accumulated more than eight years of compulsory contributions[20]. In order to be eligible according to the strict criteria, individuals need to fulfill a 15-year waiting period, have contributed[21] to the insurance for more than eight out of the last ten years, and have to have been unemployed for at least one year after the age of 58.5.

Women Old-Age Pensions In order to receive women old-age pensions according to the legal definition, women have to be at least 60 years old, fulfill a 15-year waiting period, and have to have accumulated more than 120 months of compulsory contributions after their 40^{th} birthday. These criteria correspond to the strict eligibility criteria applied in this study. The soft eligibility criteria demand that the total sum of compulsory contribution months exceeds 120 and the waiting period of 15 years is fulfilled.

Table 2 gives an overview of the number of person-months in the analyzed sample according to eligibility status. Due to the expansion of the dataset, the number of individuals is considerably lower than the number of person-months (approximately 1/72). Although the share of eligible women is lower than the share of eligible men (75% vs. 94%), a considerably higher share of women is eligible according to the strict criteria (62% vs. 25%).

4.3. Relevance of Transition Rules

Based on the given data, it is impossible to determine whether an individual belonging to the transition cohorts (1937−1940 for unemployment pensions, 1940 for women pensions)

[19] The law about part-time work allows early retirement without unemployment for employees that work only half of their original working hours for at least 24 months after turning 55. Also, unemployment compensation is often used as an unofficial pre-retirement income support scheme. Workers then receive a combination of unemployment benefits and severance paid by their employer (Wübbeke, 2005). Statistics prove the relevance of these paths into retirement: Only about one fourth of the men that retired in 2004 was employed in the year prior to retirement. More than one fourth was unemployed and about 15% were in part-time employment (DRV (2014)).

[20] Periods of compulsory contributions consist of contribution periods, periods of wage-replacement benefits like unemployment and sick-pay and periods of child-raising (§55 SGB VI (BMJV, 2012)).

[21] The total contribution time is obtained by summing up the months of vocational training, unpaid caregiving, child-raising, home production, sickness, the receipt of unemployment benefits, military and civil service, self-employment and employment subject to social insurance contributions.

Table 2: Sample Size

Pension Scheme	Soft Eligibility	Strict Eligibility	Ineligibility	Total
Unemployment	394,488	104,644	24,624	419,112
Women	445,608	371,736	153,576	599,184

Number of observations (person-months) according to soft and strict eligibility status for unemployment and women old-age pensions. The last column gives the total number of male observations in the case of unemployment pensions, and the total number of female observations in the case of women pensions. All individuals eligible according to strict criteria are also eligible according to soft criteria.

is in fact subject to transition rules. However, there exists some indication about how relevant these transition rules are. One eligibility criterion for receiving unemployment old-age pensions is to be unemployed shortly before retirement. One condition for being subject to transition rules is to be unemployed in February 1996 (or to have agreed upon a measure leading to unemployment in the years after) and to be born in 1940 or earlier. These two conditions are very likely to be fulfilled simultaneously, since unemployment is a common path into retirement and it is probable that the cohorts of interest were unemployed in 1996 or the subsequent years. The same accounts for women, who are also often unemployed before retirement.

General retirement statistics from the Federal Pension Insurance (DRV (2014)) indicate that the share of old-age pensions with deductions increased only several years after the reform came into effect (see Figure 8 Appendix B). For men, the number of pensions with deductions increased substantially only in 2000/2001 instead of 1997, when the first cohorts were actually affected by the reform. A similar pattern can be detected for women.[22]

Against the backdrop of the relevance of transition rules, two different approaches are taken to deal with them. In a baseline specification it is assumed that transition rules are indeed applicable to most individuals, and thus the cohorts until 1940 are not affected by the reform. These cohorts are therefore included into the control group instead of the treatment group. The reform effect estimated based on the baseline specification might be biased to the extent that individuals are subject to deductions though belonging to the transition cohorts. A lower average retirement age of the control compared to

[22]The share of pensions with deductions before 2000 is presumably even smaller when considering only women and unemployment old-age pensions instead of all types of old-age pensions. It is not probable that the low share of deductions before 2000 is due to compliance with the full-pension retirement age, since the vast majority of individuals retires early.

Table 3: Cohort Groups

	Control	Treatment	Post-Treatment
Unemployment Pensions			
Baseline Specification	1935 – 1940	1941	1942 – 1945
Alternative Specification	1935 – 1936	1941	1942 – 1945
Women Pensions			
Baseline Specification	1935 – 1940	1941 – 1944	none
Alternative Specification	1935 – 1939	1941 – 1944	none

Cohort groups according to pension scheme and model specification. In the baseline specification, transition cohorts are included into the control group, which is not affected by the reform. The alternative specification omits transition cohorts. Treatment cohorts are cohorts for which the reform is phasing in. Post-treatment cohorts are cohorts for which the reform is fully implemented. The threshold cohort is omitted from the estimation as reference cohort.

the treatment group might be due to the fact that the individuals do in fact not face penalties and therefore do not react to them, or due to the ineffectiveness of the reform (the individuals face penalties, but do not react). The difference between these two cases is crucial. Therefore, as a second approach, an alternative specification is chosen which omits the transition cohorts. Table 3 gives an overview of the resulting cohort groups.

5. Descriptive Statistics

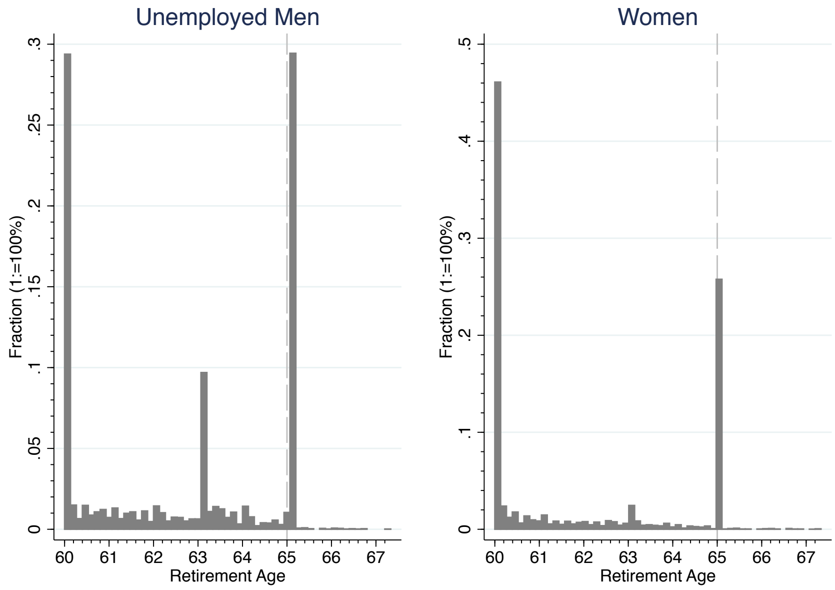
[to be completed]

Figure 2 underlines the relevance of early retirement in the analyzed sample. Less than 30% of the individuals eligible for early retirement retire at the statutory retirement age of 65 years. The highest share retires at the minimum retirement age. The hypothesis of this analysis is that the probability to retire at early ages is considerably higher for control than for treatment cohorts.

