The Effect of Pension Subsidies on Retirement Timing of Older Women: Evidence from a Kink Design in Germany

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Abstract

This paper provides a clear and transparent setting to study the effect of additional pension benefits on women's retirement decision. Using administrative pension insurance records from Germany, I examine the impact of a pension subsidy program to low pay workers, implemented in 1992. The subsidies have a kinked relationship with the recipients' average pension contribution, which led to sharply different slope of benefits for similar women to the left and to the right of the kink point. Using a regression kink design, I find that 100 euros additional monthly pension benefits induce female recipients to claim pension earlier by about 10 months. A back-of-the-envelope calculation suggests the ratio of behavioral cost to mechanical cost of this subsidy program is 0.3, which is smaller than other anti-poverty programs such as extending unemployment benefits and progressive taxation. I find that the phasing out of this subsidy program can account for one third of the increase in women's age of claiming pension over the past decade.

Keywords: pension subsidy, pension generosity, retirement, regression kink design
JEL Classification: H55, J18, J21, J26

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1 Introduction

Retirement income adequacy is an important concern for vulnerable groups, such as female workers, who are at much greater risk of old-age poverty than men. In Germany, the pension benefit of an average woman is only about half that of an average man. This issue is of particular importance during times of reducing public pension replacement rates due to the aging population.[1] Furthermore, low-income workers are disproportionately affected by the recent pension reforms that penalize claiming pension early.[2] One way to ensure workers have adequate incomes in old age is via income support programs. Many developed countries have provided safety nets for pensioners with low benefits. However, policymakers face an important trade-off: how to provide income support to elderly people without hurting incentives to work.[3] Therefore, it is important to understand the extent to which additional pension benefits affect low-income workers' retirement timing. However, this question is understudied. It is partly due to the difficulty of isolating exogenous variation in the parameters of the public pension system, including benefit levels, pension eligibility age, penalties for claiming pension early, etc. The main contribution of this paper is to provide a clear and transparent setting to isolate the casual impact of additional pension benefits by exploiting a special pension subsidy program in Germany.

The existing papers on the labor supply response to changes in retirement incentives mostly focus on the overall impact of a policy change (See, e.g., Song and Manchester (2007), Coile and Gruber (2007), Duggan et al. (2007), Mastrobuoni (2009), Staubli and Zweimüller (2013), Manoli (2016), Engels et al. (2017)). For instance, recent pension reforms are often in the form of raising pension eligibility age accompanied by financial penalties for claiming pension early. The estimated overall impact of such pension reforms is a combination of labor supply response to a change in lifetime income and response to a change in the focal reference point - the statutory pension eligibility

[1]For example, the net pension replacement rates for future retirees with low wages in Germany are among the lowest in OECD countries. "German workers earning half the average wage and retiring after a full career may expect a net replacement rate of 53% in the long term against 75% on average across the OECD. For average-wage workers, replacement rates will also be below average, at 50% compared to 63% in the OECD" (OECD (2015)).

[2]Studies have found that the sick and the poor could not adjust their labor supply in responses to recent pension reforms by working longer and had to suffer the early retirement penalties (Hupfeld (2009), Hanel (2010), Geyer et al. (2018)).

[3]Studies have shown the disincentive effects of similar welfare programs, such as disability insurance, the earned income tax credit and unemployment insurance ((See, e.g., Börsch-Supan and Schnabel (1998), Friedberg (2000), Eissa and Hoynes (2006), Eissa and Hoynes (2004), Schmieder et al. (2012)).

age (Blundell et al. (2016), Cribb et al. (2016), Seibold (2017)). For example, Seibold (2017) has documented that workers' responses to discontinuities in lifetime budget constraint at statutory retirement ages are much larger than responses to other budget constraint discontinuities, which do not link to statutory ages. In this paper, I explore a specific feature of the German pension system, which allows me to identify the causal effect of additional pension benefits in an environment in which the statutory pension eligibility age and other incentives remain unchanged. In particular, I investigate a pension subsidy program for low pay workers in Germany, implemented in 1992, using high-quality administrative data from the Research Data Centre of the German Pension Insurance. I exploit the very sharp kink in the benefit schedule as a function of predetermined past contributions to implement a Regression Kink (RK) design. This empirical design allows me to isolate the causal effect of additional pension benefits. To the best of my knowledge, this approach has never been used to study the effect of additional pension benefits in the literature.

In detail, I use administrative data from the Research Data Center of the German Pension Insurance (FDZ-RV) to study a pension subsidy program for low pay workers (Mindestentgeltpunkte bei geringem Arbeitsentgelt, SGB VI § 262) introduced by the 1992 Pension Reform Act in Germany. Several features of this pension subsidy program make it a good instrument. First, it provides an exogenous variation in pension benefits. This is because the subsidy size is predetermined by worker's pension contribution made before 1992 — before the announcement of the reform. Second, the subsidy size has a kinked relationship with worker's relative wage income before 1992. In other words, the slope the subsidy changes discontinuously at a kink point of the recipient's income distribution. This enables me to compare similar women to the left and to the right of the kink point. Lastly, the changes in benefits does not associate with changes in other parameters of the pension system, such as the statutory pension eligibility age. This allows me to isolate the impact of changes in pension benefits. Moreover, the data from FDZ-RV is a key advantage because it contains not only workers' pension contribution at monthly frequency, but also the recipients' exact subsidy level.

The baseline sample consists of female subsidy recipients in West Germany who retired between 1994 and 2014. On average, the subsidy program increases recipients' pension benefits by around 90 euros per month, that is equivalent to a 17 percent increase in the pension benefit level. This creates an average implicit tax of approximately 8%. Around the policy kink, I show graphical evidence of a realized kinked pension subsidy schedule. I find a statistically significant discontinuous change in the slope of subsidies, which is consistent with the policy schedule. I also find an induced discontinuous change in the slope of age of claiming pension. The estimation suggests that €100 additional monthly pension benefits induce female recipients to claim old age pension earlier by ten months. footnoteAll euro amounts are CPI adjusted and expressed in 2010 euro. In other words, a 1 percent increase in the pension benefit level reduces the age of claiming pension by 0.55 month, and it increases the average retirement rate from age 50 to 65 by 0.3 percentage points. In addition, the impact on age of claiming pension is mostly driven by the impact on the hazard rate to claim a pension at age 60. Compared with estimates from other studies, the estimated labor supply responses in this paper are smaller than that of settings largely due to substitution effect, and are larger than that of settings due to pure wealth effect. The estimated labor supply responses in this paper are also smaller than that of studies on the impact of financial penalties to early claim accompanied by raising legal retirement age.

I also examine the impact of additional pension benefits on the age of exiting employment. I do not find convincing impact on the age of exiting employment. The estimation shows that the impact on the age of exiting employment has the similar magnitude as the impact on age of claiming pension but is insignificant, which implies small behavioral distortions. €100 additional monthly pension benefits increase hazard to exit employment at age 60 by 14%, significant at 5% level.

Because it is common for workers not to transition directly from full-time employment to retirement in Germany. I also assess the impact on workers' behaviors regarding using unemployment insurance (UI) and marginal employment as stepping stones to retirement. I find that more pension incomes reduce low-income female workers' time spent in marginal employment during the bridge years. More pension incomes also increase recipients' probability to use UI as a pathway to retirement and prolong their time spend in UI during the bridge years.

I provide various tests for the robustness of the RK design. These tests include graphical and regression-based tests of the identifying assumptions as well as placebo tests and kink-location tests. I also use the otherwise similar non-recipients as a control group to test the functional dependence between past pension contributions and the outcomes.

The findings of this paper have two main policy takeaways. First, the empirical results suggest that this subsidy program is relatively less distortionary. While additional pension benefits induce low-income female workers to claim old age pension earlier, it has little impact on the rate of employment. Therefore, this subsidy program has a small fiscal impact due to less distortion on taxable income and pension contributions. A back-of-the-envelope calculation suggests that in order to increase the mechanical transfer to lifetime pension income by 1 euro, the government has to raise an additional 0.3 euro. It implies that the ratio of behavioral cost to mechanical cost of this subsidy program is 0.3. This number is much smaller than that of other anti-poverty programs such as extending unemployment benefits and progressive taxation. Second, I show that the phasing out of this subsidy program can account for around one third of the increase in women's age of claiming pension over the past decade.

This paper complements and extends earlier work. First, it builds on past work on the effects of pension generosity on retirement decisions (Stock and Wise (1990), Krueger and Pischke (1992), Snyder and Evans (2006), Puhani and Tabbert (2016), Gelber et al. (2017a), Lalive et al. (2017)). It is undeniable that pension provision affects retirement decision making. Prior research has found pension subsidy schemes often reduce incentives to work, either in the form of a flat-rate minimum pension (Jiménez-Martín et al. (2007)) or as earning-tested income support programs for pensioners (Gruber and Wise (2004), Feldstein and Liebman (2002)). However, there are limited studies that credibly isolate the causal impact of additional pension benefits. In the U.S., most of the evidence is based on an unanticipated decline in social security wealth for the US "notch" cohort born in the period 1917-1922. Both Krueger and Pischke (1992) and Snyder and Evans (2006) look at this variation. While Krueger and Pischke (1992) did not find significant impacts on employment, Snyder and Evans (2006) found that the affected cohorts are 5% more likely to work at older ages. A more recent study of the US "notch" cohort by Gelber et al. (2017a) is most similar to this paper. They focused on women — same as this paper– and they found a substantial increase in employment rate of the affected cohorts, exploring the discontinuous drop in social security wealth at the cohort boundary.Section compares the estimation results of this paper with this paper and other related studies. In Germany, Puhani and Tabbert (2016) estimated the impact of a large pension cut on a special low-skilled population group — the repatriated ethnic German workers, using a regression discontinuity method. They found no significant response in retirement age to the benefit cuts. While my paper also examines exogenous changes in pension benefits, unlike those studies, it looks at the impacts of a benefit increase rather than a benefit cut.

Second, this paper complements other efforts to elicit evidence on the labor supply of a particular population group - low-income older women (Hanel and Riphahn (2012), Lalive and Staubli (2015), Finkelstein et al. (2016), Gelber et al. (2016)). This group is of particular interest because women are more exposed to old-age poverty than men. Women on average have lower pension incomes because women experience more career interruptions and part-time work than men due to their childcare duties. Moreover, compared to men, women's labor supply elasticities are larger and women on average live longer. Therefore, older women's labor supply responses to additional pension benefits are more likely to have a larger financial consequence. Lalive and Staubli (2015) showed that a 3.5% deduction in pension wealth due to raising full retirement age in Switzerland strongly affects older women's labor supply. The affected women delay claiming pension by 6.6 months in their paper. The magnitude of my result is slightly smaller than their finding.

Third, this paper provides a new application of the RKD. In particular, the change in the slope of the subsidy size in my paper is starker in comparison to other studies using RKD, such as applications exploring the maximum and minimum unemployment insurance benefits. The slope of the relationship between an assignment variable and the treatment variable in this paper changes from a positive slope to a negative slope at the kink point. The more acute angel of the subsidy schedule at the kink creates a larger treatment effect, which is a unique setting for the RKD applications. Because the identification in the regression kink design relies on estimating changes in the slope of the relationship between the assignment variable and some outcome variables, it often requires larger sample size to exhibit enough statistical power. This paper provides an alternative case when the slope change is starker and sample size is relatively small.

2 Institutional Details

Key Features of the Public Pension Scheme in Germany The German Statutory Pension System ("Gesetzliche Rentenversicherung", GRV) is an earnings-related points system financed on a pay-as-you-go basis. Participation is mandatory, except for civil servants and the self-employed. The pension system is manly financed with mandatory contribution payments, which are normally shared equally by employers and employees. In 2016, the total mandatory contribution rate is 18.90%. On average, the public pension replaces around 50% of pre-retirement wage, net of tax and contribution. In 2016, the average monthly pension benefit of the insured was €951 for men and €636 for women.

The statutory retirement age for a regular old-age pension remains at 65 throughout my sample period, with the only prerequisite being 5 years of contributions.[4] Several alternate pathways make retiring before 65 an option.[5] Notably, women born before 1951 are eligible to claim pension at early retirement age (ERA) 60 via the old-age pension for women. The eligibility requirement for this pathway is 15 years of contributions of which at least 10 years must have occurred after age 40. Almost all recipients of this subsidy program are eligible for this pathway. The ERA via the women pension pathway stays at 60 during the sample period.

Moreover, workers know the expected pension benefits they will get from the public system when they retire. It is because letters with detailed pension information were sent to workers every 3 years from age 55 before 2005. Since 2005, letters have been sent annually to workers who are 27 years old and have contributed to the public pension for at least 5 years. Dolls et al. (2018) have shown that those letters inform workers about their pension entitlements in a salient fashion. Therefore, it is reasonable that workers take into account the additional pension benefits obtained via the subsidy program when they make retirement decisions.

Pension Benefits In Germany, pension benefit level is closely tied to the lifetime wage income. The main determinant of pension benefit is the sum of individual accumulated earnings points (Entgeltpunkte, EP). They are also referred to as pension points. Essentially, for each year of contribution, a worker accumulates some earnings points $EP_{i\tau}$, which are decided by the worker's relative wage position compared to average wage of all the insured. For example, a worker whose wage is half of the average wage during the contribution year τ will accumulate 0.5 point in this year.

$$PB_{it} = [\underbrace{(\sum_{\tau} EP_{i\tau} + \text{ Subsidy}_i)}_{\text{Personal Pension Base}} \times PV_t] \times AF_{it} + Subsidy_{it} \text{ , where } EP_{i\tau} = \frac{w_{i\tau}}{\bar{w_{\tau}}} \tag{1}$$

The worker's personal pension base is the sum of the EPs accumulated over time plus additional

[4]A reform in 2007 enacted the gradual raise of the age for claiming regular old age pension from 65 to 67. Starting from 2012, it will reach age 67 in 2030.

[5]There are four main early retirement pathways. They are old-age pensions for long-term insured, old-age pensions for women, old-age pensions due to unemployment (and, later, part-time work) and old-age pensions for severely disabled persons (Börsch-Supan and Wilke (2004)).

EPs credited by the subsidy program. For example, an average wage earner with 15 contribution years accumulates 15 EPs. This personal pension base is scaled up by the pension value PV_t at the time of claim, which is determined aggregately by factors such as average wage of all insured, the contribution rate and demographic changes. This pension value is adjusted on July 1 of each year. For example, one EP is equivalent to €31.03 per month in 2018 (Rentenversicherung (2018)).

The personal pension base times pension value gives the total amount of pension benefit. This benefit level is then adjusted by an access factor AF_{it}. The access factor penalizes early pension claim. Workers who claim pension at ERA face a 0.3% pension reduction per each month they retired in advance of the full retirement age. For female workers claiming old-age pension for women in our sample, only cohorts born after 1940 are affected by the access factor. [6] In sum, pension benefits increase with contribution year and relative wage income. On average, one additional year of full value contribution increases the gross replacement rate by around 1.17%. Therefore, workers with low wages or a short working history will have a low level of pension benefit.

Pension Subsidies to Low Pay Workers The pension subsidy to low pay workers (Mindestentgeltpunkte bei geringem Arbeitsentgelt) essentially provides a built-in subsidy that offers additional EPs to workers with low lifetime contribution (SGB VI § 262). It was introduced by the 1992 Pension Reform Act in Germany. Along with other policies aiming at prolonging working life and raising the statutory retirement age, the primary policy consideration of this subsidy program is to ensure adequate old-age income for low wage workers. According to the statistics from the Research Data Center of the German Pension Insurance, in December 2015, 14% of old age pensioners — 4% of all male pensioners and 26% of all female pensioners — are recipients of this subsidy program. The total payments for this subsidy program were approximately €3 billions in 2015.

The target group of the subsidy program constitutes workers with a relatively long work history and relative low wage incomes. To be more specific, there are two eligibility criteria. First, a worker should have at least 35 creditable years, which include contribution periods and parental years given to mothers with children.[7] The time of raising a child up to age 10 counts into the

[6] Pension benefit also depends on the type of pension. This factor equals to 1 for old-age pension, and is less than 1 for disability pensions. In my sample, almost all workers claim old age pension.

[7] The creditable years consist of active contribution periods, credited periods and consideration periods. Active

creditable years. The package is 10 years for one child, 15 years for two children and 20 years for more than two children. Therefore, the 35 years with pension rights is a relatively lenient criterion for mothers. Second, the average monthly EP of full-value contribution years before January 1992 and average monthly EP of full-value contribution years[8] at retirement must both be less than 0.0625 — equivalent to 0.75 EPs annually.[9] This criterion guarantees that only workers with a wage position of less than 3/4 of an average earner are eligible. Once those two conditions are satisfied, a worker will be entitled to this subsidy.

The subsidy size is exogenous and predetermined. It depends on the total EP accumulated before 1992 and the average EP of full-value contribution periods before 1992. In the data, the average subsidy amounts to 3.19 EPs with a standard deviation of 1.77. It results to an increase of benefits by 90 euros per month, which is equivalent to 17% increase in pension income. The exact subsidy formula is

$$Subsidy = min\left(0.5 \times \sum_{t<92} EP_t \ , 0.75T_{pre92} - \sum_{t<92} EP_t\right) \tag{2}$$

, where T_{pre92} is the years of full-value contribution before 1992. The subsidy equals to either 50% of total EP accumulated before 1992 or the difference between $0.75T_{pre92}$ and total EP before 1992, depending on which one is smaller. Essentially, the subsidy increases $\sum_{t<92} EP_t$ by 50%, but after the subsidy, the average annual EP before 1992 (denoted as aep_{92} from here onward) cannot exceed 0.75. It creates a kinked schedule of subsidy in relationship to aep_{92}. Figure 1 illustrates the policy schedule according to Equation 2. This kinked schedule enables me to causally identify the impact of this subsidy program. We can see from the figure, the slope of the subsidy changes

contribution periods (Beitragszeiten) are usually corresponding to regular employment or self-employment when a fixed percentage of wage is contributed to the pension system. Credited periods (Beitragsfreie Zeiten) includes periods such as maternity leave and vocational training periods. During those periods, EPs are accumulated even though no contributions were made. During the consideration periods (Berücksichtigungszeiten), workers accumulate no additional EPs.

[8]The contribution periods consist of full value contribution periods (Vollwertigen Beiträgen) and reduced contribution periods (Beitragsgeminderte). Full value contribution periods are periods when compulsory contributions are paid in according to the social security regulation. Reduced contribution periods including periods due to unemployment, sickness and vocational training.