6. Empirical Model and Implementation

To identify the effect of the 1992 reform on retirement behavior (age), we use the kinks in the schedule of pension benefits (and hence the full-pension retirement age) following a sharp Regression Kink design. Similar to Landais (2013), the change in the schedule is

Figure 2: Probability Distribution of Retirement Age



Probability distribution of retirement age. Individuals eligible for unemployment or women pensions.

solely determined by one factor, namely the birth year. Hence, we avoid considering the complex concept of pension benefits (see equation (1)), but instead use an exogenous variation in the pension benefits, a clear and known benefit cut.

6.1. Method: Regression Kink Design

The Regression Kink Design is a relatively new method that is basically a generalization of the Regression Discontinuity Design. Many of the theoretical issues applicable to Regression Discontinuity designs also apply to the RKD.

Regression Discontinuity (henceforth RD) models in the spirit of Thistlethwaite and Campbell (1960) identify local average treatment effects by associating a jump (discrete change) in the mean outcome (Y, outcome function $y(x)$) with a corresponding jump in a continuous treatment variable (B, treatment function $b(x)$) at a fixed and known threshold (c) of a certain running variable (X)(cf. Hahn *et al.* (2001), Angrist and Pischke (2008), Imbens and Lemieux (2008), Imbens and Wooldridge (2009), and Lee and Lemieux (2010)). One key advantage of RDD is the high internal validity of this method. Under some assumptions, if b_+ and b_- are the right-sided and left sided limits of $b(x)$, a discontinuity at $x = c$ implies that $b_+(c) - b_-(c) \neq 0$. The standard RD treatment effect τ_{RD} can be obtained from:[23]

$$y_+(c) - y_-(c) = \tau_{RD}(c)\,\mathbb{E}\,(B|X = c) \tag{2}$$

where

$$\mathbb{E}\,(B|X = c) = b_+(c) - b_-(c) \tag{3}$$

and

$$\tau_{RD}(c) = \mathbb{E}\,(Y(1) - Y(0)|X = c, B = 1)\,, \tag{4}$$

where $Y(1)$ and $Y(0)$ denote an individual's potential outcomes from being treated or not. Because of $b_+(c) - b_-(c) \neq 0$,

$$\tau_{RD}(c) = \frac{y_+(c) - y_-(c)}{b_+(c) - b_-(c)}. \tag{5}$$

The intuition behind the RD method is that if all observed and unobserved covariates determining outcome and treatment are continuous at the threshold, then individuals just below the threshold will be comparable to those just above the threshold, and thus may provide valid counterfactuals. Any difference in their mean outcomes can be attributed to the change in the magnitude of treatment (in the binary case: the change in treatment probability).

The standard RD estimator is only feasible if there is a discontinuity at the threshold. However, among others, Nielsen *et al.* (2010), Card *et al.* (2012) and Dong (2010) show that the standard RD model treatment effect can be identified under more general conditions like a slope change (kink). Dong (2010) notes that, when parametric models are employed on a RD design, information is implicitly exploited on first derivatives by allowing for different slopes on either side of the discontinuity threshold, so the pure kink case can be taken as an extreme case where the jump at the threshold is essentially zero.

As in RD designs, kinks in the policy assign observations to one treatment or another in a manner that is as good as random. In short, the RK estimator equals the ratio of the kinks (change in slopes) in $y(x)$ and $b(x)$ at $x = c$ instead of the ratio of the jumps. This is due to that if $b(x)$ does not have a jump, both the denominator and the numerator of the RD estimator given by equation 5 will go to zero as x approaches c. By L'Hôspital's rule (cf. Taylor (1952)), this ratio is equal to the ratio of the derivatives of the numerator and the denominator, given that these derivatives exist. This is the mathematical intuition for identification off a kink.

[23] We assume here that everyone is a complier. Proofs can be found in the appendix of Dong (2010).

Generally, the RKD can be applied in situations when a treatment changes less dramatically than required by standard RDD. Here, the increase in full-pension retirement age (and hence potential pension benefit cuts) depends in its magnitude on the individual's distance from the threshold birth year. A person born in 1937 faces a smaller change in the FPRA than a person person born in 1942.

Hence, the treatment of a change in the FPRA (and hence reacting in form of a postponement of retirement to the increase in FPRA) associated with crossing the birth cohort threshold is likely to rise as one is further away from the threshold rather than jumping the moment the threshold is crossed. We do not assume that workers that are affected by the reform in the form of an FPRA increase of one month increase their actual retirement age dramatically. This would cause slopes to change at the threshold. Instead of a jump in the outcome, one expects a jump in the first derivative. Treatment effects based on standard RD estimators would be unidentified if there is no jump at the threshold, or weakly identified if the jump is small, regardless of how much the slope changes. In this paper, the estimators proposed make use of any changes in the slope of treatment probability at $x = c$.

6.2. The Model Setup

We want to estimate the causal effect of the 1992 reform on the actual retirement behavior, i.e. the retirement age. Assume

$$Y = y(B, X, U), \tag{6}$$

where Y is the retirement age, X, the running/assignment variable, defines the birth year and B is the treatment variable of pension benefits. $B_i = b(X_i)$, and is a deterministic function of X continuous everywhere except for a kink at $X_i = c$.

Note that, in contrast to Dong (2010) and Garmann (2014), treatment is not binary but continuous, as it is in Card *et al.* (2012) and Landais (2013). We do not observe a slope change of the probability of being subject to a change in the full-pension retirement age (to benefit deductions), but a slope change in the FPRA (depending on birth year) itself. The probability of being subject to a change in the FPRA changes discretely, i.e. it jumps from 0 to 1.