[9]The de jure eligibility condition only requires the average monthly EP of full-value contribution years at retirement (aep_{retire}) to be less than 0.0625. Yet, because the average monthly EP of full-value contribution periods before 1992 (aep_{92}) cannot exceed 0.0625 after the subsidy. This implies that the the de facto eligibility condition require both aep_{retire} and aep_{92} to be less than 0.0625.

discontinuously at the kink point; this is where I base on the identification. [10]

Equation 3 shows that average subsidy per years before 1992 has a slope of 0.5 before the kinked point 0.5 and a slope of -1 after the kink point. Figure A1a shows the policy schedule according to Equation 3.

$$\frac{Subsidy}{T_{92}} = \begin{cases} 0.5aep_{92} & , aep_{92} \leq 0.5 \\ 0.75 - aep_{92} & , 0.5 \leq aep_{92} \leq 0.75 \\ 0 & , aep_{92} > 0.75 \end{cases} \tag{3}$$

To illustrate graphically, Figure 2 plots actual total subsidies measured in 2010 euro against $ape92$ for the main sample. Figure A1b plots the average subsidy per years before 1992 against $ape92$. The actual subsidy exhibits the kinked relationship predicted by the formula. The maximum of average subsidy per year before 1992 in the data is 0.25 EP as the policy suggests. However, there are two deviations from the policy schedule. First, compared to the policy, the slope of average subsidy per year before 1992 is flatter at the left of the kink. Second, the observed kink is at 0.45 rather than 0.5. Those deviations are measurement errors coming from constructing $ape92$ in the data. This is because the majority of the sample are female workers who have had childcare periods, which involve complex accounting. When I look at sub-sample of workers who were employed during their entire working history, I could obtain an actual kink very close to 0.5. For more details see Appendix 2.1.

It is worth noting that this subsidy program will phase out eventually for workers who started contributing after 1992.[11] Low wage workers, who started contribute to the public pension system after 1992, will not receive any subsidies from this program. In Section 7, I extrapolate the age of claiming pension in a world where the subsidy level stays in 1996, using the estimated impact of additional pension benefits. As the gender pension gap widens, policymakers in Germany have started to consider a new subsidy program for younger cohorts. Therefore, understanding the impact of this program also has immediate significance.

[10]See Appendix 1.1 for examples illustrating the calculation of pension benefit and subsidy amount. The German Pension Office provides detailed examples on the website.

[11]The 1992 reform introduced parental pension credits for mothers who gave birth after 1992 during the first 3 years of childcare. At the time of the reform, the parental pension credits policy is considered as a compensation for the fact that this subsidy for low pay workers will phase out eventually. See Thiemann (2015) for more details on the parental pension credits.

Bridge to Retirement: Unemployment Insurance and Marginal Employment It is plausible that older workers do not transition directly from full-time employment to retirement. They may use unemployment insurance, marginal employment, and other social support programs as stepping stones into retirement (Inderbitzin et al. (2016), Manoli (2016), Engels et al. (2017)).

The German unemployment insurance (UI) system provides about 60% income replacement to eligible workers who lose their job.[12] The maximum benefit duration for older workers ranges from 18 months to 32 months during our sample period, depending on age and previous working history.[13] Time spend on UI also increases future pension benefits. Workers who exhaust UI benefits are eligible for unemployment assistance (UA) benefits with an effective average replacement rate of around 30%. Eligible workers can stay in UA until they reach the full retirement age 65.[14] Time spent on UA does not increase pension benefits. The generosity of the unemployment insurance benefits and the lenient job search requirement for older workers make UI an attractive pathway to bridge to retirement.

Another alternative activity is marginal employment. The most popular type of marginal employment in Germany is the mini job, which is commonly called a "400 euro" job. Those jobs pay the maximum €400 per month and they are exempt from both social security contributions and income taxation.[15] The marginal employment is especially relevant for my sample, because majority of exclusive mini jobbers are women and older workers (Gudgeon and Trenkle (2017)). Moreover, unemployed workers whose UA benefits are lower than €400/month have incentives to engage in marginal employment before old age pension becomes available. Additionally, pension recipients can keep working at mini jobs while claiming pension without subject to any earnings test. [16]

[12]The replacement rates for UI were relatively stable over the sample periods. They were 67-68% for individuals with children and 63-60% for individuals without children.

[13]See Börsch-Supan and Wilke (2004) and Gudgeon et al. (2017) for more details about the UI system.

[14]From 2005 on, UA was replaced by unemployment insurance benefits 2 (UIB 2), a completely means-tested program. Both UA and UIB 2 provide unlimited benefit duration.

[15]This threshold was €325 before 2003 and €450 after 2013. During most of our sample period, it stayed at €400 per month.

[16]If pensioners work at jobs pay more than 400 euros per month, they face very strict earnings test between ERA and NRA. After the normal retirement age, pension recipients do not face earnings test anymore.The benefits that are "taxed" away due to the earnings test are not lost, but postponed at an actuarially fair rate.

3 Data and Sample Selection

The data used is from the anonymized Scientific Use File (SUF) of the Insurance Account Sample (Versicherungskontenstichprobe, VSKT) of the German Federal Pension Register. The main dataset is assembled from 11 years of cross-sectional SUFVSKT (2002, 2004 to 2014). The SUFVSKT contains 5% of all individuals with an active public pension insurance account, who were between the ages of 30 and 67 at time of data collection. Each cross-sectional SUFVSKT contains around 50 to 60 thousand individuals, among which around 7 to 8 thousand are subsidy recipients. It includes time-invariant information of the insured person at the time of data collection, such as accumulative pension points, gender, birth month, number of children and age of claiming pension, etc. Two important advantages of the data are worth noting. First, SUFVSKT data contains accurate information on the level of subsidies. The accurate measurement of the treatment is crucial to implement the regression kink design. Second, SUFVSKT data provides all relevant information to calculate the assignment variable — average earnings points from full value contribution before 1992 and at retirement. It contains monthly biographical information of each insured person from age 14 up to the sample year, such as social employment status that are relevant for pension benefit calculation and pension points accumulated in each month. However, unfortunately education and occupation are not accurately measured. Additionally, it is not possible to observe marital status and link spouses in the data.

Sample Construction The main sample is restricted to female subsidy recipients who are at least 63 years old at the sample year, who have at least 35 service years and have never worked in East Germany.[17] I only look at females in the analysis for two main reasons. First, majority of the subsidy recipients are female workers. More than 80% of the recipients are women around the kink. Second, there are not enough male recipients around the kink. This is not only because men only consist a small fraction of the subsidy recipients, but also because average earning point of 0.5 is the below tail of male workers' income distribution. I exclude individuals who worked in East Germany because they face a different set of pension rules, which is not comparable to that of West Germans. Moreover, two-thirds of the recipients have never worked in East Germany. I exclude people who are civil servants and self-employed, because they face different pension systems. I

[17]See Appendix for more details on the sample construction

further restrict the sample to workers who are older than cohort 1952 and have at least 15 years of contribution. It is to ensure that all individuals in the sample are eligible to retire at age 60 via old age pension for woman.[18] I restrict the sample to workers who are at least 63 years old at the sample year to make sure that workers are old enough to claim pension. In the original data set, most women claim old age pension by age 63, therefore I can observe age of claiming pension for most female recipients in the sample.[19] The final sample contains 6,021 individuals, covering cohorts from 1935 to 1951. It amounts to 3.7 million person-month observations.

Summary Statistics In 2015, around 25.5% of all female pensioners was subsidy recipients. More than 80% of subsidy recipients are female. Two-thirds of the recipients have never worked in East Germany. The recipients' distribution of post-subsidy pension benefits is centered around €750. The majority of the recipients' pension benefits are in between €500 and €1000. Table 1 reports descriptive statistics of some key variables for the baseline sample of female workers and female recipients around the kink. The baseline specification focuses on the window of recipients whose aep_{92} are from 0.25 to 0.65, 0.2 EPs around the kink 0.45. There are 5,218 individuals in this window. The average size of the subsidy is 3.19 EP with a standard deviation of 1.77, which is equivalent to 90 euros per month and around 17% of the monthly pension benefits.[20] The recipients in the baseline sample on average have 24 EPs and 42 years of the creditable period, within which 17 EPs and 32 years are from full-value contribution. They on average worked 19 years before 1992. The recipients around the kink are the ones whose aep_{92} are from 0.4 to 0.5. Their average subsidy size is around 3.76 EPs with a standard deviation of 1.9, which is slightly higher than the sample average.

4 Lifetime Labor Supply Model

In this section, I describe a simple life budget constraint model in the spirit of Brown (2013) to illustrate the main incentives of the subsidy program. For simplicity, bequests and savings are not

[18] Old age pension for women is one of the early retirement pathways in Germany. For cohorts older than 1952, women can retire as early as age 60 by claiming old age pension for women if they have at least 15 years of contribution. Women who were born in 1952 and later can no longer retire at 60.

[19] I test for robustness to sample construction in section 7. I vary the sample selection by looking female recipients who are at least 60, 61, 62 and 64 years old at the sample year.

[20] All monetary values are CPI adjusted and expressed in 2010 euro.

modeled, and retirement is an absorbing state. I assume workers start work from period 0. Let C be total consumption, Y be lifetime income, T be the last period of life, T^E be the year of exit from regular employment, T^R be the year of claiming pension. I assume no discounting and that T is known with certainty. Retirement is an absorbing state. I assume an individual earns a constant (after tax and pension contribution) annual wage w and receives annual pension benefits pb at retirement. If an individual leaves labor force before the earliest pension claiming age, I assume she receives an annual income of v. v can be interpreted as wage income from marginal employment or unemployment insurance benefits.

The lifetime budget constraint with pension subsidies is $C = Y = w \times T^E + v \times (T^R - T^E) + pb \times (T - T^R)$, where pb is the pension benefit per year and $pb = w/\bar{w} \times T^E \times PV + b$. b is the additional pension benefits provided by the subsidy program. I denote the pension replacement rate per year of contribution as p, where $p = PV/\bar{w}$. Therefore, $pb = p \times w \times T^E + b$. The financial penalties due to early claiming is not modeled.

An individual's utility in each period is assumed to be additively additively separable in consumption and leisure as in Brown (2013). $u_t(c_t, l) = v(c_t) - \phi_t l$, where ϕ_t is the disutility from working in period t and l takes the value one if the individual works in period $v(.)$ is increasing and concave in consumption. The individual will maximize utility by perfectly smoothing consumption over the lifecycle. Therefore, the lifetime utility function is $U(C) = T \times v(C/T) - \sum_{t=0}^{T^E} \phi_t$. The optimal age of exiting employment T^{E^*} is characterized by $v/\phi_t = dC/dT^E$.

For simplicity, I make two assumptions: 1) If one leaves job before early retirement age 60 ($T^E < 60$), then $T^R = 60$. Worker claims pension immediately as pension become available at early retirement age. In the sample, among the individuals whose leave employment before 60, half retire at 60. 2) If one leaves a job after early retirement age 60, then the worker claims pension immediately ($T^E = T^R$). In the sample, among the individuals who exit employment after age 60, 70% claim immediately. Then lifetime budget constraint is the following:

$$Y = \begin{cases} w \times T^E + v(60 - T^E) + (p \times w \times T^E + b)(T - 60) & T^E < 60 \\ w \times T^E + (p \times w \times T^E + b)(T - T^E) & T^E \geq 60 \end{cases}$$

$$\frac{dY}{dT^E} = \begin{cases} w - v + p \times w(T - 60) & T^E < 60 \\ w + p \times w(T - T^E) - (p \times w \times T^E + b) & T^E \geq 60 \end{cases}$$

The slope of the budget constrain dY/dT^E is the total financial return to work. For ages of exiting T^E before the pension eligibility age 60, the gain of one additional year of work has three components — one year of wage income w, one year of forgone "bridge wage" v and an increase of total pension income due to one more year of contribution $p \times w(T - 60)$. The return to work is independent of pension subsidy b if age of exiting is younger than 60. For ages of exiting T^E older than 60, the gain of one additional year of work comes from annual wage income w, an increase in total pension income $p \times w(T - T^E)$ and one year of foregone pension benefits $p \times w \times T^E + b$. The change in the return to work due to pension subsidy b is -1 if an individual exits employment after age 60 and claims pension immediately.

The effect of the subsidies is a combination of wealth effect and substitution effect. Additional pension benefits not only shift the budget set upwards but also change the slope of the budget set. Figure 3 illustrates the stylized lifetime budget constraint for a workers with and without subsidy. The solid black line in Figure 3 is the budget without subsidy, and the blue dashed line is the budget with subsidies. These two lines are parallel before the age 60. This implies that if a worker leaves employment before 60 in absence of the subsidies, additional lifetime income will make this worker to leave employment earlier due to pure wealth effect. This is because the return to work additional year is independent of pension subsidy b if age of exiting is younger than 60. After age 60, the subsidies change both the level and slope of the budget set. Compared to the non-recipients, recipients forgone one year of pension subsidies b by the excess. Pension subsidies increase the cost of delaying pension claim and make working less attractive. Notice that these two budget lines intersect at the age of death. In other words, if a worker passes away without claiming any pension benefits, then additional pension benefits have no impact on lifetime consumption.

Both wealth and substitution effects work in the same direction. No matter where the individual was located on the budget line in absence of the subsidy program, additional pension benefits induce her to exit earlier. The average impact on labor supply depends on the distribution of people's age of exiting employment in absence of subsidies. The ones exit employment before 60 and claim pension immediately in absence of the subsidies are affected only via wealth effects. However, I can not observe the counterfactual distribution of the recipients. Yet, because ages of claiming pension T^R can only be older than 60, I expect the average impact of subsidy on age of claiming pension is relatively larger than the impact on age of exiting employment T^E. Moreover, because the subsidy makes the kink at 60 in the lifetime budget constraint at relatively larger, I also expect to observe more subsidy recipients to bunch at age 60.

5 Empirical Methodology

5.1 Regression Kink Design

The kinked schedule of this subsidy policy allows me to identify the causal effect of pension subsidies on retirement timing. Following Landais (2015), Card et al. (2015b) and Card et al. (2017), I use a Regression Kink Design to estimate the local average treatment effect of the pension subsidies. I examine the induced change in the slope of the relationship between the outcome of interest (Y) and the assignment variable (r) at the exact location of the kink in the policy formula. The average treatment effect of subsidy B on Y at the kink ($r = 0$) is expressed as

$$\mathbb{E}(\frac{dY}{dB}|r = 0) = \frac{\lim_{r_0 \to 0^+} \frac{d\mathbb{E}(Y|r)}{dr}|_{r=r_0} - \lim_{r_0 \to 0^-} \frac{d\mathbb{E}(Y|r)}{dr}|_{r=r_0}}{\lim_{r_0 \to 0^+} \frac{d\mathbb{E}(B|r)}{dr}|_{r=r_0} - \lim_{r_0 \to 0^-} \frac{d\mathbb{E}(B|r)}{dr}|_{r=r_0}}$$

The average treatment affect is obtained by dividing the estimated slope change in the outcome variables is by the estimated slope change in the pension subsidy with respect to aep_{92}. Because the observed relationship between pension subsidy B and r varies from the policy rule, I adopt a fuzzy RKD approach. I obtain the estimates of the numerator and denominator by running parametric polynomial regressions of the following forms:

$$Y_i|(r = 0) = \alpha_y + [\sum_{p=1}^{p=\bar{p}} \rho_p r_i^p + \beta_p r_i^p \times \mathbb{1}(r_i \geq 0)] + \theta_y X_i + \epsilon_i \text{ , where } |r_i| \leq h \tag{4}$$

$$B_i|(r = 0) = \alpha_b + [\sum_{p=1}^{p=\bar{p}} \tau_p r_i^p + \gamma_p r_i^p \times \mathbb{1}(r_i \geq 0)] + \theta_b X_i + \epsilon_i \text{ , where } |r_i| \leq h \tag{5}$$

where r is the assignment variable. It is aep_{92} centered around kink 0.45. $\mathbb{1}(r_i \geq 0)$ is an indicator for aep_{92} being above the kink, p is polynomial order, h is the bandwidth size.Y are the outcome variables — age claiming a pension, age of exiting employment, the hazard rate to claim a pension at 60, etc. B is the pension subsidy level. The estimated change in the slope of Y around the kink $\frac{dY}{dr}|r = 0$ is β_p, the estimated change in slope of B around the kink $\frac{dB}{dr}|r = 0$ is γ_p. In the baseline analysis, I show results in a linear case with a bandwidth of 0.2EP. h is set to be between 0.25 and 0.65. This window contains female recipients whose average monthly wage income before 1992 are around €500 above and below the kink point.

5.2 RKD Assumptions

There are two main assumptions to obtain a valid regression kink design. First, the density of the recipients evolve smoothly around the kink. Intuitively, this assumption rules out the possibility that the induced changes in Y are not due to changes in B, but rather due to sample selection or changes in other predetermined covariates. This can be tested by checking the probability density function of the assignment variable at the kink. Figure 4 plots the density of the recipients around the kink. It shows the number of individuals observed in each bin of average EP from full-value contribution before 1992. The bin size is 0.01525 aep_{92}, which is equivalent to €40 in monthly wage income. The graph shows a small dip in density of the recipients to the left of 0.45. The density shows a quadratic relationship with aep_{92} with the mode of the p.d.f. being around the kink point. To formally test for discontinuity, I performed McCrary tests as done in Landais (2015).[21] The results of McCrary test of the discontinuity of the p.d.f and the discontinuity of slope of the p.d.f are reported in Figure 4. The McCrary tests suggest that the discontinuities in density is statistically insignificant. The change in slope of the p.d.f. is statistically significant for a linear specification and statistically insignificant for a quadratic specification.

The above results could be problematic, however the natural of this subsidy program makes it less of a concern. The smoothness assumption is to make sure that there is no manipulation of the assignment variable at the kink. Workers to the left and the right of the kink are comparable. Because this subsidy program was announced in 1992 and the assignment variable is average EP from full-value contribution before 1992, it virtually impossible to manipulate the system. It is very unlikely that individuals sort themselves to one side of the kink. Moreover, because the benefit

[21]Following Landais (2015), I regress the number of observations N_i in each bin on polynomials of aep_{92} in each bin and the interaction term of being above the kink. The coefficient in front of the aep_{92} interacted with a dummy variable for being above the kink is the estimate of the change in slope of the p.d.f.

level only changes slightly across the kink, there are no strong incentives to manipulate as well. Furthermore, Figure A2 has shown that the shape of the density is not unique for female subsidy recipients but rather a pattern that is common for all female workers in the pension system. The red squares in Figure A2 show the distribution of female workers in West Germany. The distribution is bell-shaped and centers at the kink, which has the shape as the p.d.f. of the female subsidy recipients in West Germany. The blue triangles show the distribution of male workers in West Germany, which is also bell-shaped, but centers at 0.6 EP to the left of the kink.

The second assumption is that the conditional expectation of any covariates evolve smoothly with the assignment variable at the kink. This assumption further rules out the chance that the induced kink in outcomes is caused by kink in recipients' characteristics. Figure 5 visually shows the mean values of covariates in each bin of aep_{92} and the slopes at two sides of the kink. I look at individual characteristics, such as number of children, age of first birth and age of first employment. Social economics status (SES) is also investigated. Months spend in unemployment insurance, unemployment assistant, childcare and sick leave before 1992 and before age 50 are tested for nonlinearity at the kink. Table 2 presents the regression results in the form of Equation 4. The estimated changes in slope of the predetermined covariates are estimated. The p-values for testing the null hypothesis that the coefficient is equal to zero are also reported. The p values of all covariates are larger than 0.05. This suggests that the covariates evolve smoothly at the kink. The second assumption is satisfied.