To generate exogenous variation in B_i, we use the fact that the treatment of benefits (depending on full-pension retirement age) is a deterministic function of birth year X_i with a kink at $X = c$. Individuals of the cohorts 1937 and later (unemployment old-age pensions) and 1940 and later (women old-age pensions) are affected by the increase in full-pension retirement age, whereas individuals born earlier are not. The increase is stronger, the further the individual's cohort from the threshold c. If B exerts a causal effect on Y, and there is a kink in the relationship between B and X at $X = c$, then we expect to see an induced kink in the relationship between Y and X at $X = c$. The identification is based on the magnitude of the treatment as a kinked function of the running variable.

Behaviorally, similar to the RD argumentation, individuals just below the kink point and individuals just above the kink point are comparable except for the different rate of treatment magnitude changes, so once can use the slope change of their mean outcome and the associated slope change of their treatment to identify the local average treatment effect at the cutoff.

Card *et al.* (2012) define a treatment-on-the-treated parameter of interest:

$$TT_{b|x}(b, x) = \int \frac{\partial y(b, x, u)}{\partial b} \mathrm{d}F_{U|B=b,X=x}(u) \tag{7}$$

where $F_{U|B=b,X=x}(u)$ denotes the CDF of U conditional on B, X equal to b and x, respectively. TT captures the average effect of a marginal increase in b at a specific value of (b, x), holding fixed the distribution of the unobservables $F_{U|B=b,X=x}(u)$.

A standard problem would be that u_i is correlated with X_i and hence B_i. However, Nielsen *et al.* (2010) and Card *et al.* (2012) define four mild regularity conditions to identify TT. In less technical words, identification relies on two main assumptions. First, the direct marginal effect of the assignment variable X on the outcome Y should be smooth. Second, the density of the unobserved heterogeneity should evolve smoothly with the assignment variable at the kink (local random assignment condition). Since birth year is used as a running variable, individuals are not likely to manipulate their birth year to sort near the cutoff, so the observed kink should not be caused by endogenous sorting.

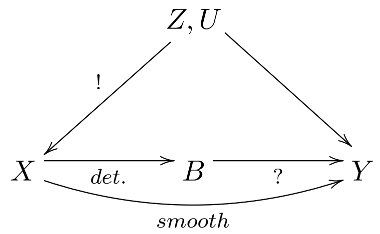
To sum up, if everything else is continuous near the kink point, any changes in the slope of the outcome can be attributed to the kink in the policy schedule. Any observed trend-discontinuity in the average retirement age between individuals born before and after the threshold year is due to the corresponding change in the slope of the full-pension retirement age schedule. The RKD will identify the treatment-on-the-treated parameter at the kink point, which is the average effect of a marginal increase in FPRA (maximum penalties) near the kink point, holding constant the distribution of unobservables.

Assuming heterogenous treatment effects, the RK estimate determines the weighted average of marginal effects across the entire population, where the weight assigned to an individual reflects the relative likelihood that the individual has a value of X close to the kink point (Card *et al.*, 2015).

The extent to which the local treatment effect applies to individuals belonging to cohorts further away from the threshold cohort is determined by the degree to which X and U are correlated. In settings where U is highly correlated with X, the RKD estimate is only representative of the treatment effect for individuals with realizations of U associated with values of X close to c. In settings where X and U are independent, the weights for different individuals are equal, and the RKD identifies the average marginal effect evaluated at $B = b_c$ and $X = c$.

The correlation between X and U is a critical point in our analysis, in particular because of the relatively large range of years included in the estimation. Unobserved differences between included cohorts that are far away from the threshold and cohorts that are close to the threshold might bias the reform effect.

Figure 3: Correlations between Variables



Correlations between variables. Arrows indicate the hypothesized direction (causality) of effects.

Figure 3 sums up the relations between the variables involved according to the identifying assumptions. The effect of interest is the effect of B on Y. Birth year X determines policy schedule B. X might have a direct effect on Y, as long as there is no kink in the relation at the kink point of B. X is likely to be correlated with some observables Z. This correlation might be problematic if treatment and control cohorts differ not only in the slope of the policy schedule, but also in other factors that exhibit a kink at the kink point. Direct effects of Z on Y should be controlled for by including Z in the estimation. Unobserved heterogeneity U might bias the estimated effect. A high correlation between X and U compromises the validity of the estimate.

To determine the effect of pension deductions introduced by the 1992 pension reform on the timing of retirement entry, the additive constant-effects model

$$Y = \tau B + g(X) + U \tag{8}$$

is estimated, where g is a continuous function. A naïve Ordinary Least Squares (OLS) estimate of the parameter of interest τ will presumably be biased due to reverse causality, as the year of birth as the source of variation in the treatment B might be endogenous to retirement age.

In other words, policy B will tend to be endogenous, because it is not randomly distributed but motivated by X. X is likely to be directly related to retirement age, which implies that perceived correlations between B and Y partly stem from the determinants of the distribution of X rather than from the causal effect of B in itself.

Conventional approaches to causal inference relying on the existence of an instrumental variable will not work, as noted by Card *et al.* (2012). Conditional on X, there is no variation in the full-pension retirement age B, and the model is not non-parametrically identified. The attempt to get around this by treating X as an error component correlated with B will not solve the problem either, because any variable that is independent of X will by construction be independent of the regressor of interest B. Therefore, it will be impossible to find instruments for B while holding constant the policy regime. The Regression Kink Design is a remedy for this problem.

Under the assumptions explained in Card *et al.* (2012), the treatment effect is identified[24] by

$$\tau_{RK} = \frac{\lim_{x\downarrow c} \dfrac{\partial\,\mathbb{E}(Y_i|X_i = x)}{\partial x} - \lim_{x\uparrow c} \dfrac{\partial\,\mathbb{E}(Y_i|X_i = x)}{\partial x}}{\lim_{x\downarrow c} \dfrac{\partial b(x)}{\partial x} - \lim_{x\uparrow c} \dfrac{\partial b(x)}{\partial x}} \tag{9}$$

The RKD estimand τ_{RK} is the change in the slope of the conditional expectation function $\mathbb{E}(Y|X = x)$ at the kink point $X = c$, divided by the change in the slope of the known deterministic policy function $b(x)$ at the kink point.[25] The actual estimation procedure merely requires the estimation of the numerator.

As most studies that apply an RKD we estimate τ_{RK} as β_1 from a local polynomial regression model of type

$$\mathbb{E}\left[Y|X = x\right] = \mu_0 + \left[\sum_{p=1}^{\bar{p}} \gamma_p\,(x-c)^p + \beta_p (x-c)^p \cdot T^*\right], \tag{10}$$

with $|x - c| < h$ for bandwidth h. p is the polynomial order of the fit. $T^* = \mathbb{1}(X > c)$ is an indicator for being above the threshold. Many of the former studies use a symmetric

[24] See Card *et al.* (2012, 2015) for a detailed proof.

[25] In settings where there is incomplete compliance with the policy rule, or measurement error exists in the actual assignment variable, a fuzzy RKD replaces the denominator of the sharp RKD estimand with the estimated kink in the relationship between the assignment and the policy variable. Incomplete compliance can be ruled out here. People comply with the full-pension retirement age and the maximum penalties (note the difference to the realized penalties). The probability that they are subject to the new policy schedule changes from zero to one.

uniform kernel, a polynomial order of 1 and different bandwidth sizes to estimate these local polynomial regressions.

7. Results and Conclusions

This section presents graphical and econometric evidence of a kink in the relationship between the year of birth and the retirement age, which identifies the causal effect of pension deductions on retirement age. For the sake of transparency, the estimates for all of the discussed model setups are reported. The preferred setup is the model with additional covariates, baseline specification applying soft eligibility criteria.

7.1. Graphical Evidence

Since for the validity of the RKD, kink points in the cohort-specific mean retirement age and in the cohort-specific FPRA need to exist and to coincide, crucial evidence of the applicability of the RKD can be derived through visual inspection of the cohort-specific average retirement age as plotted in Figures 4 (baseline specification) and 9 (alternative specification). The existence of the kink in the policy function is visible in Figure 1. The last cohort not affected by the reform is chosen as the kink point.[26]

In all plots, a clear slope change in the retirement age can be detected at the threshold of the last control cohort. This threshold coincides with the kink point of the policy schedule. The kinks are a clear indicator for the applicability of the RKD.

Women retire on average earlier than unemployed men. Strictly eligible individuals retire earlier than softly eligible individuals. The difference between the average retirement age of the treatment and the control group is higher for men than for women and higher for strictly than for softly eligible individuals. Men belonging to the post-treatment group continue to increase their retirement age compared to the treatment group, although the reform is already fully implemented and hence a flat linear fit would be expected.

On average, strictly eligible unemployed men affected by the reform retire almost 16 months later than those not affected (soft eligibility: 7 months). The average retirement age increases by about 13 months from the last control cohort 1940 to cohort 1945 (soft eligibility: 9 months). Strictly eligible treated women retire about seven months

[26] This seems to be at odds with figure 1, where the first affected cohort is the kink point. But this is only a matter of visualization: If figure 1 showed the cohort-specific policy function instead of the cohort-month-specific one, the kink point would be at the last cohort affected, like in figures 4 and 9.

later (soft eligibility: 5 months) than non-treated women. The average retirement age increases by about seven months from cohort 1940 to cohort 1944. The plots for the alternative specification show similar patterns.

Further graphical evidence of a change in the retirement behavior following the reform is provided by the comparison of the treatment and the control group's cumulative distribution functions of retirement age.

This form of proof is especially enticing as the applied estimation method suggested by Mastrobuoni (2009) exploits particularly this distance between the CDFs to determine the retirement trends and thus the change in the retirement trend due to the reform.

If the hypothesis that treated individuals retire later than non-treated individuals is true, the CDF of the treatment group will lie below the CDF of the control group. Figure 5 (baseline specification) contains graphical evidence of the validity of this hypothesis.

Only for strictly eligible women at age 64, the treatment group's CDF is above the control group's CDF. For all other pensioner groups and ages, the control group's CDF lies above the treatment group's CDF, which indicates that treated individuals indeed retire later.

The distance between the CDFs is larger for strictly eligible individuals in the case of unemployment pensions, and for softly eligible individuals in the case of women pensions. The jump observed at age 63 is potentially due to individuals who claim early retirement pensions for the long-term insured, which are available at a minimum age of 63.

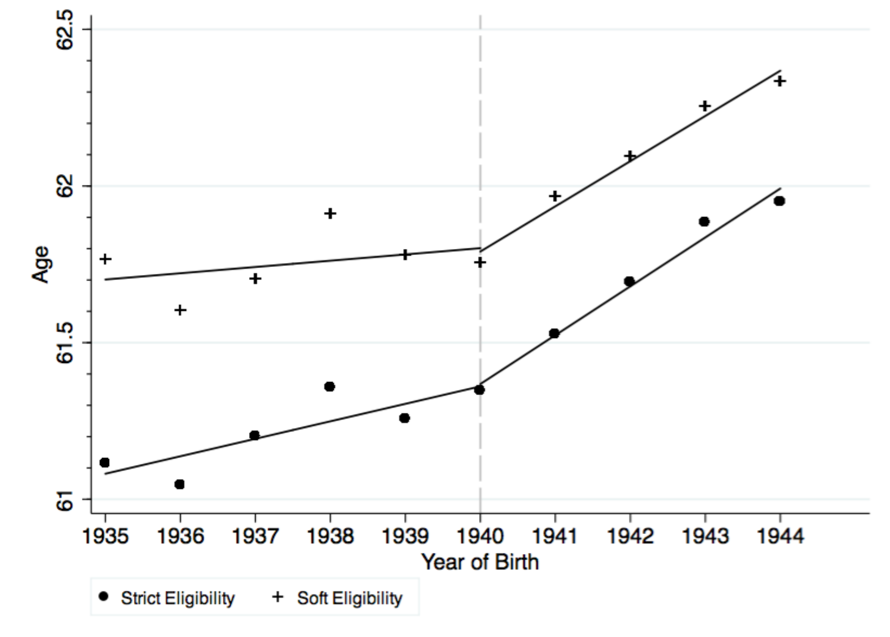
While the distance between the CDFs for the treatment and the control group supports the assumption of the existence of a reform effect, it is presumably not only due to this reform effect, but also originates from differences in individual characteristics and labor market factors. Table 5 in Appendix contains summary statistics per cohort group which indicate that the treatment and control groups differ on various observable variables.[27]

All in all, the provided graphical evidence suggests that the treatment cohorts do indeed retire later than the control cohorts, and that there exists a change in the retirement trend at the threshold of the last control cohort. The basic premise for the applicability of RKD, the existence of coinciding kink points in the cohort-specific retirement age and the policy function, is hence fulfilled.