6 Results

In this section, I present the estimation results of the impact of pension subsidies on age of claiming pension, age of exiting employment and labor supply activities during the bridge years. I also show several robustness tests of the RK estimates and present heterogeneous responses for subgroups.

6.1 Graphical Evidence

Figure 6 shows the relationships between aep_{92} and subsidy size, age claiming pension and hazard rate to claim a pension at age 60 around the kink. The bin sizes are the same as Figure 4. The estimated changes in slopes of the outcome variables without any controls are displayed in Figure

6. There is a clear kinked relationship between aep_{92} and age of claiming pension. The slope becomes flattered at the left of the kink. Visually, we can see that additional pension benefits induce workers to claim pension earlier. If I assume that age of claiming pension decreases linearly as aep_{92} increases, then the age of claiming pension would be 62 years old in absence of the subsidy program — that is the mean age of claiming pension for workers within 0.2 EPs distance to the kink. The the age of claiming pension is 61.5 on average at the kink. The extra pension income makes worker retire earlier. Figure 6 b shows a sharp visible change in the slope of the relationship between aep_{92} and hazard to claim pension at age 60.

Figure 7 investigates the relationships between aep_{92} and age of exiting employment and hazard rate to exit employment at age 60. I define age of exiting employment as the age of the last job, including both regular jobs that contribute to the pension system and marginal employment that have no social security contribution obligations. The figure suggests that the change in slope of age of exiting employment have similar size as the change in slope of age of claiming pension, however the pattern is much noisier. The change in slope of hazard to exit employment at 60 is more visible. It is consistent with the predictions made in the conceptual framework. If a large proportion of recipients would leave employment before age 60 in absence of the subsidy program, then we expect to see a small impact of subsidies on the age of exiting employment. It is because the slope of the life-time budget constraints only changes after age 60. For the workers whose age of exiting employment were located before 60 in absence of the subsidy program, the incentive to leave early comes from pure wealth effect. Therefore, I expect to see a smaller and nosier change in slope of age of exiting employment.

6.2 Effect of Subsidies on Claiming Behavior

In Table 3, I present fuzzy RK estimates of the responses concerning the location of aep_{92} along with the first-stage estimates. The results are from local linear regressions with a bandwidth of 0.2 EP around the kink for the baseline specification of Equation 4 and Equation 5. In each column, I report the estimated change in slope of Y around the kink and the estimated change in slope of benefit level B around the kink. Here, subsidies are rescaled to 2010 euros, and the unit is €100 per month. The local average treatment effects are reported in row 3 as $\frac{dY}{dB}$. The standard errors are obtained using delta method.[22] Each estimate shows the effect of an extra 100 in monthly pension benefits on the outcome variables. Columns 1 to 3 measure the impacts on age of claiming pension. Columns 4 to 6 measure the impacts on the hazard rate to claim pension at age 60. Columns 1 and 4 show results of linear regressions without any controls. Columns 2 and 5 show results of linear regressions with controls, such as the number of children, the age of first employment, age of first birth, pension credible years, social economics status (unemployment insurance, sick leave, childcare periods) before 1992, etc. Columns 3 and 6 further add cohort fixed effects to the regression. The cohort fixed effects take into account incentive changes caused by raising the statuary retirement age, which was implemented gradually by cohorts. The average values of subsidy size, age of claiming pension and hazard to claim at age 60 are also reported in Table 3. Female recipients at the kink on average receive €108/month of subsidy, and they on average claim pension at age 61; the average hazard rate to claim pension at 60 is 42%. The estimation results are very similar across specifications. I find that an extra €100 in monthly pension benefits makes the female recipients claim pension earlier by 0.8556 years, which is around 10 months. An extra €100 of pension benefit per month makes recipients 17% more likely to claim pension at age 60. In Table 8, I also look at the impact on the retirement rate of female recipient aged from 55 to 65. An extra €100 monthly pension benefits increases the average retirement rate by about 5.9 percentage points.

To better understand how the subsidies affect workers' labor market decisions at older ages, I further look at the hazard rate of claiming pension at different ages. Figure 8a plots estimated change of hazard to claim pension from age 50 to age 65, when there is a €100 increase of pension subsidy per month. Figure 9a plots the survivor curve in blue dots when there is a €100 increase of pension subsidy per month. I observe that most of the actions happen at statutory retirement ages - age 60, 63 and 65. It is reasonable given the institutional setting of the German pension system.[23] Subsidies increase the hazard of claiming old age pension at age 60 and 63 significantly and decrease the hazard of claiming pension at age 65 but the impact is not statistically different from zero.

Due to the limitations of the data set, I cannot take the family structure, spouse income, and

[22]I have also calculated standard errors using bootstrap method. The results are similar.
[23]The liquidity effects of public pension cause this kind of behavior.

other income sources into consideration. Husbands and wives often determine their labor supplies jointly. Wives who have access to husbands' income and other income sources are less responsive to the availability of subsidy, and vice versa. If I assume that the household income is in a range of 1 to 3 times of the female recipient's income, then I obtain an estimate of the elasticity of retirement age with respect to income in a range of -0.025 to -0.008. That is, a 1% increase of pension income decreases age of claiming pension by 0.08% to 0.25%. And the elasticity of hazard rate to claim pension at age 60 with respect to pension income is in a range of 0.075 to 0.025. That is, 1% increase of pension income increases the hazard to claim pension at 60 by 0.025% to 0.075%.

6.3 Effect of Subsidies on Labor Supply

Impacts on Age of Exiting Employment Individuals with additional pension income also adjust their labor supply decisions. In Table 4, I present the regression results for the impacts on age of exiting employment. The regression specifications are the same as Table 3. Consistent with the graphical evidence in Figure 7, the estimated impacts on age of exiting employment are statistically insignificant. The magnitude of RKD estimate of the impact on age of exiting employment is close to the impacts on pension claim age but much nosier. In Table 8, I also look at the impact on the employment rate of female recipient aged from 55 to 65. An extra €100 monthly pension benefits reduces the average employment rate by about 4.7 percentage points, but insignificant.

In responses to additional pension benefits, hazard to exit employment at 60 increased by 14% with a significance level of 0.05. Figure 8b plots the change of hazard to exit employment when there is a 100 euro more pension subsidy per month. It has a similar pattern as the impact on hazard to claim pension. Apart from the responses of hazard to exit at age 60, the hazard to exit at age 57 declines slightly when there is a higher pension. The impact is two percentage points at 10% significance level. In the meanwhile, the hazard to exit at age 56, 58 and 59 increase. It is hard to interpret those pattern. Nevertheless, the responses at ages before 60 suggest that additional pension benefits also change workersâĂŹ activities during the bridge years. Figure 9b plots the estimated survival rate when monthly pension benefits increase by 100 euros. We can see the similar pattern as in Figure 8b. Workers start to change their labor supply before age 60.

Bridge to Retirement In Germany, it is common that older workers do not transition directly from employment to retirement. On average, 43% of the female recipients enter to pension claiming via regular employment; 5% of them enter via marginal employment; 30% of them enter via unemployment. In this section, I investigate the impact of additional pension benefits on worker's activities during the bridge years.

First, I investigate the impact on age of last regular jobs. Regular jobs are the jobs with mandatory social security contribution obligations. Table A2 shows that the estimated impact on age of last regular jobs is noisy, and with a magnitude close to zero. Because workers claim pension earlier but do not exit regular job earlier, it would be interesting to look at how workers alter their behaviors during those bridge years. On average, the gap between the age of last regular employment and age of claiming pension is around eight years: 16 months in UI, 9 months in UA, 5 months in marginal jobs and 3 months in sickness leave and the rest are relied on supplementary pension.

Figure 10 plots the means of months spent in marginal employment and unemployment insurance in relationship to the assignment variable aep_{92}. Table 5 shows the regression results. The estimates suggest that €100 additional monthly pension benefits induce workers reduce time spend in marginal jobs during the bridge years by about 4 months. It is reasonable that the impact is relatively large, because the gain of delaying pension claim is relatively smaller for workers engaged in marginal jobs. The forgone wage from marginal jobs is lower and the additional time spent in the marginal jobs will not increase future pension entitlements.

Column 2 of Table 5 shows that €100 additional monthly pension benefits induce workers to increase their time spent on UI by 4 months. However, the estimated impact is statistically insignificant. Moreover, I also test the impact of €100 extra monthly pension benefits on the probability of being in different activities at time t, conditional on claiming pension benefits at time t+1. Table 7 suggests that workers are 9 percentage points more likely to use UI as a pathway to early retirement when pension benefits are higher. Additional benefits make workers more likely to use UI as a pathway to retirement while they stay in UI longer. Combining the above two findings, I infer that the overall effect makes workers exit employment earlier to bridge via UI.

In order to understand how additional pension benefits affect workerâĂŹs retirement trajectory, I examine the conditional probability to transition from regular employment, unemployment and marginal employment to other activities between age 50 and age 59. Table 6 displays estimation results. Conditional on participation in regular employment at time t-1, €100 extra monthly pension benefits increase the probability to transition from regular job to being on UI by 0.84%. The impacts on the probability to stay employed, transition to marginal employment or to other residual activities between age 50 to 59 are negative, yet not statistically significant. This suggests that more future pension increase the chance of a worker leaving regular job and enter unemployment insurance. Panel 2 of Table 6 shows the estimated impacts on being in different activities at time t, conditional on participation in unemployment insurance at time t-1. It shows that €100 extra monthly pension benefits increase the probability to transition from unemployment to other residual activities by 0.25%. The probability to remain unemployed declines by 1.58% but not significant. The transition to other status are also not significant. Panel 3 of Table 6 shows the estimated impacts on being in different activities at time t, conditional on participation in marginal employment at time t-1. None of the impacts are statistical significant.

6.4 Placebo Kinks and Placebo Forcing Variable

I provide various placebo tests of the RK estimates. For the sake of brevity, most of the details of these tests are given in Appendix A. As Card et al. (2015b) and Landais (2015) point out, one main concern with the RKD identification assumptions is the functional dependence between the assignment variable and the outcome variable. To ensure that the estimated impact on age of claiming pension is not caused by the quadratic functional form but by the kinked schedule in subsidy, I run some placebo tests. First, I test for existence and location of the kink. Figure A3a shows the R-square and adjusted R-square of the baseline model when the kink is placed at "placebo" locations around the kink. Following Landais (2015), I run regressions of Equation 4 for a series of virtual kink points and look for the kink that maximizes the R-square. In Figure A3a, we can see that both R-square and adjusted R-square increase sharply as one moves closer to the actual kink point and then decrease when moves away from the kink point. I also perform a permutation test in the spirit of Ganong and Jäger (Forthcoming). Figure A3b shows that the estimate with the kink placed at the actual kink point is statistically significantly larger in magnitude than the distribution of estimates with placebo kinks.

Moreover, I use average EP after last employment as a placebo forcing variable instead of aep_{92}. The average EP after last employment is a good proxy for lifetime earnings but not directly correlated with aep_{92}. Figure A4 shows scatter plots using mean EP 5 years after last regular employment, with 4 years, 3 years, 2 years and 1 year after last regular employment as the placebo forcing variables. Figure A4 suggests that the subsidy amount and outcome variables have no obvious kinked relationship with the placebo forcing variables. Table A5 presents the RKD results when those placebo forcing variables are used. It shows that all of the $\frac{dY}{dB}$ estimates are insignificant across all placebo specifications.

Lastly, I look at female workers in West Germany whose creditable period is less than 35 years as the counter-factual sample. Those female workers are not eligible for the subsidy but hey have similar earnings history as the female recipients. Their annual average EP from full contribution at retirement and before 1992 are both less than 0.75. Figure 12 shows scatter plots for age of claiming pension and hazard to claim pension at age 60 using this counter-factual sample. This figure is strongly supportive of the validity of the RKD. It shows that there is no visible change in slope of age of claiming pension at the kink point for the counterfactual women. Regression results confirm the graphical pattern. It is also worth noting that the p.d.f. of the mean of age of claiming pension is very flat in relationship to aep_{92}. This further indicates that the estimated impact on age of claiming pension is not caused by the quadratic functional form but instead of by the true effect of the subsidies.

6.5 Robustness and Heterogeneity

Estimates by Polynomial Order and Bandwidth Several exercises further establish the robustness of the estimates. Table A4 reports the results of the estimation of Equation 4 for a linear, a quadratic, and a cubic specification. For all three specifications, bandwidth is 0.2 around the kink, same as all baseline analyses. Aikake Information Criterion (AIC) and Bayesian information criterion (BIC) and AICc (AIC with a correction for small sample sizes) with a correction are reported as well. The estimates are quite sensitive to polynomial orders; however, the difference among AIC, BIC and AICc are small across specifications. According to those criteria, the linear specification fits slightly better than the other two specifications. One explanation for the sensitivity to polynomial order could be that high-order polynomial regression takes on extreme values to the weights. Gelman and Imbens (2017) suggests that high-order polynomial regression is a poor choice in regression discontinuity analyses. For causal inference, they recommend local linear or quadratic polynomials for RD design. In the case of regression kink design, Card et al. (2017) have shown that the quadratic estimator is typically larger than the mean squared bias for the linear estimator with the same bandwidth selection and bias correction. In this paper, the mean squared bias, obtained by Monte Carlo simulations based on data generating process that closely resemble the sample, also suggests that linear specifications dominate quadratic models.

Figure 11 shows the point estimates and 95 percent confidence intervals for the effect of a €100 increase in monthly pension benefits on age of claiming a pension and hazard rate to claim pension at age 60. All the estimations use the linear specification with controls and cohort fixed effect. The blue dotted line shows the number of observations. The four red vertical dash-dot lines correspond to four different bandwidth selections: the Imbens and Kalyanaraman (2012) bandwidth for fuzzy RKD (Fuzzy IK), the bias-corrected estimates per Calonico et al. (2014) (Fuzzy CCT), the "rule-of-thumb" bandwidth based on Fan et al. (1996) (FG), and the baseline bandwidth used in the baseline analysis. The four bandwidths are 0.114, 0.102, 0.28 and 0.2, respectively. Even though 0.1 is the optimal bandwidth suggested by both Fuzzy IK and Fuzzy CCT , the result is compromised by the small sample size at this bandwidth. I find that the results are significant and relatively stable over bandwidths between 0.125 and 0.25, which is equivalent to €325 to €650. Once the observation number falls below 3000, the results are very sensitive to the choice of bandwidth.

Heterogeneous Behaviors In this subsection, I look at heterogeneous responses for subgroups by pension subsidy size, health status, and family attachment. Table A3 shows estimates for recipients with higher than average subsidies and recipients with lower than the average subsidies. The regression results suggest that the impacts are only significant for workers with higher subsidies. It might be a result of insignificant slope change in subsidy size for recipients with lower than average subsidies. However, the test for difference between the impact for high and low subsidy groups is statistically insignificant. We cannot infer any heterogeneous effect in terms of subsidy size. The number of years worked before 1992 is a main determinant of the subsidy level. I also test for heterogeneous impact for the group worked more years before 1992 and for the group worked few years before 1992. The regression results are similar as separating the sample by subsidy size. It is suggestive that when subsidy level is lower than a certain threshold, workers' labor supply is not responsive to the additional benefits. It would be interesting to measure the continuous impact of subsidy on retirement behavior. However, I don not have enough individuals to perform a quantile regression.

Health status is a key factor that affects retirement decisions. Poor health makes it harder to stay in employment and induces workers to claim pension earlier. Workers with poor health might also value leisure more. I proxy healthiness using a dummy of never spending any time on sick leave before age 50. A worker is healthy when the dummy takes value one and is unhealthy when the dummy takes value zero. The estimation result suggests that unhealthy workers claim pension earlier by around 1 year and healthy workers claim pension earlier by around 8 months. The difference in impacts on pension claim age, however, is statistically insignificant. The difference in estimated impacts on hazard to claim pension at 60 of those two groups is fairly larger and significant at 10% level.

Lastly, I separate female recipients by the number of children. It is because the labor force attachment of women is largely affected by their child-bearing activities. Mothers with more children are less likely to be strongly attached to employment. I expect mothers with more than one child are more responsive to additional pension income. Row 4 in Table A3 confirms this hypothesis. The impact of additional income to women with no child or with only one child is an order of magnitude smaller than the impacts to mothers with more than one child. I also look at women with children and without children, the results are similar.

7 Implications and Discussions

The primary objective of this subsidy program was to provide additional income support to older workers at retirement. However, as I mentioned earlier, this program is being phased out gradually. Low-income workers who never contributed to the pension system before 1992 won't benefit from this subsidy program. The average subsidies of female workers in West Germany declined from €33 /month for cohort 1935 to €20 /month for cohort 1948. Over time, the average subsidy size also decreased from €50 /month to below €10 /month from 1996 to 2014. The red dashed lines in Figure 13a and Figure 13b show these declining patterns. In meanwhile, the average age of claiming pension has increased by 1.5 years since the 1990s. The blue dash-dot lines in Figure 13a and Figure 13b display the profile of age of claiming pension for female cohorts between 1935 and 1948, and for female workers from year 1996 to 2014. From a policy perspective, it would be interesting to know what the retirement age of female workers would be if the subsidy level remains at a high level. In other words, how much the phasing out of this subsidy program accounts for the increase in women's retirement age over the past decades.

The RK estimates suggest that one euro extra monthly pension benefit induces female recipients to claim pension earlier by 0.00856 years, which is around 3 days. Based on this estimate, I extrapolate age of claiming pension if the subsidy level remained at the average level of the 1935 cohort in Figure 13a; and if the subsidy level remained at the average level of year 1996 in Figure 13b. The corresponding changes in retirement age are shown as the grey area between the black solid line and blue dash-dot line. For instance, the extrapolated age of claiming pension has increased by around 1 year from 1996 to 2014. This suggests that phasing out of this pension subsidy program can account for one third of the increasing trend in age of claim pension over the past decade.

7.1 In Comparison with other studies

It would be useful to compare the magnitude of the estimates in this paper with other studies. I compare the results with three types of studies. Because both wealth and substitution effect of this subsidy program make recipients to claim pension earlier and exit employment earlier, I cannot distinguish those two effects. The comparison with estimates due to pure income or wealth effects and due to pure substitution effect can help us better understand the results.