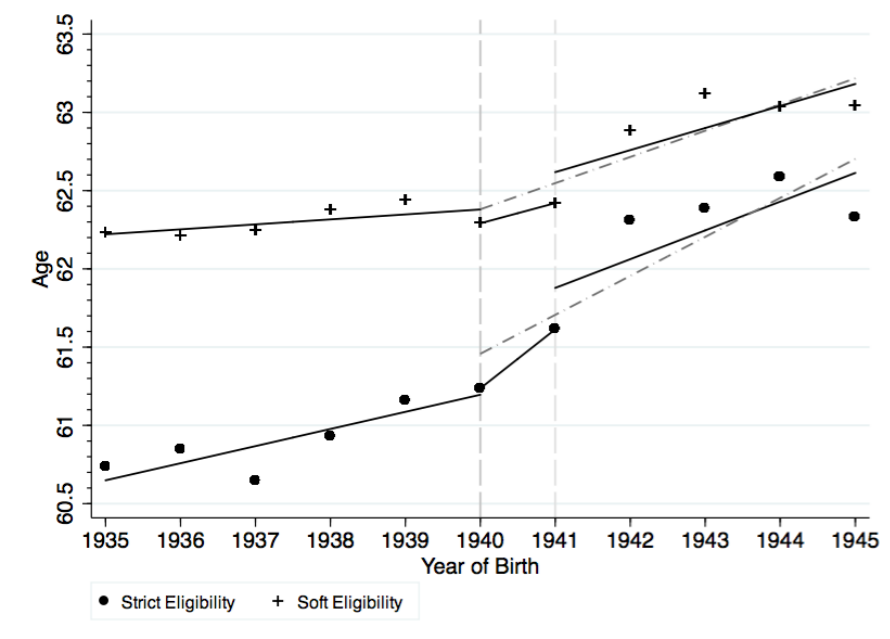
Whether the kink in the retirement age is a causal effect of the 1992 pension reform is analyzed by estimating a Regression Kink Design model. The results of this estimation are presented in the following.

[27] Education and unemployment rates are higher for treatment cohorts than for control cohorts. Treated individuals have less children than non-treated. The number of employment, unemployment and sickness periods since age 58 is higher for the treatment group.

Figure 4: Average Retirement Age



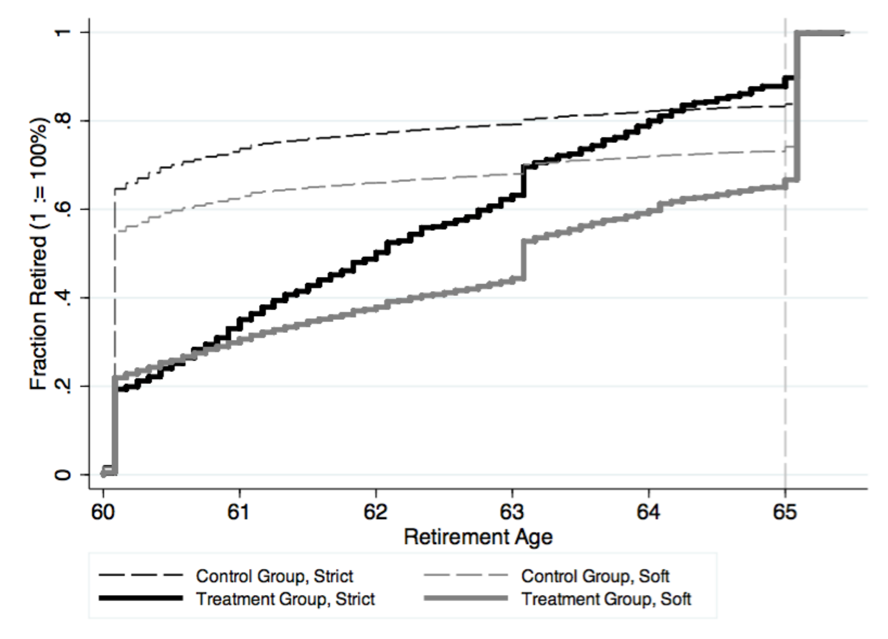
Women



Unemployed Men

Average retirement age and piece-wise linear fits for the control, treatment, and (for unemployed men) post-treatment group. The grey dash-dotted line shows the linear fit for treatment and post-treatment cohorts combined. Threshold cohort 1940 and men's treatment cohort 1941 are marked. Baseline specification.

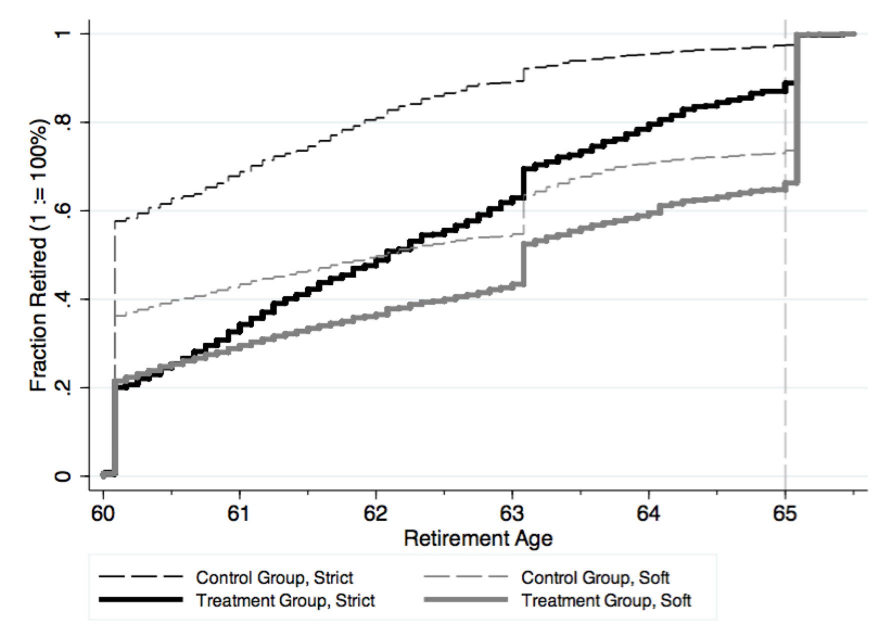
Figure 5: CDF of Retirement Age



(a)

b

Figure 6: Women



(a)

b

Figure 7: Unemployed Men

Cumulative distribution functions of retirement age for the control and the treatment group (incl. post-treatment cohorts of unemployed men). Baseline specification.

In the following, the effect of pension deductions is estimated according to the RKD estimation procedure. Kernel-based local polynomial regressions are estimated based on the model given in equation (10).[28] Following Imbens and Lemieux (2008) and common practice in the RK literature, a uniform kernel is applied.

Because of the uniform kernel, continuity in the estimation can be imposed[29] and a simple OLS regression can be run over the entire population support, combining both sides of the threshold. The RKD estimate is given by the coefficient on the interaction of the assignment variable and the treatment dummy, β_1 in equation (10) (divided by the change in the slope of the policy function measured in years, 1). The applied polynomial order is 1.[30]

Results are given in Table 4. The baseline specification shows similar estimates for men and women. For strictly eligible men, they are not statistically significant. If we apply soft eligibility criteria, the estimates are larger. A marginal effect of 0.109 (Model VI) means that men increase their retirement age by 0.109 months per month increase in the FPRA (given deductions of 0.3% per month). In other words, the fully phased in reform leads to an increase of the average retirement age of the treated by 6.5 months. This is almost the same effect as for women using the same specification and sample.

These effects are considerably smaller than previous estimates of the same reform (e.g., Siddiqui, 1997; Berkel and Börsch-Supan, 2004; Börsch-Supan *et al.*, 2004; Hanel, 2010). Furthermore we cannot confirm the gender differences that were found in previous studies.

[to be completed]

[28] The least squares problem that is to be solved is

$$\min_{\tilde{\beta}_p^-} \sum_{i=1}^{n^-} \left(Y_i^- - \sum_{p=1}^{\bar{p}} \tilde{\beta}_p^- (X_i^-)^p \right)^2 K\left(\frac{X_i^-}{h}\right)$$

and, analogously, $\min_{\tilde{\beta}_p^+}$, where the $-$ and $+$ superscripts denote quantities in the regression on the left and right side of the kink point, respectively. p is the polynomial order, K the kernel, and h the bandwidth (Card *et al.*, 2015).

[29] Imposing continuity in the estimation instead of estimating separate local polynomials on either side of the threshold does not affect the asymptotic bias and variance of the kink estimator if a uniform kernel is applied (Card *et al.*, 2012, 2015).

[30] Card *et al.* (2012) underline that a local quadratic regression leads to an asymptotically smaller bias than a local linear regression at the cost of a significantly larger asymptotic variance (bias-precision trade-off). Dong (2010) notes that higher order terms are asymptotically unnecessary for consistency, and empirically cause numerical multicollinearity issues. Gelman and Imbens (2014) warn of using a polynomial order of more than 2. Most researchers therefore apply a local linear regression.

Table 4: RKD Estimates

	Women				Unemployed Men			
	Raw		With covariates		Raw		With covariates	
	Strict	Soft	Strict	Soft	Strict	Soft	Strict	Soft
	I	II	III	IV	V	VI	VII	VIII
Baseline	0.0976**	0.114***	0.0841*	0.118***	0.0711	0.109***	0.0921	0.128***
	(0.0423)	(0.0428)	(0.0442)	(0.0444)	(0.0556)	(0.0365)	(0.0586)	(0.0373)
Alternative	0.0810*	0.0863*	0.0603	0.0820*	−0.0117	0.0720*	0.0454	0.113***
	(0.0459)	(0.0465)	(0.0478)	(0.0480)	(0.0662)	(0.0413)	(0.0702)	(0.0433)

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Marginal effect of a one year increase in the full-pension retirement age on the actual retirement age per year, measured in years. The underlying estimation procedure is the conventional RKD method. Individual-clustered robust standard errors in parentheses. Baseline and alternative specification, raw and sophisticated model, strict and soft eligibility criteria.

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A. Importance of the Public-Pension System

The German public retirement insurance is based on a pay-as-you-go scheme. The social security contributions of the current insured workers finance the pension benefits received by the current retirees. The federal insurance covers about 90% of the entire population (Rehfeld and Mika, 2006), most of them private-sector workers, and thus is almost universal. Only the self-employed and, until the year 1998, workers with earnings below the official minimum-earnings threshold (*Geringfügigkeitsgrenze*; 15% of average monthly gross wage) are not subject to mandatory coverage.[31] In 2011, 89% of the men and 86% of the women living in West Germany and older than 65 years obtained pension benefits from the federal insurance. In East Germany, the shares were 99% each (Bundesministerium für Arbeit uns Soziales (BMS), 2011). The German public-pension system provides old-age pensions, disability benefits for workers at all ages, and survivor benefits for spouses and children. As our focus is on the changes in old-age retirement following a pension reform, we will focus on old-age pensions from now on.

Public pensions are by far the largest income source after retirement. In 2011, on average 64% of the gross income of people aged 65 years and older is based on benefits from the public pension insurance. 21% stems from other old-age provisions like company pensions and civil servant pensions. Private old-age provisions amount to 9%, transfer payments like social benefits have a share of 1%. 6% of the gross income stem from other income sources like interests and life insurance. The share of the federal pension is a lot higher in East Germany, amounting to 91% of gross income compared to 58% (Bundesministerium für Arbeit uns Soziales (BMS), 2011).

As opposed to other countries, public pensions in Germany were from the start designed to extend the standard of living achieved during work life to the time after retirement. Accordingly, public pensions are roughly proportional to labor income averaged over the entire life course and feature only few redistributive properties. The replacement rate is very high, generating net retirement incomes that are more than 50% of the most recent net earnings for a retiring worker with a 45-year earnings history and average lifetime earnings. The replacement rate declined from 57.6% in 1980 to 51.6% in 2010 (before tax; Deutsche Rentenversicherung (2014)). Defining the replacement rate alternatively as the current pension divided by the current average earnings of all dependently employed workers (life-time average), the rate amounts even to 70% com-

[31] The self-employed contain about 9% of the workforce. They are mainly self-insured, although some of them voluntarily participate in the public retirement insurance system. Some branches like civil servants, which contain about 7% of the workforce, have their own pension system.