First, I compare the results with estimates due to pure income or wealth effects. The magnitude of results in this paper is close to the size of findings in those papers. For example, Marie and Castello (2012) and Gelber et al. (2017b) focus on wealth effect from changes in Disability Insurance generosity. Marie and Castello (2012) measured the labor supply response to a 36% increase in the disability insurance benefits in the U.S. and found the labor force participation rate declines by 8% for the disabled individuals who receive the increase in benefits. Gelber et al. (2017b) studied the impact of more generous Disability Insurance using RKD. They found the annual employment rates decrease of 1.3% per $1000 of additional lifetime DI benefits. In the context of retirement pensions, estimates in Atalay and Barrett (2015)and Gelber et al. (2017a)are similar our estimates are modestly larger. Atalay and Barrett (2015) studies the Australian pension reform which increased the eligibility age for women which reduced social security wealth only via the wealth effect. This is because the benefit levels are not conditional on prior earnings in Australia. They found that an increase in the eligibility age of one year induced a decline in the probability of retirement by 12 to 19 percentage points. Gelber et al. (2017a) is the closest to my paper in the sense that they isolate the impact of additional pension benefits by looking at the US "Notch" cohort. They find that an increase in lifetime discounted OASI benefits of $10,000 causes a decrease in the employment rate for ages 61 to 95 of 1.24 percentage points. To compare with their finding, I assume the subsidy recipients have 20 years of pension duration, therefore 100 euros extra monthly pension leads to an increase of €24,000 in lifetime income. This result suggests that $10,000 of additional lifetime income decrease retirement age by 4 months and the retirement rate for ages from 55 to 65 increases by 2.3%.

Second, I compare the results with estimates due to substitutional effects (Hanel (2012), Manoli and Weber (2016), Lalive and Staubli(2017) . The estimate in this paper is much smaller in magnitude. For example, Hanel (2012) reports a semi-elasticity of propensity to enter disability retirement with respect to the implicit tax rate of 2.10. Manoli and Weber (2016) measured the retirement age responses to discontinuities in the incentives for workers to delay retirement due to a severance pay package. They found a semi-elasticity of participation ranging from 0.1 to 0.3. Due to the limitations of the data set, I could not take the family structure, spouse income, and other income sources into consideration. Husbands and wives may determine their labor supplies jointly. Wives who have access to husbands' income and other income sources are less responsive to the availability of subsidy, and vice versa. It needs to be taken into account when interpreting the estimation results. If we assume that the household income is in a range of 1 to 3 times of the female recipient's income, then we obtain an estimate of the elasticity of retirement age with respect to income in a range of -0.025 to -0.008. That is, a 1% increase of pension income decreases pension claim age by 0.08% to 0.25%. And the elasticity of hazard rate to enter old age pension at age 60 with respect to pension income is in a range of 0.075 to 0.025. That is, 1% increase of pension income increases the hazard to claim pension at 60 by 0.025% to 0.075%.

Lastly, I compare the results with estimated impacts of changes in financial incentives accompanied by raising pension eligibility age. For example, Mastrobuoni (2009) exploited the 1983 Social Security Amendments in the U.S., which increased the NRA while simultaneously increasing the penalty for claiming benefits at the early retirement age. They found that workers increase retirement age by 1 month for each 2 months increase of NRA. The lower bound of benefit deduction of early claim in the U.S. is $\frac{5}{9}$ of one percent for each month of early claim. This suggests that results from Mastrobuoni (2009) imply that the a 1.8 months increase in NRA combined with a financial penalty of 1% increases the retirement age at least by 0.9 months. This is larger than my finding — 0.5 months as a result of 1% increase in benefits. My result is also smaller than the results of Engels et al. (2017). They investigated the impact of a cohort-specific pension reform in Germany, as mentioned briefly above. The total effect of the reform in their paper, i.e. the shift in normal retirement age combined with a financial penalty of 18% increases the retirement age of women by 15 months. This is reasonable as the overall impact of those studies is may be a combination of labor supply response to a change in lifetime income and response to a change in the focal reference point - the statutory pension eligibility age.

7.2 Fiscal implications

Policymakers are interested in the total fiscal of one euro increase in monthly pension subsidy. Here, I separate the fiscal cost into two parts, mechanical cost (MC) and behavioral cost (BC). The ratio of behavioral cost to mechanical cost (BC/MC ratio) is a context-robust measure of disincentive cost, which helps to compare the disincentive effect of this pension subsidy to low pay workers with other redistribution programs. The MC represents the increase in government spending if there were no behavioral responses. If I assume the average duration of pension claim to be 20 years, which is the length of the period between pension claim and death, then the mechanical cost of €1 increase in monthly pension benefit equates €240 increase in lifetime pension benefits per each infra-marginal worker. The BC is the additional costs imposed on the government budget by the fact that people claim pension earlier, leave regular job earlier and more likely to enter unemployment insurance and then take the early retirement pathway [24].

In details, the BC consists of four parts. The first part is the increase in total pension benefit payment due to early claim. €1 increase in monthly pension benefit induces worker to claim early by 3 days. Therefore, the government pays €60 per worker[25] The second part is the increase in

[24]In this paper, I didn't look at the âĂIJenrollmentâĂİ responses. Potentially, workers may lower their average earnings point at retirement in order to meet the eligibility threshold for the pension subsidy program. Therefore, I donâĂŹt consider the fiscal externalities from the marginal workers.

[25]I take average monthly pension €600 in the data as the baseline pension benefits. Therefore, 3 additional days of

UI benefit payment caused by the change in UI claim behavior. Recall that €1 additional monthly pension benefit increases the duration spent in unemployment after exiting regular employment job by around 1.3 days. Consider that average daily UI benefit is roughly 67% of the average wage, 1.3 more days in UI increases government spending by €26 [26] Additionally, on average, 30% of the recipients bridge to retirement via unemployment. Therefore, the expected value of the second part of the behavioral cost is €8. The third part is the decrease in revenue due to less contribution to the public pension system. The reduction in contribution comes from two sources: first, a change in age of exiting regular employment; second, a change in time spent in UI. The magnitude of the first part is close to zero, as the estimated distortion on age of exiting regular job is close to zero (Table A2). The change in contribution due to change in time spend in UI is €8 multiplied by pension contribution rate 18%. The third part of the behavioral cost is approximately equal to €1.5. The last part is the decrease in tax revenue. This part of behavior cost is also close to zero. It again is because the estimated impact on age of exiting regular job is close to zero. To sum up, the total behavioral cost for one additional euro of pension benefit per month is around €70 per worker.

The resulting BC/MC ratio under the assumptions made above is approximately 0.3. It implies that in order to increase the lifetime income of the low-income pensioners by 1 euro, 1.3 euros have to be raised by the government, either via taxes or pension contribution.[27] The BC/MC ratio helps me to compare the distinctive effect of the pension subsidy program with other anti-poverty programs. For instance, Schmieder and von Wachter (2017) report an average BC/MC ratio of UI benefit extensions of 1.35.[28] The BC/MC ratio of a public policy is conceptually the same as the âĂIJfiscal externalityâĂİ (FE) in Hendren (2016). The FE measures the impact on government budget due to behavioral response to the policy change, per dollar of government expenditure.[29] Hendren (2016) reports that the FE of increasing EITC generosity is 0.14 and the FE of âĂIJfood stampsâĂİ ranges from 0.53 to 0.64. Saez et al. (2012) reports the fraction of tax revenue lost

pension amounts to €60.

[26] I take average monthly wage €900 in the data as the baseline wage income.

[27] If we donâĂŹt take into account the additional costs to the UI system, then BC is €62, MC is €240, the BC/MC ratio is 0.26.

[28] This is obtained under the assumption that nonemployment affects the social planner's budget by both income tax and UI payroll tax. If only the UI payroll tax is considered, BC/MC ratio of UI benefit extensions is on average around 0.35.

[29] Hendren (2016) proposes a simple benefit-cost ratio, marginal value of public fund (MVPF), to measure welfare impact of policy changes. MVPE =1/(1+FE), where FE stands for fiscal externality.

through behavioral responses of raising top tax rate to be 0.43. This suggests the average BC/MC ratio of raising top tax rate of 0.43. Using the formula in Saez et al. (2012), I calculate the BC/MC ratio of a tax cut for low income workers using an labor supply elasticity estimate of 0.5 (Eissa and Hoynes (2006)). [30] The BC/MC ratio of a tax cut for low-income workers is approximately 0.375.

The BC/MC ratio suggests that compared to other anti-poverty programs that aim to redistribute income to workers in danger of old age poverty, the pension subsidy program has a relatively small disincentive effect than expanding UI generosity, in-kind transfer, such as food stamps, and reducing low-income marginal tax rates; and it is more distorting than the EITC program.

While the BC/MC ratio expresses the fiscal costs of increasing pension benefits, it is difficult to provide the welfare implication of the pension subsidy program. The social value of increasing pension benefit by €1 depends on the gap between the marginal utility of subsidy recipients relative to the marginal utility of other pension contributors. Evaluating the social value is beyond the scope of this paper. Additional lifetime income can change the marginal utility from many perspectives. One potential positive impact of additional lifetime income is the increase in life expectancy. Snyder and Evans (2006) use an exogenous cut in Social Security benefits in the US for the notch cohorts to identify the causal impacts of income on mortality. They have found the notch cohort, who faced approximately $50 cut in pension per month, have a statistically significant 2% higher mortality. Additionally, in Germany, long-term health care is a part of the pension entitlement; claiming pension earlier could improve the longevity of workers who frequently experience health shocks (Coile (2004b)). Therefore, it is important to keep in mind that the subsidy recipients of this program might have a longer and healthier life after retirement due to additional pension income.

8 Conclusion

This paper presents a clear and transparent setting to estimate the disincentive effect of an increase in the generosity of the public pension system. In particular, there is relatively little evidence on the

[30]Consider a small tax cut $d\tau > 0$ for income below z^*, the mechanical decrease in tax revenue is $(z^* - z)d\tau$, and the behavioral responses is increase in tax revenue. $BC = \frac{\tau}{1-\tau} * \epsilon * z * d\tau$. Therefore, the BC/MC ratio is $\frac{\tau}{1-\tau} * \epsilon * \frac{z}{z^*-z}$. In Germany, the first €677 earned each month by a single worker is tax-free. Afterwards, the income tax increases from 14 % to 42 % incrementally. Let's assume z^* to be €1200 per month, and mean income of workers earn less than €1200 per month and above €677 per month is €900. The tax rate for low-income workers before a tax cut τ is assumed to be 20%. Plugging those numbers and the estimated labor supply elasticity in Eissa and Hoynes (2006) (0.5), we obtain the BC/MC ratio of a tax cut for low-income workers to be 0.375.

extent to which additional pension benefits induce early claim and early exit of labor force. This is because of the difficulty of isolating the causal impact of changes in pension benefits from changes in other parameters of the public pension system, such as the raising statutory pension eligibility age. Exploring a pension subsidy program in Germany with predetermined benefit levels and a kinked benefit schedule, I study the labor supply effect of additional pension benefits for low wage female workers. The specific feature of the German pension system allows me to identify the effect of additional pension benefits on retirement decisions in an environment in which the statutory pension eligibility ages remain unchanged. This is the first paper evaluates this pension subsidy program in Germany and first paper to utilize this particular quasi-experimental design to study the effect of additional pension benefits in the literature.

I found that female workers retire earlier by around 16 days if monthly pension benefits increase by 1%. The hazard rate to claim a pension at age 60 increases by 0.94 percentage points. The impact on age of exiting regular jobs is close to zero but is insignificant. The hazard rate to exit any kind of employment at age 60 increases by 0.78 percentage points at 5 percent significant level. I further look at the impact on recipientsâĂŹ transition activities after exiting regular jobs and before claiming a pension. Conditional on participation in regular employment at time t-1, 1% increase in monthly pension benefits increases the probability to transition to unemployment insurance at time t by 0.046 percentage points. Workers are more likely to use UI as a pathway to early retirement. Moreover, I look at the duration spent in marginal jobs, unpaid care and other activities during those bridge years. I find that recipients shorten time spent in marginal jobs and prolong time in unpaid care as a result of more pension benefits. My estimates suggest that the phaseout of this subsidy program can account for one third of the increase in age of claiming pension of women over the past decade in West Germany. The main policy implication of this paper is that while an income transfer to low-income workers induces early pension claim, it has little impacts on the probability to exit regular jobs, which have mandatory social security contribution obligations. This suggests that a pension subsidy program with predetermined benefit level has small fiscal externalities. A back-of-the-envelope calculation suggests the ratio of behavioral cost to mechanical cost of this subsidy program is 0.3, which is smaller than other anti-poverty programs such as extending unemployment benefits and progressive taxation.

While my specific coefficient estimates only directly apply to this particular pension subsidy program in Germany, I believe this paper offers some general contributions. First, this paper provides estimates of impact of subsides to the labor supply responses of low-income older women. This is of particular interest because women are more at risk of old age poverty and also on average live longer. The magnitude of subsidiesâĂŹ disincentive effect on low income women is both policy relevant and budgetary important. Second, this paper provides a new application of the RK design, where the slope change is starker in comparison to other existing RK applications.

9 Figures and Tables

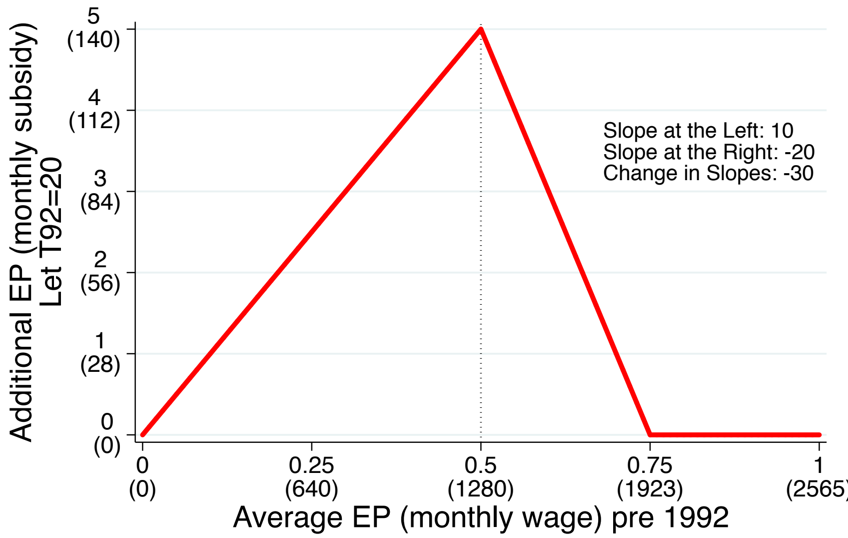


Figure 1: Subsidy Size as a Function of Average Monthly Earning Points before 1992

Note: Figure 1 plots the subsidy size for recipients who have contributed for 20 years before 1992. The subsidy size is measured in earnings points. The average year worked before 1992 of the baseline sample years is 20 years. The theoretical slope of total subsidy measured changes from 10 to -20.
Source: Author's own construction according to SGB VI § 262

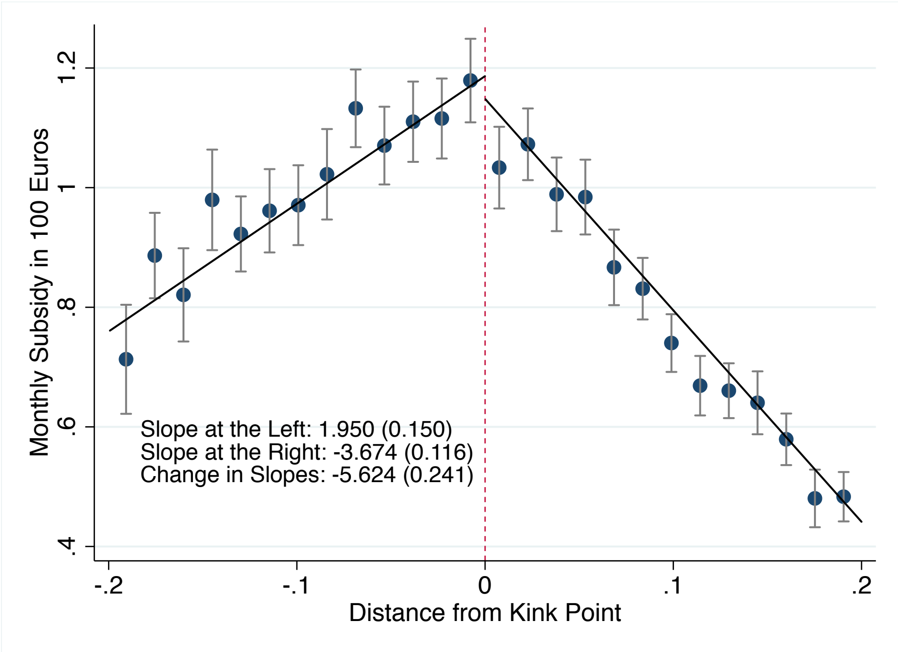


Figure 2: First Stage: Observed Subsidy Schedule

Note: Figure 2 plots the observed monthly subsidy size measured in euro for the recipients. It shows that the relationship between aep_{92} and subsidy size is consistent with the policy schedule in Equation 1. The monthly subsidy is measured in 100 euros. The reduced form regression without controls reports an estimated change in slopes of subsidy around the kink of -5.6. The corresponding slope change when subsidy is measured in earnings points is -19.9, from 6.9 to -12.9.