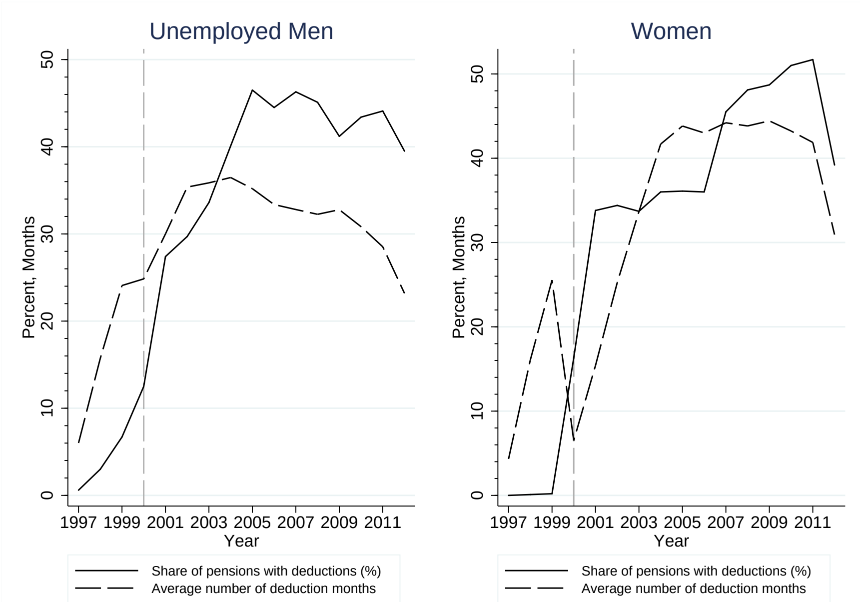
pared to 53% in the US (2003 values; Börsch-Supan and Wilke (2003)). This generous system is costly. In the year 2000, public pension expenditures amounted to about 200 billion Euro, representing one fifth of public spending and about 12% of GDP, the second largest pension budget in the OECD after Italy (OECD, 2001).

The public retirement insurance is by about 70% financed by contributions levied equally on employers and employees as payroll taxes (Börsch-Supan *et al.*, 2004).[32] The contribution rate was 14% of monthly gross labor income in 1960, 18.7% in 1990, 19.3% in 2000, 19.5% in 2005 and 19.9% in 2010 (Deutsche Rentenversicherung, 2014). At the end of the 1980s, the contribution rate was projected to exceed 40% of gross income at the peak of population aging in 2035 (Prognos, 1987). The low minimum retirement ages and high replacement rates was predicted to continue having a high cost to society. This lead to a major pension reform in 1992 to secure the financial basis of the generous pension system against the threat of population aging.

B. Extended Results

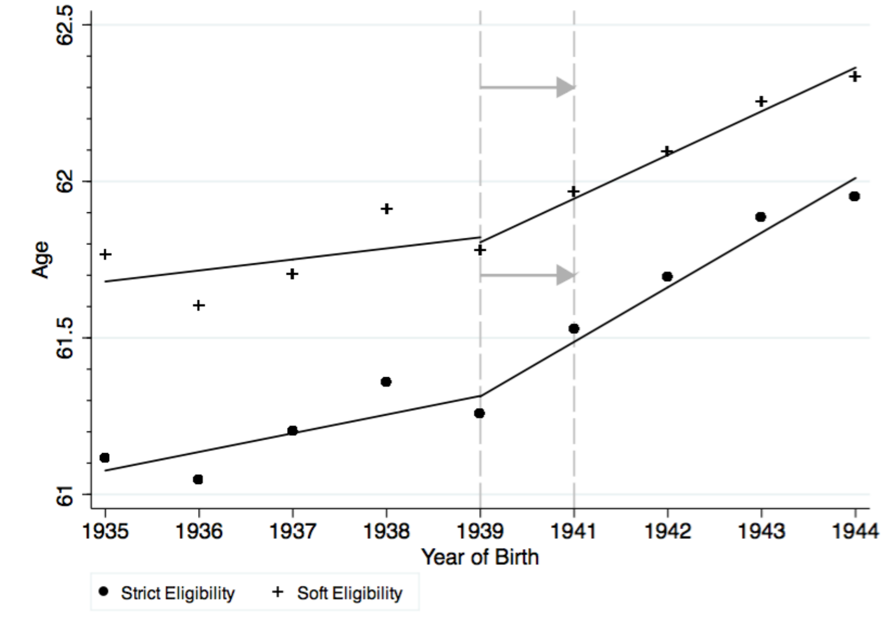
[32] The remaining 30% of the social security budget are financed by earmarked indirect taxes (fraction of value-added tax and the eco-tax on fossil fuel) and a subsidy from the federal government.

Figure 8: Pension Benefit Deductions

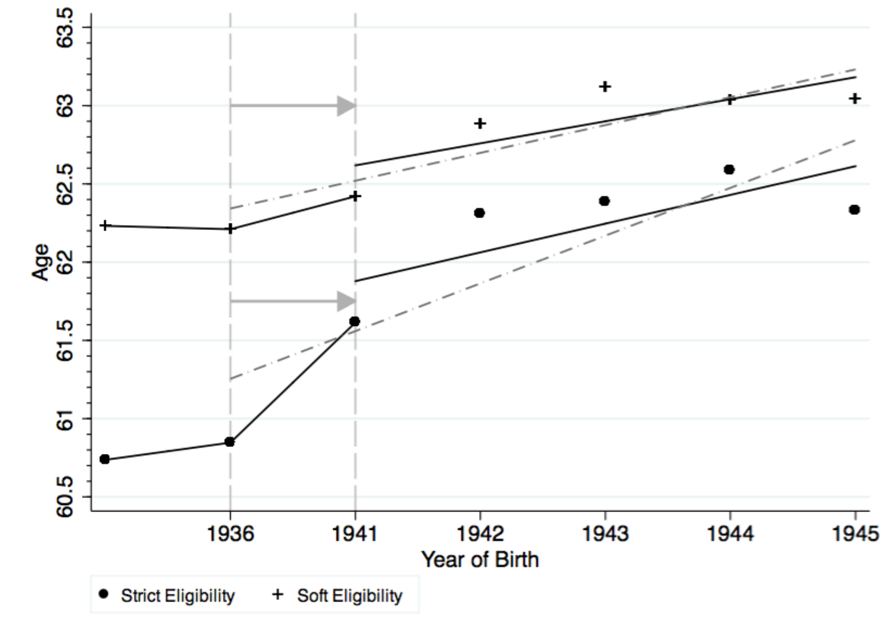


Share of pensions with benefit deductions in the total number of old-age pensions, measured in percent, and average number of deduction months. Based on a dataset from DRV (2014) containing the analyzed sample.