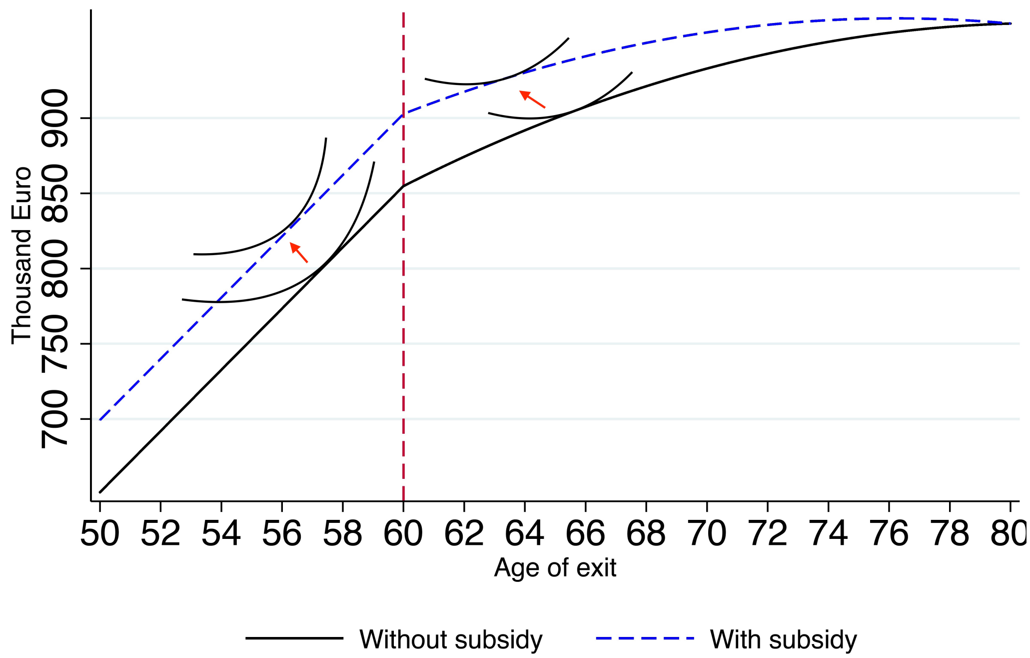


Figure 3: Illustration of lifetime budget constrain

Note: Figure 3 plots the lifetime budget constraint to age of exiting employment with and without subsidies. The black solid line is the lifetime budget constraint of non-recipients and the blue dashed line is that of recipients. Here, age 60 is the earliest possible age to claim pension and age 80 is the age of death. For simplicity, this figure does not describe "bridge" activities. I assume that if workers exit employment before age 60, they will claim a pension immediately when they are 60.
Source: Author's own construction

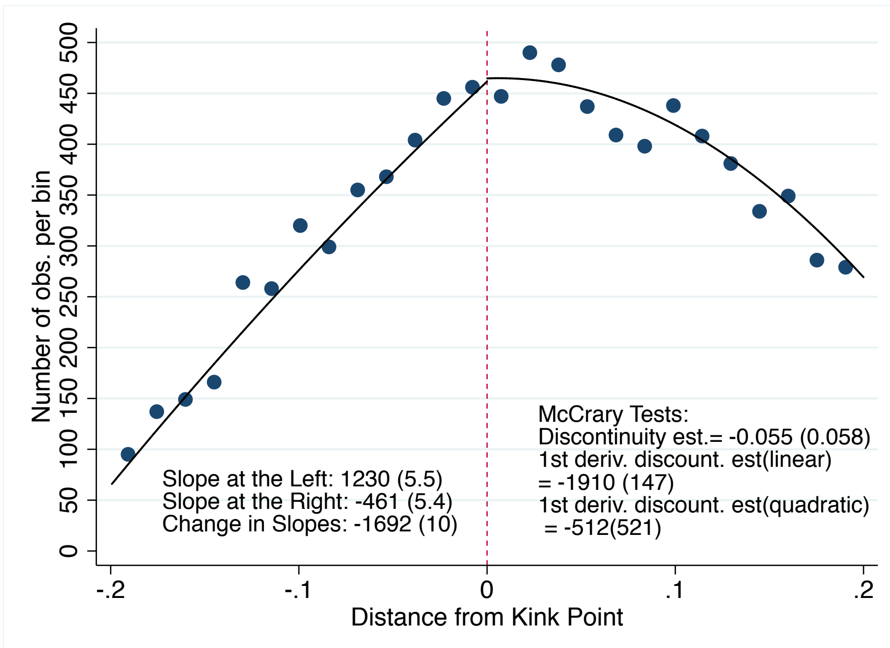
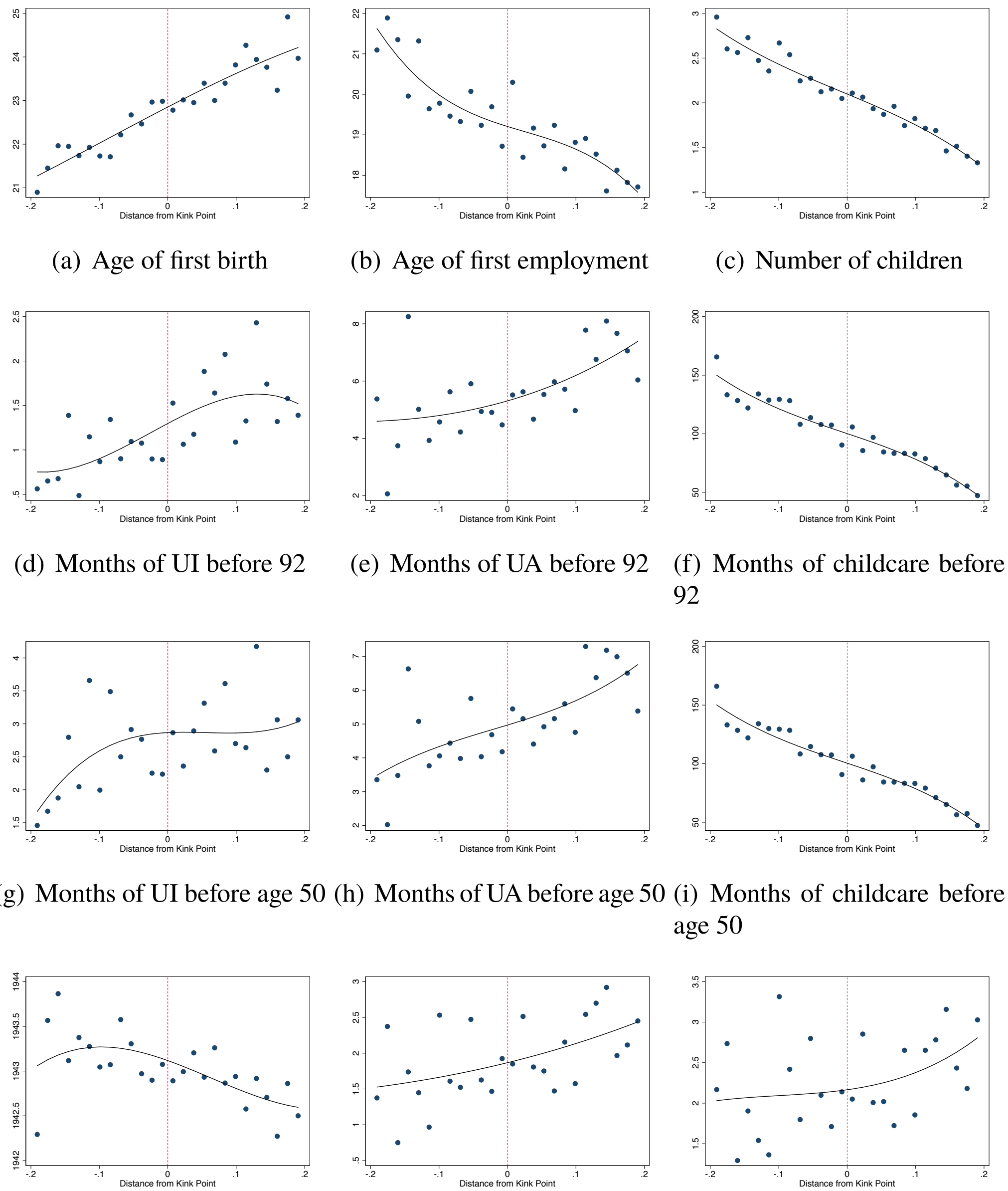


Figure 4 : Density around the Kink

Note: Figure 4 shows the density plot of aep_{92}, normalized at the kink point. A bin size of 0.05125 (∼ 40 €in 2010) is used in this figure. I display the results of a standard McCrary test of the discontinuity of the p.d.f. at the kink. Also, the test results of the discontinuity of slope of the p.d.f for a linear specification and statistically insignificant for a quadratic specification are reported in the figure.



(a) Age of first birth (b) Age of first employment (c) Number of children

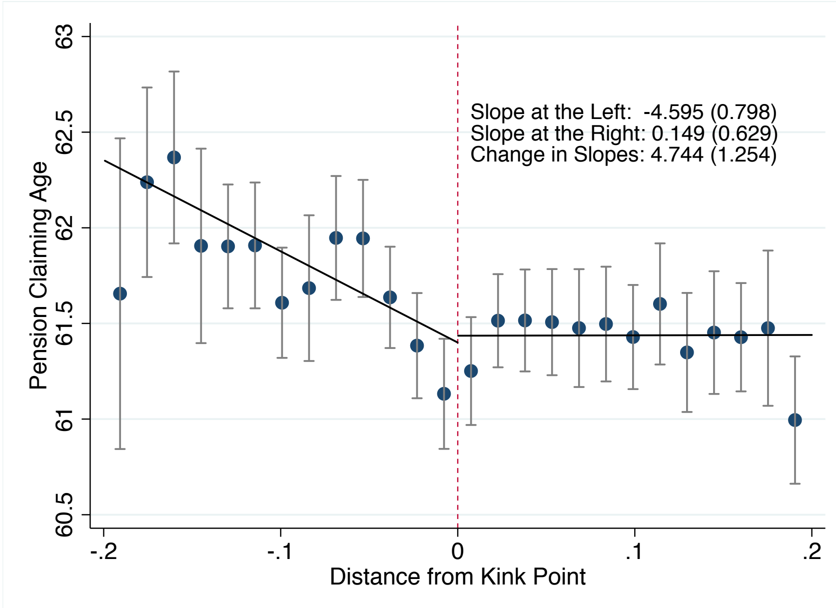
(d) Months of UI before 92 (e) Months of UA before 92 (f) Months of childcare before 92

(g) Months of UI before age 50 (h) Months of UA before age 50 (i) Months of childcare before age 50

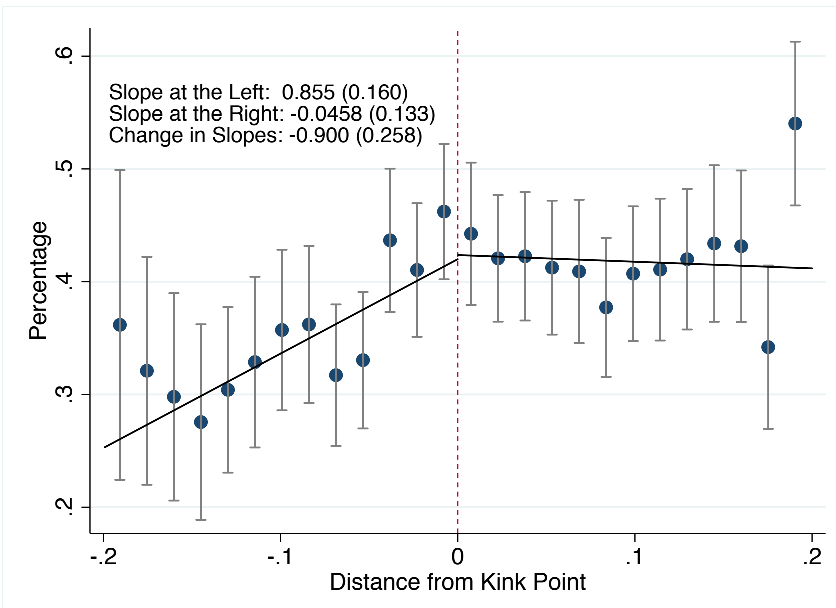
(j) Birth cohort (k) Months of sickness before 92 (l) Months of sickness before age 50

Figure 5 : Predetermined Covariates around the Kink

Note: Figure 5 shows the scatter bin plots of aep_{92} in 0.05125 (~ 40 €in 2010) bins as a function of distance to the observed kink point for the predetermined covariates. These distributions are smooth around the kink. Table 2 has listed the p-values for changes in slopes of covariates around the kink.



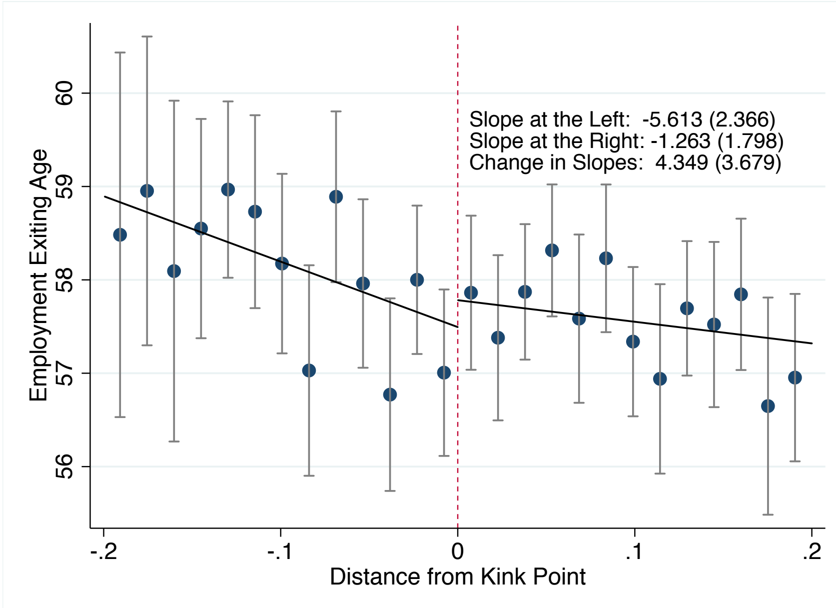
(a) Bin plots: Age of claiming pension



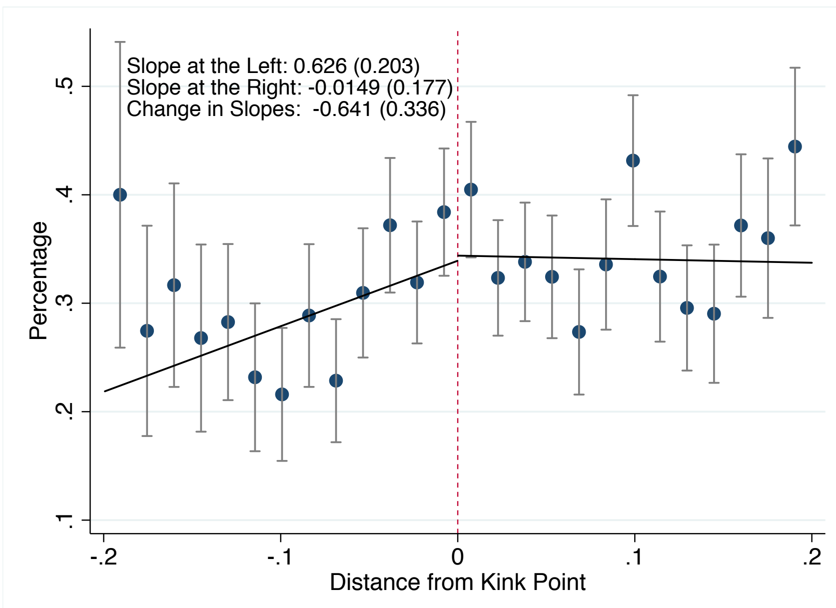
(b) Bin plots: hazard to claim pension at age 60

Figure 6: Scatter Plots of Age of Claiming Pension around the Kink

Note: Figure 6 shows the scatter bin plots of aep_{92} in 0.05125 ($\sim$ 40 €in 2010) bins as a function of distance to the observed kink point for the main outcome variables: age of claiming a pension and the hazard rate to claim a pension at age 60. The black solid lines are the linear fitted lines. The reduced-form regression results without any controls are reported in the figure.



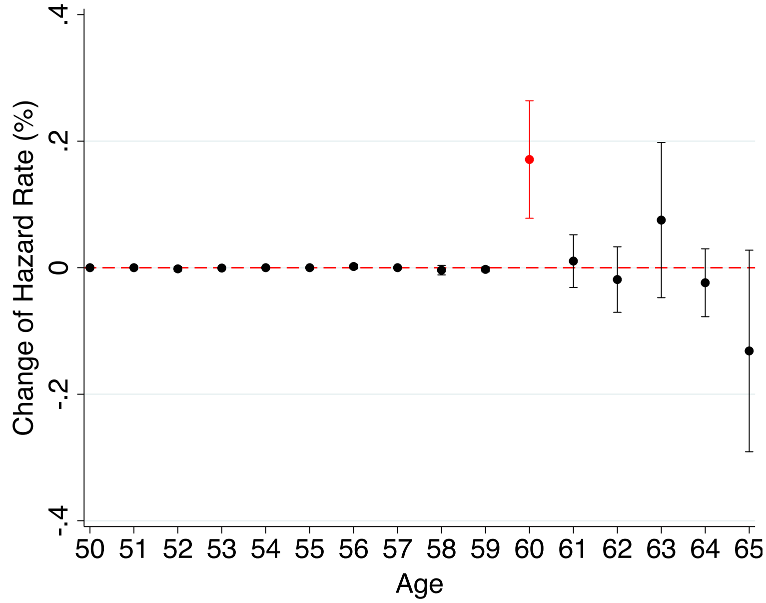
(a) Bin plots: age of exiting employment



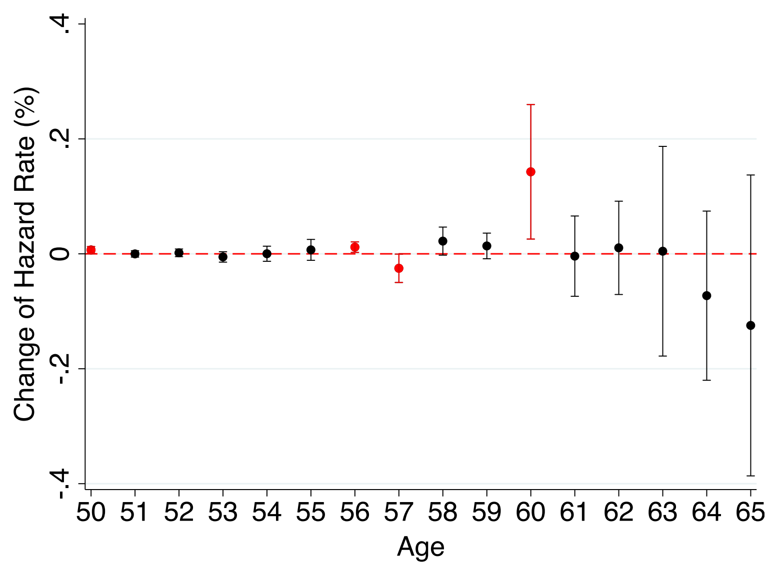
(b) Bin plots: hazard to exit employment at age 60

Figure 7: Scatter Plots of Age of Exiting Employment around the Kink

Note: Figure 7 shows the scatter bin plots of aep_{92} in 0.05125 ($\sim$ 40 €in 2010) bins as a function of distance to the observed kink point for the main outcome variables: age of exiting employment and the hazard rate to exit employment at age 60. The black solid lines are the linear fitted lines. The reduced-form regression results without any controls are reported in the figure.



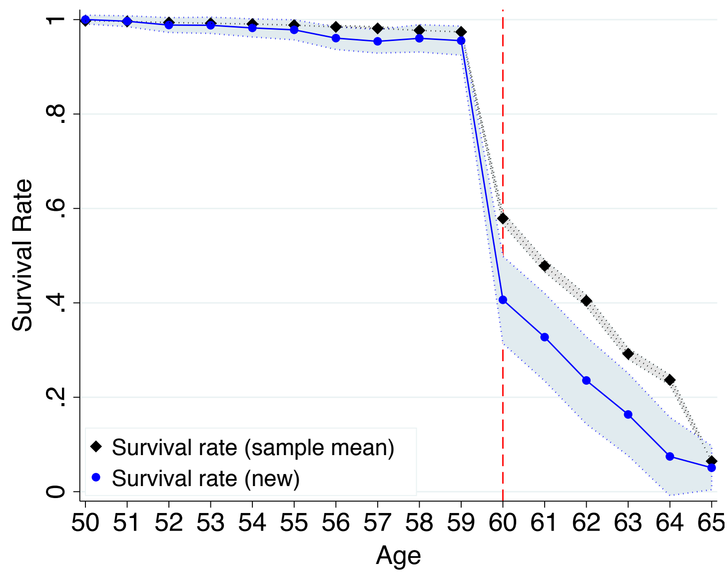
(a) Change of hazard to claim pension with 100 euro pension subsidies



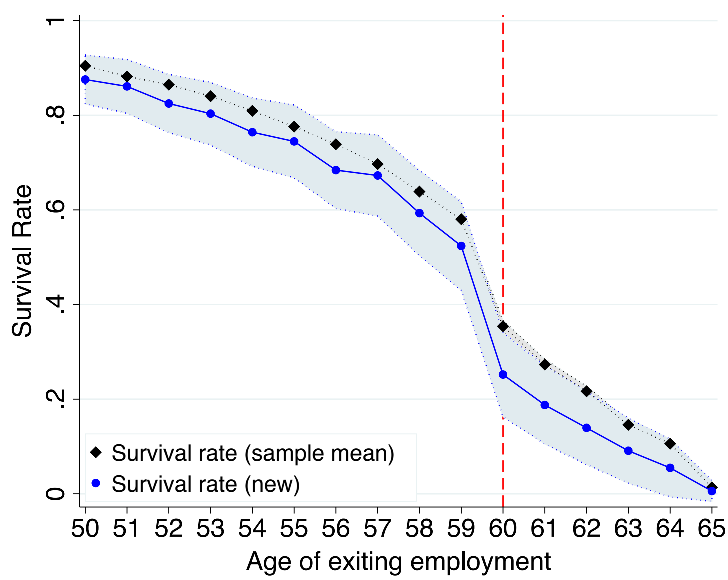
(b) Change of hazard to exit employment with 100 euro pension subsidies

Figure 8: Hazard analysis from Age 50 to age 65

Note: Figure 8 shows the estimated percentage change of hazard rate to claim a pension and the estimated change of hazard rate to exit employment at ages from 50 to 65 when there is an increase of pension benefits of €100 per month.



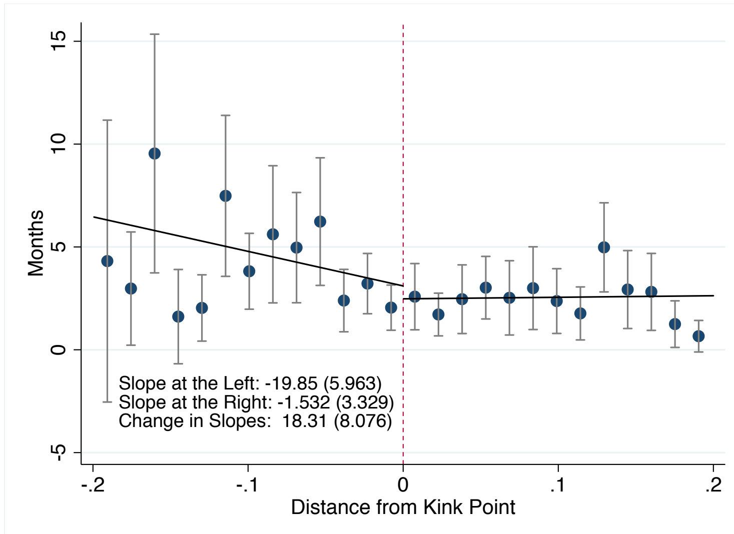
(a) Change in survival rate in terms of age of claiming pension



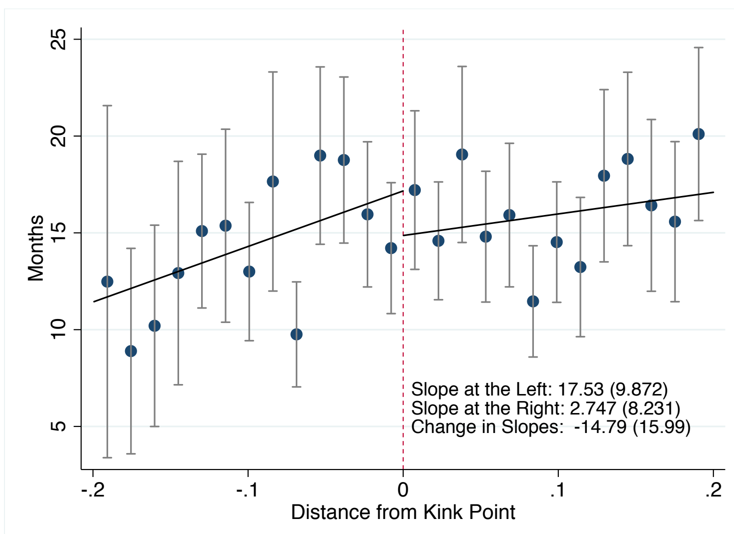
(b) Change in survival rate in terms of age of exiting employment

Figure 9: Survival analysis from age 50 to age 65

Note: Figure 9 shows the change in survival rate in terms of age of claiming pension and age of exiting employment from age 50 to age 65. The blue solid line shows the estimated survival rate when there is an increase of pension benefits of €100 per month.



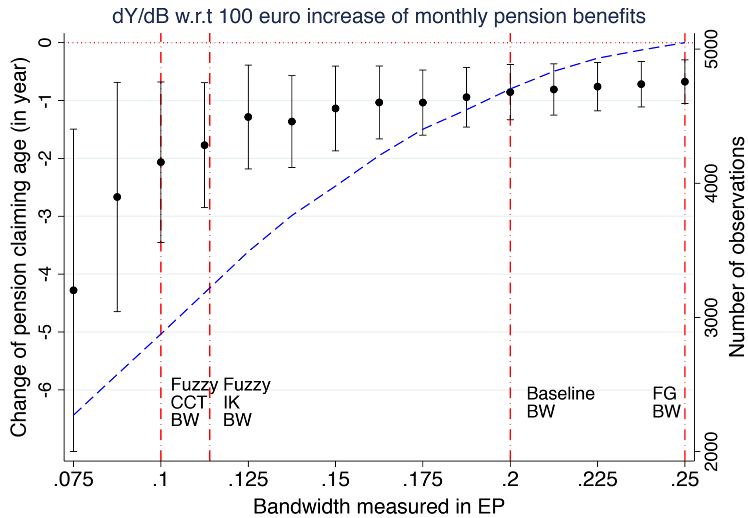
(a) Bin plots: months in marginal employment



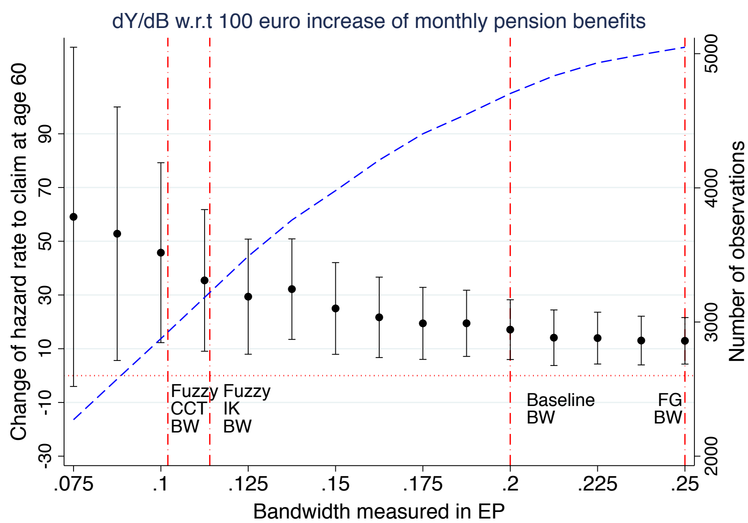
(b) Bin plots: months in unemployment

Figure 10: Scatter Plots of Bridge Activities around the Kink

Note: Figure 10 shows the scatter bin plots of aep_{92} in 0.05125 ($\sim$ 40 €in 2010) bins as a function of distance to the observed kink point for the outcome variables: months spent in marginal employment and months spent in unemployment during the bridge years. The black solid lines are the linear fitted lines. The reduced-form regression results without any controls are reported in the figure.



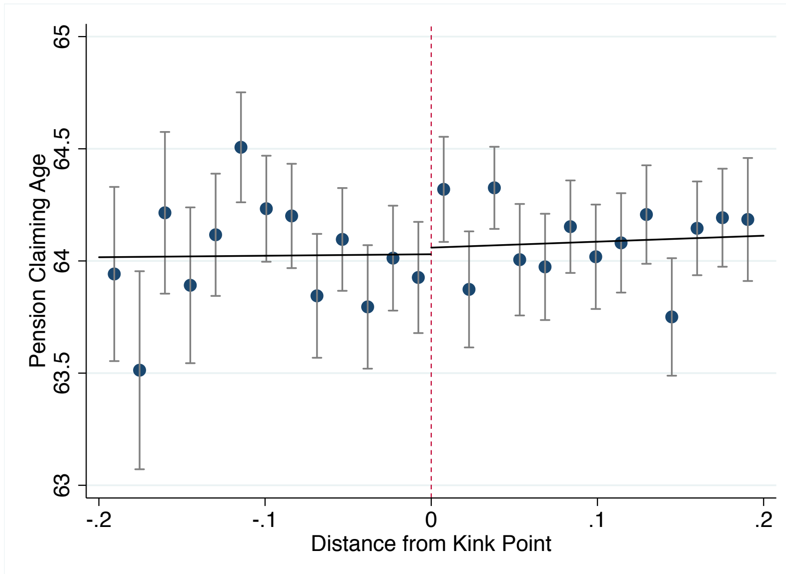
(a) Retirement age



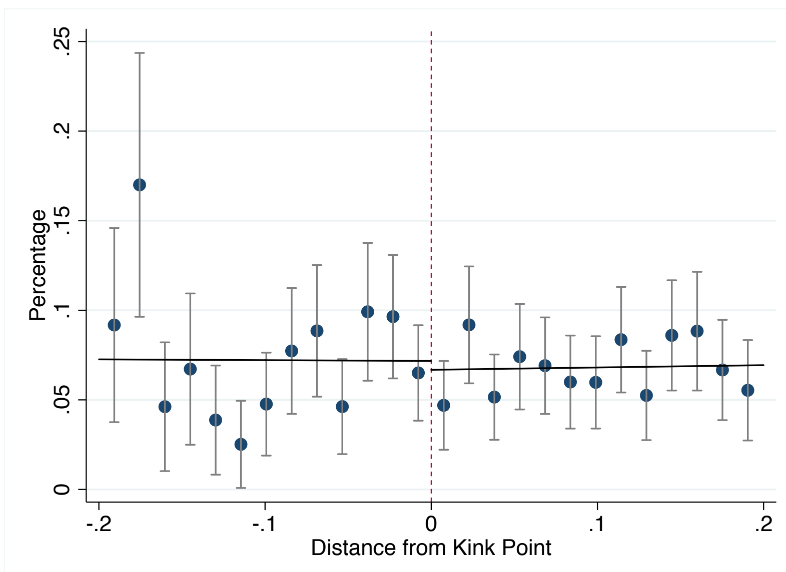
(b) Hazard to claim pension at age 60

Figure 11: RKD estimates by bandwidth

Note: Figure 11 shows the point estimates and 95 percent confidence intervals (on the y-axis) for the impact of a €100 increase in monthly pension benefits on age of claiming pension and hazard rate to claim a pension at age 60. The estimations are obtained using linear specifications with controls and cohort fixed effect. The four red vertical dash-dot lines correspond to four different bandwidth selections: the Imbens and Kalyanaraman (2012) bandwidth for fuzzy RKD (Fuzzy IK), the bias-corrected estimates per Calonico et al. (2014) (Fuzzy CCT), the "rule-of-thumb" bandwidth based on Fan et al. (1996) (FG), and the one used in the baseline analysis. Those four bandwidths are 0.114, 0.102, 0.28 and 0.2, respectively. They correspond to 260, 295, 517, 647 euros per month. The number of observations is shown by the blue dotted line. The figures suggest that the point estimator becomes robust to bandwidth selection when the number of observation exceeds 3000.



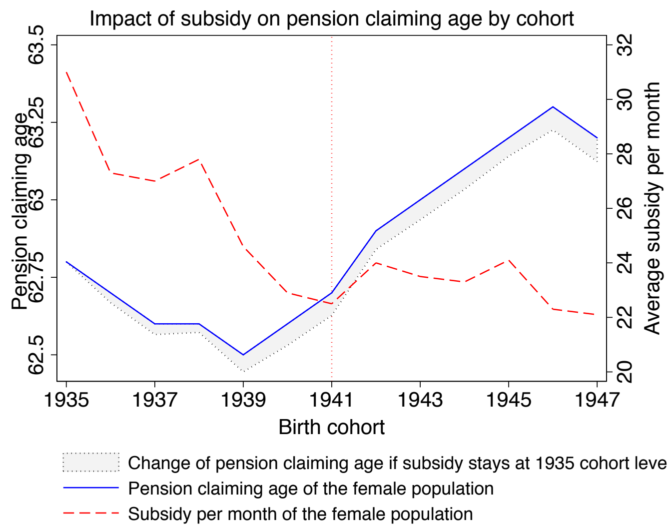
(a) Bin plots: Age of claiming pension



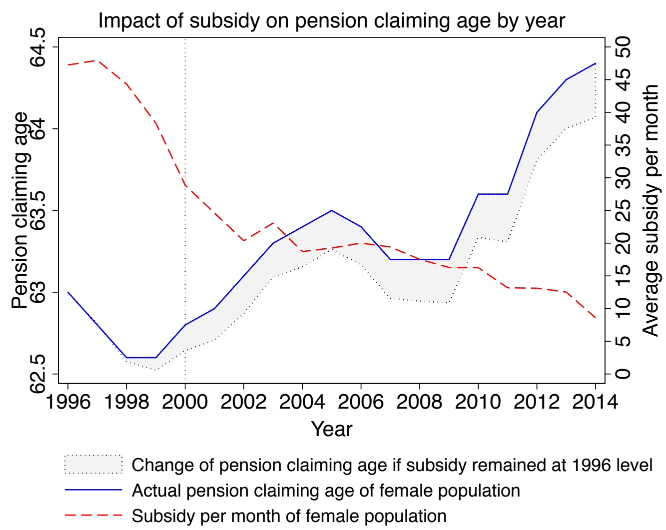
(b) Bin plots: hazard to claim pension at age 60

Figure 12: Scatter Plots of Age of Claiming Pension around the Kink for Workers with Less than 35 Credible Years

Note: Figure 12 provides evidence that the estimated impact on age of claiming pension is not caused by the quadratic functional form. The figures shows the relationship of age of claiming pension with average earnings points before 1992 for an control group - similar female workers with less than 35 creditable periods. Both panels show that there are no visible changes in slope of age of claiming pension and hazard to claim pension at age 60.



(a) Change in age of claiming pension by cohort



(b) Change in age of claiming pension by year

Figure 13: Policy Implications

Note: Figure 13 shows the counter-factual retirement age for female workers if subsidy size remained at the same level as the 1935 cohort and in 1996, respectively. The average subsidy size is calculated by the author using VSKT data.
Source: The pension claim ages for female workers in West Germany by cohort and by year are obtained from the report "Rentenversicherung in Zeitreihen (Pension insurance in time series)"

Table 1: Summary Statistics

Variables	Baseline sample Mean	s.d.	N	Around kink Mean	s.d.	N
Subsidy related characteristics						
Subsidy in EP	3.19	1.77	5218	3.84	1.92	1720
Subsidy in Euro/Month	90.29	50.31	4994	108.74	54.26	1643
Subsidy Share	17%	1%	5218	20%	1%	1720
Years worked before 92	19.74	6.65	5218	19.43	6.46	1720
Mean annual EP	0.55	0.11	5218	0.53	0.08	1720
Mean annual EP pre92	0.47	0.1	5218	0.45	0.03	1720
Mean wage pre92	1228	255	5218	1169	75	1720
Wage before pension claim	899	768	4416	872	723	1456
Mean wage 1 year before last regular employment	1350	543	4787	1302	496	1580
Pension related characteristics						
Total Pension benefits	673	189	4994	665	179	1643
Total EP	24.11	6.75	5218	23.83	6.41	1720
EP from contribution periods	16.58	5.24	5218	15.76	4.35	1720
EP from contribution periods pre92	9.58	4.22	5218	8.80	3.03	1720
EP from consideration periods	20.91	5.74	5218	20.73	5.32	1720
Pension years	41.64	3.8	5218	41.64	3.82	1720
Contribution years	32.4	6.44	5218	32.09	6.26	1720
Consideration years	6.28	4.53	5218	6.57	4.36	1720
Yrs of full-value contribution	30.34	7.42	5218	30.12	7.3	1720
Yrs of full-value contribution pre92	19.43	6.46	5218	19.08	6.37	17207
Outcome variables						
Age of claiming pension	61.57	2.33	5763	61.474	2.286	1643
Hazard to claim at 60	0.396	0.489	5774	0.416	0.493	1654
Age of exiting regular employment	56.81	7.45	6021	56.71	7.58	1720
Age of exiting any employment	57.68	6.93	6021	57.53	7.12	1720
Individual characteristics						
Number of kids	2.03	1.08	5218	2.1	0.99	1720
Age of first employment	19.18	5.51	5218	19.25	5.57	1720
Age of first birth	22.95	3.72	4912	22.83	3.61	1720
Birth Cohort	1943	3.75	5218	1943	3.74	1720

Notes: Table 1 reports descriptive statistics for the baseline sample of female workers and female recipients around the kink. The baseline specification focuses on the window of recipients whose aep_{92} are from 0.25 to 0.65, 0.2 EPs around the kink 0.45. There are 5,218 individuals in this window. The recipients around the kink are the ones whose aep_{92} are from 0.4 to 0.5.
Source: FDZ RV -SUFVSKT 2002, 2004âĂŞ2012, own calculations.

Table 2: Changes in Slopes of Covariates around the Kink

Covariates	Coeffi.	s.d.	p-values	mean at kink	s.d.
Fixed Characteristics					
Number of kids	-0.551	(0.470)	0.241	2.00	(1.06)
Age when having 1^{st} child	-0.450	1.712	0.793	22.90	(3.73)
Age of first employment	4.990	2.570	0.052	19.03	(5.37)
Years of consideration periods	-0.803	(2.008)	0.689	6.21	(4.51)
Durations of SES before 1992					
Months of UI	1.493	(1.724)	0.387	1.311	(4.027)
Months of UA	10.39	(6.176)	0.093	5.726	(13.68))
Months of Childcare	-4.097	(28.03)	0.884	94.62	(62.99)
Months of Sickness	-0.375	(2.131)	0.860	1.849	(4.686)
As a share of total years before 1992					
Share on Employment	-0.140	(0.076)	0.065	0.590	(0.187)
Share on UI	0.004	(0.005)	0.401	0.003	(0.010)
Share on UA	0.028	(0.016)	0.083	0.015	(0.035)
Share on Childcare	0.0127	(0.073)	0.861	0.242	(-0.164)
Share on Sickness	-0.002	(0.005)	0.745	0.005	(0.011)
Characteristics before age 50					
Months of UI	3.339	(3.906)	0.393	3.102	(8.481)
Months of UA	7.507	(5.975)	0.209	5.456	(13.46)
Months of Childcare	-3.775	(28.16)	0.893	95.05	(63.22)
Months of Sickness	0.177	(2.429)	0.942	2.269	(5.333)

Notes: Table 2 show the estimated changes in slopes of the predetermined covariates at the kink point. I look at individual characteristics, such as the number of children, the age of first birth and age of first employment. Social economics status, such months spend in unemployment insurance, unemployment assistant, childcare and sickness leaves before 1992 and before age 50 are also tested for nonlinearity at the kink. All estimates are for the linear case. The p-values of all covariates are larger than 0.05. This suggests that the covariates evolve smoothly at the kink.