Figure 9: Average Retirement Age (Alternative Specification)



Women



Unemployed Men

Average retirement age and piece-wise linear fits for the control, treatment, and (for unemployed men) post-treatment group. The grey dash-dotted line shows the linear fit for treatment and post-treatment cohorts combined. Threshold cohorts 1936 (men) and 1939 (women) and cohort 1941 are marked. Alternative specification: Transition cohorts 1937 – 1940 (men) and 1940 (women) are omitted, as is indicated by the arrows.

Table 5: Summary Statistics

	Unemployed Men								Women					
	Strict Eligibility				Soft Eligibility				Strict Eligibility			Soft Eligibility		
	$C^{(b)}$	$C^{(a)}$	T	PT	$C^{(b)}$	$C^{(a)}$	T	PT	$C^{(b)}$	$C^{(a)}$	T	$C^{(b)}$	$C^{(a)}$	T
Retirement Age	60.93	60.80	61.61	62.41	62.30	62.22	62.42	63.02	61.23	61.20	61.76	61.75	61.92	62.16
(in years)	(1.33)	(1.28)	(1.63)	(1.75)	(2.11)	(2.12)	(2.03)	(2.02)	(1.95)	(1.97)	(1.90)	(2.22)	(2.17)	(2.07)
Retirement Status	0.84	0.87	0.73	0.60	0.62	0.63	0.60	0.50	0.80	0.80	0.71	0.71	0.68	0.64
(Retired := 1)	(0.36)	(0.34)	(0.44)	(0.49)	(0.49)	(0.48)	(0.49)	(0.50)	(0.40)	(0.40)	(0.46)	(0.45)	(0.47)	(0.48)
Region	0.62	0.62	0.63	0.56	0.76	0.77	0.76	0.72	0.58	0.58	0.59	0.63	0.63	0.63
(West := 1)	(0.48)	(0.48)	(0.48)	(0.50)	(0.43)	(0.42)	(0.43)	(0.45)	(0.49)	(0.49)	(0.49)	(0.48)	(0.48)	(0.48)
Education	12.00	11.84	12.31	12.62	11.95	11.79	12.34	12.60	10.97	10.92	11.57	10.94	11.20	11.57
(in years)	(0.29)	(0.19)	(0.12)	(0.37)	(0.26)	(0.16)	(0.11)	(0.32)	(0.36)	(0.37)	(0.38)	(0.35)	(0.47)	(0.38)
Married	0.86	0.88	0.84	0.83	0.86	0.87	0.84	0.83	0.72	0.71	0.76	0.72	0.74	0.76
(Married := 1)	(0.05)	(0.05)	(0.02)	(0.04)	(0.04)	(0.05)	(0.02)	(0.03)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Unemployment Rate	11.64	11.09	12.29	11.71	10.51	10.05	11.25	10.48	12.70	12.78	12.01	12.18	11.99	11.70
(in %)	(4.31)	(3.55)	(4.74)	(4.41)	(3.95)	(3.05)	(4.42)	(4.22)	(5.63)	(5.65)	(4.94)	(5.49)	(5.26)	(4.88)
Hartz Reform	0.06	0.00	0.42	0.81	0.05	0.00	0.41	0.80	0.06	0.02	0.65	0.06	0.30	0.66
(Implemented := 1)	(0.23)	(0.00)	(0.49)	(0.40)	(0.23)	(0.00)	(0.49)	(0.40)	(0.23)	(0.13)	(0.48)	(0.23)	(0.46)	(0.48)
Children	0.03	0.02	0.02	0.03	0.04	0.03	0.06	0.02	2.12	2.15	1.89	2.08	1.99	1.86
	(0.28)	(0.26)	(0.19)	(0.22)	(0.33)	(0.31)	(0.36)	(0.20)	(1.52)	(1.55)	(1.21)	(1.51)	(1.40)	(1.20)
Earnings Points	48.75	49.05	47.49	46.44	46.82	46.95	47.23	46.20	30.43	30.40	31.68	28.16	28.74	29.58
	(10.73)	(10.48)	(11.42)	(12.13)	(14.17)	(14.22)	(13.91)	(15.02)	(10.68)	(10.43)	(11.13)	(11.55)	(11.69)	(11.85)
Months Worked	8.52	8.11	11.43	14.90	16.50	15.34	20.71	25.02	10.02	9.54	18.26	8.74	11.52	15.57
(since age 58)	(13.24)	(13.11)	(15.19)	(17.38)	(24.35)	(23.28)	(25.64)	(29.09)	(16.92)	(16.42)	(23.43)	(16.26)	(19.36)	(22.56)
Months Unemployed	21.11	20.21	25.93	30.43	8.33	7.85	9.48	9.94	7.02	6.75	9.04	6.12	6.90	8.03
(since age 58)	(7.69)	(6.69)	(14.20)	(14.58)	(10.72)	(10.32)	(13.98)	(15.87)	(9.73)	(9.50)	(12.89)	(9.56)	(10.97)	(12.66)
Months Sick	0.68	0.70	0.63	1.15	0.77	0.97	0.70	0.81	0.43	0.45	0.50	0.38	0.40	0.44
(since age 58)	(2.65)	(2.91)	(2.38)	(3.18)	(2.85)	(3.17)	(2.67)	(2.77)	(1.92)	(2.00)	(2.29)	(1.83)	(1.97)	(2.16)
Year	2000.64	1998.61	2004.01	2006.44	2000.49	1998.44	2003.96	2006.42	2000.57	2000.05	2005.43	2000.54	2002.53	2005.43
	(2.42)	(1.84)	(1.78)	(2.09)	(2.46)	(1.85)	(1.78)	(2.09)	(2.45)	(2.27)	(2.10)	(2.46)	(3.34)	(2.10)
Observations														
(person-months)	57,635	17,607	10,319	36,690	213,192	68,688	36,864	144,432	220,320	180,504	151,416	264,384	445,608	181,224

Summary statistics. $C^{(b)}$ denotes the baseline control group (cohorts $1935-1940$), $C^{(a)}$ denotes the alternative control group (cohorts 1935/1936 for men; cohorts $1935-1939$ for women); T denotes the treatment group (1941 for men; $1941-1944$ for women); PT denotes the post-treatment group for men (cohorts $1942-1945$). Standard deviation in parentheses.