Table 3: Impacts of pension subsidies on age of claiming pension

	Age of claiming			Hazard rate at 60		
	(1)	(2)	(3)	(4)	(5)	(6)
First-stage						
$\Delta\frac{dB}{dr}$ (1)	-5.6240***	-5.6296***	-5.3798***	-5.6240***	-5.6296***	-5.3798***
	(0.2940)	(0.2808)	(0.1993)	(0.2940)	(0.2808)	(0.1993)
Reduce-Form						
$\Delta\frac{dY}{dr}$ (2)	4.7437***	5.0352***	4.6032***	-0.9004***	-0.9833***	-0.9202***
	(1.3559)	(1.3287)	(1.3416)	(0.3158)	(0.3053)	(0.3104)
RKD estimator						
$\frac{dY}{dB}$ $\frac{(2)}{(1)}$	-0.8435***	-0.8944***	**-0.8556*****	0.1601***	0.1747***	**0.1710** ***
	(0.2361)	(0.2323)	**(0.2436)**	(0.0548)	(0.0533)	**(0.0567)**
Means at the kink						
Subsidy size	108.74	108.74	108.74	108.74	108.74	108.74
Outcome variable	61.47	61.47	61.47	0.42	0.42	0.42
Sample means						
Subsidy size	90.29	90.29	90.29	90.29	90.29	90.29
Outcome variable	61.57	61.57	61.57	0.39	0.39	0.39
Controls	No	No	Yes	No	No	Yes
Cohort Fixed Effect	No	Yes	Yes	No	Yes	Yes
Observations	4994	4994	4703	5218	5218	4912
R^2	0.0092	0.0363	0.0569	0.0071	0.0696	0.0958

Notes: Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Subsidies are measured in €100. The results are from local linear regressions with a bandwidth of 0.2 EP around the kink for the baseline specification. The standard error for RKD estimator is obtained from delta method.

Table 4: Impacts of pension subsidies on age of exiting employment

		Age of exiting			Hazard to exit at 60	
	(1)	(2)	(3)	(4)	(5)	(6)
First-stage						
$\Delta \frac{dB}{dr}$ (1)	-5.6240***	-5.6296***	-5.3798***	-5.6240***	-5.6296***	-5.3798***
	(0.2940)	(0.2808)	(0.1993)	(0.2940)	(0.2808)	(0.1993)
Reduce-Form						
$\Delta \frac{dY}{dr}$ (2)	4.3494	4.2372	4.8460	-0.6410	-0.7022*	-0.7679*
	(4.4284)	(4.4111)	(4.1229)	(0.4095)	(0.3894)	(0.3880)
RKD estimator						
$\frac{dY}{dB}$ $\frac{(2)}{(1)}$	-0.7734	0.7527	**-0.9001**	0.1139	0.1247	**0.1427***
	(0.7928)	(0.7894)	**(0.7718)**	(0.0719)	(0.0686)	**(0.0717)**
Means at the kink						
Subsidy size	108.74	108.74	108.74	108.74	108.74	108.74
Outcome variable	57.53	57.53	57.53	34.83%	34.83%	34.83%
Sample means						
Subsidy size	90.29	90.29	90.29	90.29	90.29	90.29
Outcome variable	57.75	57.75	57.75	32.03%	32.03%	32.03%
Controls	No	No	Yes	No	No	Yes
Cohort Fixed Effect	No	Yes	Yes	No	Yes	Yes
Observations	5218	5218	4912	5218	5218	4912
R^2	0.0023	0.0120	0.1183	0.0046	0.1284	0.1558

Notes: Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.Subsidies are measured in €100. The results are from local linear regressions with a bandwidth of 0.2 EP around the kink for the baseline specification. The standard error for RKD estimator is obtained from delta method.

Table 5: Impacts on months spend in other activities between last regular employment and pension claiming

RKD estimator	Marginal Employment (1)	Unemployment (2)
$\frac{dY}{dB}$	-3.6100*	4.3650
	(1.7785)	(3.3544)
Controls	Yes	Yes
Cohort Fixed Effect	Yes	Yes
Observations	4912	4912

Notes: Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Subsidies are measured in €100. The results are from local linear regressions with a bandwidth of 0.2 EP around the kink for the baseline specification. The standard error for RKD estimator is obtained from delta method. Time spent in unemployment include months spent in both UI and UA.

Table 6: Effect on transition from regular employment and unemployment

Status at t	Regular Employment (1)	Marginal Employment (2)	Unemployment (3)	Others Activities (4)
Conditional on participation in regular employment at t-1				
RKD estimator				
$\frac{dY}{dB}$	-0.0061	-0.0002	0.0084†	-0.0020
	(0.0086)	(0.0002)	(0.0046)	(0.0069)
Sample means	0.966	0.0002	0.014	0.019
Observations	473,287			
Individuals	5,527			
Conditional on participation in unemployment at t-1				
RKD estimator				
$\frac{dY}{dB}$	0.0120	0.0011	-0.0158	0.0025*
	(0.0127)	(0.0024)	(0.0150)	(0.0011)
Sample means	0.030	0.0029	0.948	0.0008
Observations	86,765			
Individuals	2,622			
Conditional on participation in marginal employment at t-1				
RKD estimator				
$\frac{dY}{dB}$	0.0006	-0.0051	-	-0.0126
	(0.008)	(0.025)	-	(0.0235)
Sample means	0.007	0.965	-	0.0190
Observations	15,586			
Individuals	556			
Controls	Yes	Yes	Yes	Yes
Cohort Fixed Effect	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses † $p < 0.10$ * $p < 0.05$. Subsidies are measured in €100. The results are from local linear regressions with a bandwidth of 0.2 EP around the kink for the baseline specification. The standard error for RKD estimator is obtained from delta method. The sample consists of female recipients from age 50 to 59 in West Germany.

Table 7: Effect on SES before pension claim

Status before pension claim	Regular Employment (1)	Marginal Employment (2)	Unemployment (UI+UA) (3)
RKD estimator			
$\frac{dY}{dB}$	-0.004	-0.0224	**0.090**†
	(0.0569)	(0.0261)	(0.052)
Sample means	0.43	0.05	0.29
Observations	924,059		
Individuals	5,763		
Controls	Yes	Yes	Yes
Cohort Fixed Effect	Yes	Yes	Yes

Notes: Standard errors in parentheses † $p < 0.10$. Subsidies are measured in €100. The results are from local linear regressions with a bandwidth of 0.2 EP around the kink for the baseline specification. The standard error for RKD estimator is obtained from delta method.

Table 8: Effect on rate of retirement and rate of employment

	Retirement Rate			Employment Rate		
	(1)	(2)	(3)	(4)	(5)	(6)
RKD estimator						
$\frac{dY}{dB}$	0.0578***	0.0595***	0.0589***	-0.0358	-0.0345	-0.0471
	(0.0163)	(0.0160)	(0.0167)	(0.0308)	(0.0306)	(0.0301)
Sample means	0.27	0.27	0.27	0.54	0.54	0.54
Controls	No	No	Yes	No	No	Yes
Cohort Fixed Effects	No	Yes	Yes	No	Yes	Yes
Observations	5218	5218	4912	5218	5218	4912

Note: Standard errors in parentheses *** $p < 0.001$ 100 euros additional benefits increase the average retirement rate of female recipients from age 50 to 65 by 5.89%, and reduce the average employment rate from age 50 to 65 by 4.72%.

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A Online Appendix

B Additional Details on Institution

B.1 Example of Pension Benefit and Subsidy Calculation

Below is an example of a hypothetical pensioner who started contributing to the system since 1982 and claimed a pension in 2015. Her contribution period is 34 years. For each year of work, some earnings points are accumulated. For incidence, in 1983, she earned 1000 euros per month, and the average monthly wage of all insured was 1000 as well. Therefore, 1 EP was credited. In 1991, her wage income was half of the average. Therefore, 0.5 EP was credited. The sum of EP between 1982 and 2015 was 18. The average annual EP at retirement was 0.529. Pension value in 2015 was 30 euros. Her pension benefits without the subsidies were 540 euros per month. The sum of EPs

An Example of Pension Benefit Calculation

	10 years				24 years			
Year	1982	1983	...	1991	1992	1993	...	2015
Monthly Wage	500	1000	500	500	750	750	500	600
Average Monthly Wage of All Insured	1000	1000	1000	1000	1000	1000	1000	1200
EP	0.5	1	3.5	0.5	0.75	0.75	10.5	0.5

Sum of EP	18	Sum of EP pre 92	5.5
Mean EP	0.529	Mean EP pre 92	0.55
PV in 2015	30	Subsidy in EP	2
Monthly Pension Benefit	**540**	**Monthly Subsidy**	**60**

Monthly Pension Benefit + Subsidy **= 600**

before 1992 was 5.5 EPs. She has contributed 10 years before 1992. Her annual average EP before 1992 was 0.55. I also assume this hypothetical pensioner has one child. Therefore, the condition of 35 years credible periods is satisfied. Because both her average annual EP before 92 and average annual EP at retirement were below 0.75, she was entitled to the subsidy for low pay workers. The subsidy size was (0.75-0.55)*10=2, which was equivalent to 60 euros in 2015. Her total pension benefits was around 600 euros per month.

B.2 Pension Reforms

The statutory retirement age in Germany for a regular old age pension remained at 65 throughout our sample period, with the only prerequisite being 5 years of contributions. Several alternate pathways make retiring before 65 an option. The five main pathways to retirement are regular old-age pensions, old-age pensions for long-term insured, old-age pensions for women, old-age pensions due to unemployment (and, later, part-time work) and old-age pensions for severely disabled persons, see for example Börsch-Supan and Wilke (2004). We focus on the old-age pensions for women pathway. Eligibility for this pension requires 15 years of contributions of which at least 10 years have to be earned after the age of 40. All recipients in our sample are eligible for this pathway. The early retirement age (ERA) via the women pension pathway stayed at 60 for cohorts born before 1951. The 1992 pension reform has increased the retirement age with full benefit, normal retirement age (NRA), and introduced actuarial adjustment for claiming early. Specifically, for women pension pathway, NRA increases to 65 by monthly step since cohort 1941. In the meanwhile, beginning with cohorts born in January 1941, each year of early claim renders a 3.6% benefit deduction. The penalty to retire at 60 was phased in gradually in monthly steps, up to 18%. The penalty stabled at 18% for cohort younger than 1945. The 1999 reform abolished the early retirement program for women in cohorts born after 1951. Female workers can no longer retire at age 60. They retire the earliest at age 63 via pension for long-term insured.

In Table A6, I examine how the impact of the subsidies interacts with the financial penalties to early claim. The early retirement pathway through old age pension for women stayed at age 60 in my sample. According to the pension reform schedule, I separate the sample into three groups: 1) no-penalty group: cohort 1935 to 1940; 2) transitional group: cohort 1940 to 1944; 3) maximum-penalty group: cohort 1945 to 1951. I expect that there is the subsidy impact is smaller for younger cohorts who face penalties, because one additional euro is discounted for workers retire after ERA. In Table A6, I see the impact on hazard to claim pension at age 60 is slightly smaller than the impact for cohorts younger than 1945, however it is insignificant. However, on the contrary, the impact on age of claiming pension is the largest for the maximum-penalty group. Additional 100 euros make recipients younger than 1945 claim pension earlier by 1.2 years. One explanation might be that the younger cohorts are choosing between 65 and 60 and the older cohorts are choosing between 60 and 63. Figure A5 showed that indeed younger cohorts (the red dashed line)'s responses are only at age 60 and age 65, while older cohorts (black and blue lines) react to additional benefits by changing hazard to claim at age 60 and age 63. However, some of the estimates are not statistically significant from each other.

B.3 Information Revelation

Workers know the expected pension benefits they will get when they retire. It is because letters with detailed pension information were sent to insured individuals every 3 years from age 55 before 2005. Since 2005, letters have been sent annually to workers who are 27 years old and have contributed to the public pension for at least 5 years. Dolls et al. (2018) have shown that those letters inform workers their pension entitlements in a salient fashion. The salience of information helps individuals plan and allows individuals to take into account the additional pension benefits when they make labor supply choices. In detail, the statement is a two-page letter with a summary of the insurance record, including pension service year, full contribution year, accumulated pension points and projected pension entitlement conditional on future contributions. It also indicates warnings and risks, such as shifting of relative income position.

B.4 Parameters in the Illustrated Budget Constraint

The taxable wage income is after social security contribution (SCC) and child allowance. Healthcare insurance is almost always 100% deductible during the sample period. Before 2005, pension contributions were 100% tax-free. As of 2005, to balance the changes in pension income tax, 60% of pension contributions were tax-free, and it increased by 2% each year. In 2025, 100% of contributions will be taxed. For simplicity, I assume all SCC are tax deductible.

The social security contribution (SSC) includes contributions to healthcare insurance, long-term care insurance, unemployment insurance and pension insurance. The average SSC is around 20% of gross wage income. The baseline budget set is constructed for the sample of the married female without dependent children. Given that in the sample, around 90% have non-dependent children, it is representative to construct the lifetime budget constraint for the married couple without children.

According to online tax calculator [31], the average tax rate of the married individual with average wage income and whose spouse makes zero income is 0.12.

The public pension benefits are calculated on a complex formula of individual career earnings, average pay, revaluation, and insurance periods. The main determinant of pension payments is the sum of individual accumulated earnings points. Some periods without contribution also count as insurance periods after the age of 17, such as years of further education, time spent in military service, and time spent in raising children. The annual pension wealth of a worker who claims old age pension without financial adjustment and insured for $T^E - s$ years is the following:

$$pb_{gross} = \sum_{t=T^R}^{T} AR_t \times \sum_{\tau=s}^{T^E} \frac{w_\tau}{\bar{w}}$$

, where AR_t is aggregate pension base of year t, w is gross annual individual income τ , $\bar{w}$ is the average income of all insured people in the pension system. If we assume constant wage and take the mean of AR_t, the total pension wealth is

$$PB_{gross} = (T - T^R)\frac{AR}{\bar{w}}(T^E - s) = pw(T^E - s)(T - T^R)$$

, where p is the gross pension replacement rate per year of the pension contribution. The interest portion (Ertragsanteil) of pension is subject to income tax. The taxable portion depends on retirement age. It is 27% if one retires at full retirement age 65. The taxable rate of pension is around 30%. Because the taxable portion of pension on average falls into the zero tax bracket, we assume that pension is not subject to income tax.

C Additional Details on Sample Construction

C.1 Construction of Average Earning Points Before 1992

The assignment variable is average monthly pension points accumulated from full-value contribution. In the VSKT dataset, we observe 624 months of pension-related biographies. Respondents enter the data set in January of the year they turn 14 until the December of the year they become 65 years old. I use the birth year and birth month to back out the corresponding year and month when

[31]The tax rates are obtained from https://www.bmf-steuerrechner.de/ekst

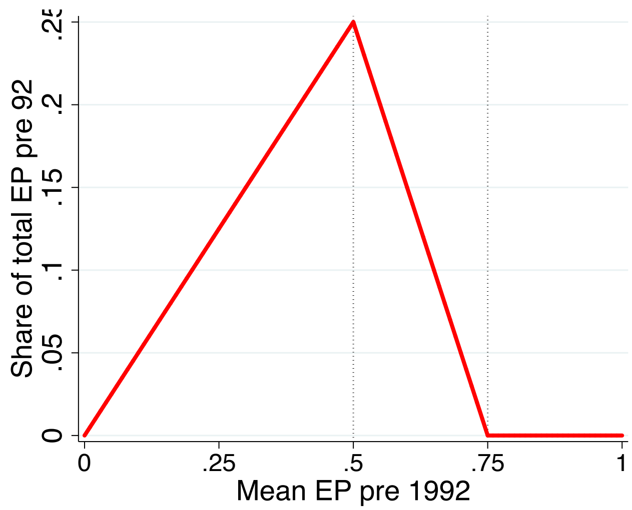
the contribution was made. Additionally, I also observe the socioeconomic status associated with the recorded pension contribution. To calculate average EP from full-value contribution before 1992, I sum up EP and number of months with " gainfully employment with pension contribution obligations." Because in the data, I observe the number of months before 1992 used to calculate the subsidy amount, I compare this variable with the constructed number of months contributed before 1992. This way I can test for the accuracy of the variable construction. I have estimated the regression kink estimates using the policy-defined cutoff 0.5 as the kink point. I find the impacts on pension claim age is around 5 months and on hazard rate to claim at age 60 is around 9%.

C.2 Sample Construction

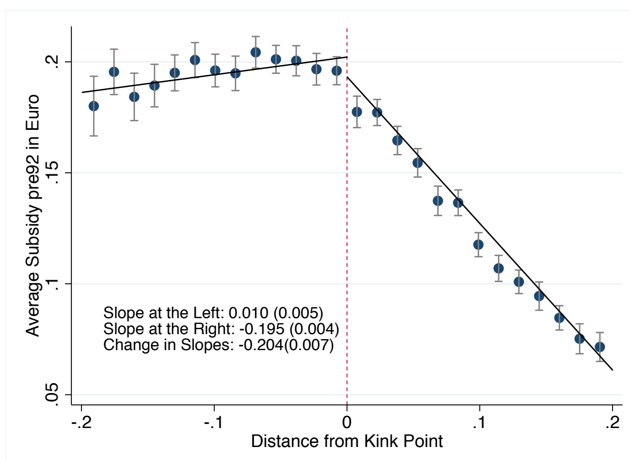
Since the personal identification number varies over time in the VSKT data, I can not guarantee that the same individual won't be surveyed again over different waves of VKST. Following the method used by Engels et al. (2017), For the baseline sample, I take cohorts that are at least as old age 63 from each wave. That corresponds to cohorts 1935, 1936, 1937, 1938 and 1939 from 2002 wave, cohorts from 1937 to 1941 from 2004 wave, 1938 to 1942 from 2005 wave, and so on. I further use time-invariant information, such as kids' birth months, total pension points, pension periods, birth month, etc., to jointly rule out potentially duplicated individuals.

The baseline sample is constructed by taking the individuals who are at least 63 from each year of the Pension Insurance Account Sample. I treat retirement age of workers who haven't claimed pension at 63 as missing. This might bias my estimates. In order to test if the estimated effects are sensitive to sample construction, I show in Table A7 the estimates constructed with individuals who are older than 60, older than 61, older than 62, older than 63 and older than 64. We can see that $\frac{dY}{dB}$ for age claiming pension ranges from -0.63 to -0.85. Hazard rate to claim a pension at age 60 ranges from 0.15 to 0.17. In panel B, I impute the age of pension claiming for all missing values using the average probability to retire next year conditional that the individual hasn't claimed a pension in the sample year in each bin. After the adjustment, the hazard rate to claim at age 60 doesn't change much. The impacts on retirement age range from -0.43 to -0.85 when I use linear specification. The impacts on retirement age ranges -0.39 to -0.43 for both the adjusted retirement age and adjusted when a quadratic specification is used.

D Additional Figures and Tables



(a) Average subsidy before 1992



(b) Scatter plots: average subsidy per year before 92

Figure A1:Average subsidy before 1992 as a function of average monthly earnings points before 1992

Note: Figure A1 (a) shows the slope of average subsidy per year before 92 changes from 0.5 to -1 at the kink, as Equation 2 suggests.Figure A1 (b) plots the distribution of average subsidies per year before 1992. It should change from 0.5 to -1 as in Figure A1 (a). However, the slope to the left is smaller than 0.5. Those deviations are measurement errors coming from constructing aep_{92} in the data.

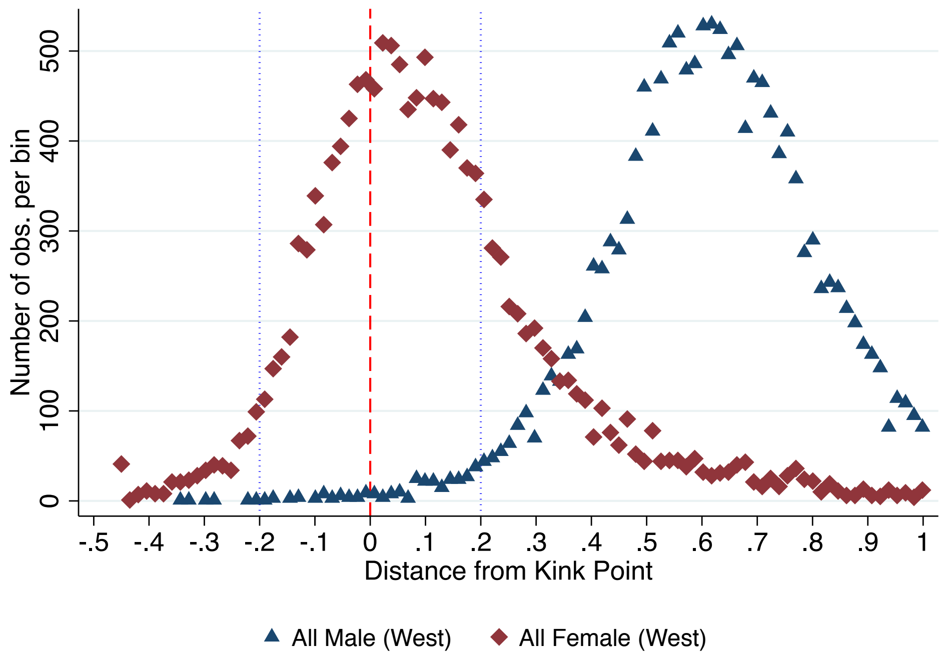
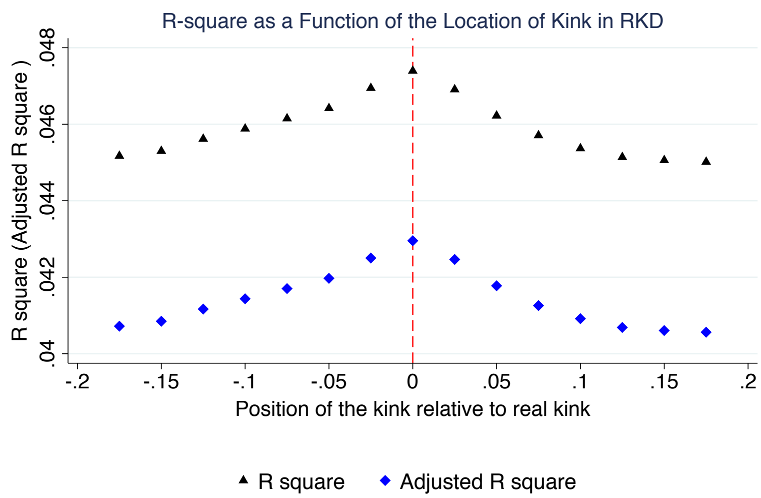
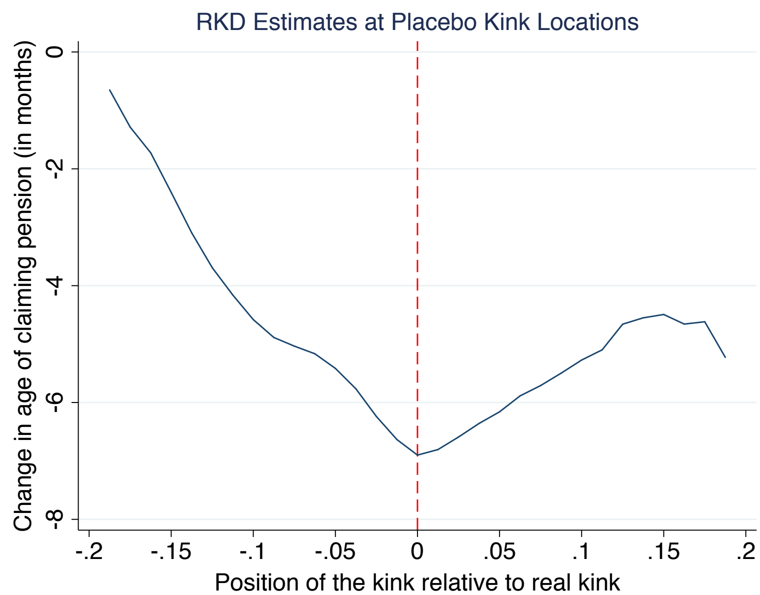


Figure A2 : Density of Female and Male Population

Note: Figure A2 shows the density of female workers in West Germany and male workers in West Germany. This figure shows that the bell shaped density for the female recipients is not unique but rather a pattern that is common for all female workers in the pension system in West Germany.



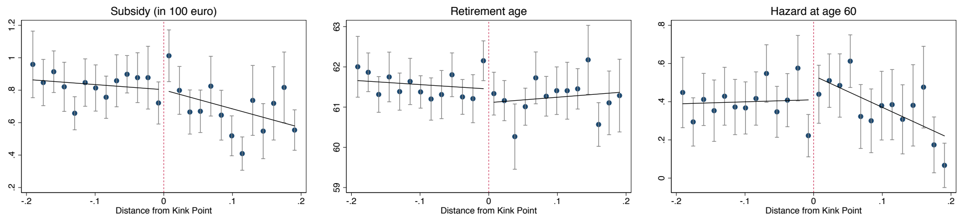
(a) R-squares as a function of Placebo Kinks



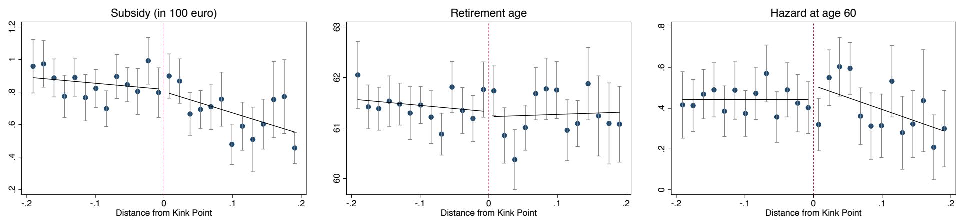
(b) Estimates at Placebo Kinks

Figure A3 : Global Kink Points

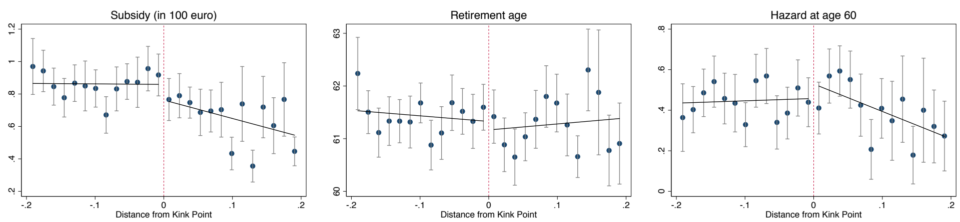
Note: Figure A3a shows the R-squares and adjusted R-squares of the baseline model when the kink is placed at "placebo" locations around the kink. This method follows Landais (2015). Both the R-squares and adjusted R-squares are maximized at the real kink. Figure A3b shows the estimates as a function of the placebo kinks.



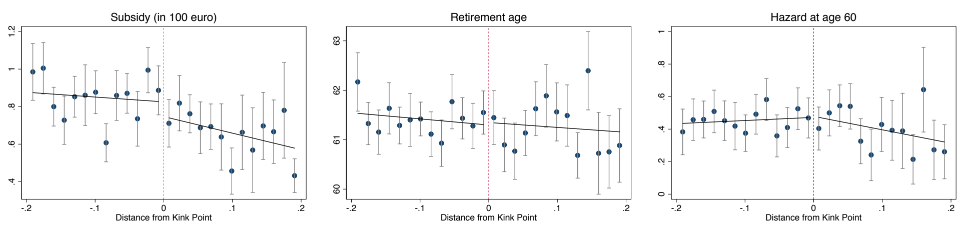
(a) Average EP 1 year after employment



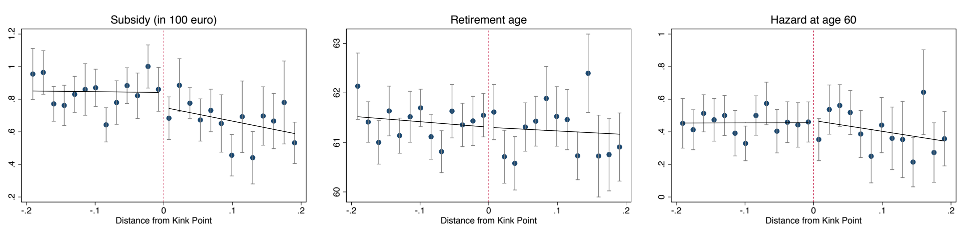
(b) Average EP 2 year after employment



(c) Average EP 3 year after employment



(d) Average EP 4 year after employment



(e) Average EP 5 year after employment

Figure A4 : Scatter plots around the kink using placebo forcing variables

Note: The scatter plots show the relationship between the placebo forcing variables — post-employment average annual earnings points — with subsidies, age of claiming pension and hazard to claim pension at age 60, respectively.

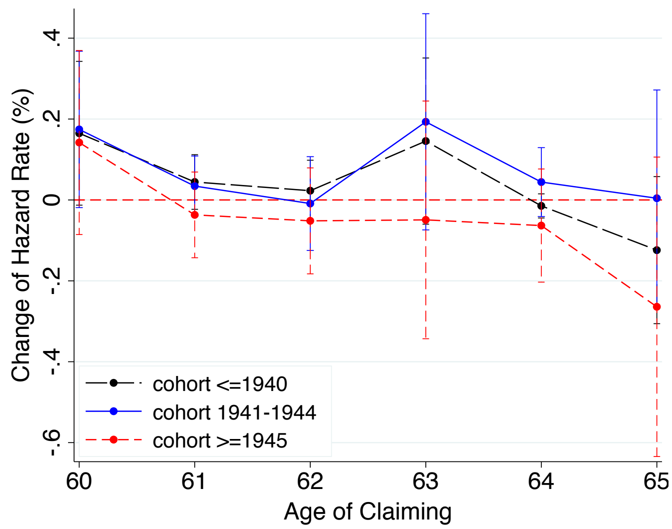


Figure A5: RKD estimates by cohort groups

Note: Figure A5 the estimated percentage change of hazard rate to claim a pension and the estimated change of hazard rate to exit employment at ages from 60 to 65 for three different cohort groups. They are 1) no-penalty group: cohort 1935 to 1940; 2) transitional group: cohort 1940 to 1944; 3) maximum-penalty group: cohort 1945 to 1951. This figure suggests that the impact on old cohorts are mostly on hazard to claim at 60 and 63, while the impacts for younger cohorts are mostly on hazard to claim at age 60 and age 65.

Table A1: RKD Estimates of the effect of pension subsidies: by different measure of treatment variables

	Age of claiming			Hazard rate at 60		
	(1)	(2)	(3)	(4)	(5)	(6)
First-stage	Subsidy Size	Subsidy Share	Total pension	Subsidy Size	Subsidy Share	Total pension
$\Delta \frac{dB}{dr}$ (2)	-521.4***	-0.674***	-525.6***	-521.4***	-0.674***	-525.6***
	(14.99)	(0.0292)	(18.35)	(14.99)	(0.0292)	(18.35)
Means at the kink	112.2	0.20	669.9	112.2	0.20	669.9
Sample means	89.2	0.16	672.4	89.2	0.16	672.4
Reduce-Form						
$\Delta \frac{dY}{dr}$ (1)		4.489***			-0.927***	
		(1.217)			(0.230)	
Means at the kink		60.86			0.43	
Sample means		61.35			0.38	
RKD estimator						
$\frac{dY}{dB}$ $\frac{(1)}{(2)}$	-0.0086***	-6.660***	-0.0100***	0.0018***	1.37***	0.0021***
	(0.0022)	(1.61)	(0.0004)	(0.0022)	(0.30)	(0.0008)
Controls	YES	YES	YES	YES	YES	YES
Cohort Fixed Effect	YES	YES	YES	YES	YES	YES
Observations	5605	5605	5605	5750	5750	5750
R^2	0.048	0.007	0.173	0.001	0.091	0.061

Notes: Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Treatments are subsidy size measured in 2010 euro, subsidy as a share of total pension and total pension size in 2010 euro. The results are from local linear regressions with a bandwidth of 0.2 EP around the kink for the baseline specification. Means at the kink are obtained when aep_{92} is within 0.1 EP around the kink.

Table A2: Impacts of pension subsidies on age of exiting

	Age of exiting regular employment			Age of exiting employment		
	(1)	(2)	(3)	(4)	(5)	(6)
First-stage						
$\Delta\frac{dB}{dr}$ (1)	-5.6240***	-5.6296***	-5.3798***	-5.6240***	-5.6296***	-5.3798***
	(0.2940)	(0.2808)	(0.1993)	(0.2940)	(0.2808)	(0.1993)
$\Delta\frac{dY}{dr}$ (2)	-0.4023	-0.3019	0.1865	4.3494	4.2372	4.8460
	(5.001)	(4.9841)	(4.6512)	(4.4284)	(4.4111)	(4.1229)
RKD estimator						
$\frac{dY}{dB}$ $\frac{(2)}{(1)}$	0.0715	0.0536	-0.0347	-0.7734	0.7527	-0.9001
	(0.8886)	(0.8848)	(0.8648)	(0.7928)	(0.7894)	(0.7718)
AIC	35776	35788	32547	31927	34907	34928
BIC	35795	35906	32723	32102	35025	34948
AICc	21020	21021	21021	21021	21021	21020
Means at the kink						
Subsidy size	108.74	108.74	108.74	108.74	108.74	108.74
Outcome variable	56.71	56.71	56.71	57.53	57.53	57.53
Sample means						
Subsidy size	90.29	90.29	90.29	90.29	90.29	90.29
Outcome variable	56.83	56.83	56.83	57.75	57.75	57.75
Controls	No	No	Yes	No	No	Yes
Cohort Fixed Effect	No	Yes	Yes	No	Yes	Yes
Observations	5218	5218	4912	5218	5218	4912
R^2	0.0002	0.0036	0.1683	0.0023	0.0120	0.1183

Notes: Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.Subsidies are measured in €100. The results are from local linear regressions with a bandwidth of 0.2 EP around the kink for the baseline specification. The standard error for RKD estimator is obtained from delta method.

Table A3: Placebo tests using average EP five years after exiting employment as the forcing variable

	Pension claiming age (1)	Employment exiting age (2)	Hazard rate at age 60 (3)
	Average EP 1 year after employment		
$\frac{dY}{dB}$	-1.0375	5.4465	2.1327
	(7.9755)	(20.0896)	(5.2783)
	Average EP 2 year after employment		
$\frac{dY}{dB}$	-0.0808	-0.0655	0.5217
	(2.1288)	(4.2719)	(0.6693)
	Average EP 3 year after employment		
$\frac{dY}{dB}$	-1.9119	-2.5791	1.0317
	(2.9564)	(5.7393)	(1.0544)
	Average EP 4 year after employment		
$\frac{dY}{dB}$	-2.3722	-3.8350	1.4814
	(3.4679)	(7.3996)	(1.4893)
	Average EP 5 year after employment		
$\frac{dY}{dB}$	-2.2762	-2.0570	1.2687
	(3.7713)	(7.2694)	(1.4869)

Notes: Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Subsidy is measured in €100. The bandwidth is 0.2 around the kink point 0.45 with 1st order polynomial. The table explores the robustness of the RKD results by using average EP after exiting employment as placebo forcing variables. Post employment EPs are correlated with post employment wage incomes, thus lifetime earnings but are not correlated to aep_{92} strongly. The results show that there are no effect in these placebo specifications.

Table A4: Heterogeneous RKD Estimates

Outcome variables		Age of claiming pension		Hazard to claim pension at 60		
ΔB = €100		$\frac{dY}{dB}$	p-value	$\frac{dY}{dB}$	p-value	Obs.
Subgroups						
Subsidy Size	High	-0.7172*	0.0971	0.2732***	0.0012	2634
		(0.3441)		(0.0800)		
	Low	0.3225		-0.1178		2269
		(1.444)		(0.3066)		
T_{92}	High	-0.5849*	0.6732	0.1758 ***	0.1069	2312
		(0.2367)		(0.0628)		
	Low	-1.4618		0.2227		2600
		(0.8007)		(0.1667)		
Sick period before age 50	Yes	-1.0307*	0.6036	0.2272 **	0.3603	1869
		(0.4372)		(0.0975)		
	No	-0.7498**		-1.3009		3043
		(0.2971)		(0.0722)		
More than 1 child	Yes	-1.0258***	0.1694	0.1925***	0.1185	3702
		(0.2865)		(0.0664)		
	No	-0.1122		-0.0055		1210
		(0.3610)		(0.0841)		
Cohort Fixed Effects		YES		YES		
Controls		YES		YES		

Notes: Standard errors are in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. The RKD estimates are the changes in outcome variable in response to an 100 €additional pension income from the subsidy. Subsidies are measured in €100. The results are from local linear regressions with a bandwidth of 0.2 EP around the kink for the baseline specification.The high subsidies group are recipients with subsidies above average (82 euro/month). High T_{92} group are recipients who contributed more than 20 years before 1992. I define the healthy group as workers who have never experienced any sick leave before age 50. Lastly, I look at recipients have more than one child. All regressions control for predetermined covariates and cohort fixed effect. The p-values are from a test of the hypothesis that the coefficients are equal within a category.

Table A5: RKD estimates by polynomial orders

	Age of claiming			Hazard rate at age 60		
	(1)	(2)	(3)	(4)	(5)	(6)
	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic
RKD estimator						
$\frac{dY}{dB}$ $\frac{(2)}{(1)}$	-0.8556***	-3.9487**	-11.5541	0.1710***	0.8101***	1.5606
	(0.2436)	(1.4978)	(7.7411)	(0.0567)	(0.3489)	(1.2990)
AIC	21020.485	21020.486	21020.9	6188.4008	6188.3959	6191.8902
BIC	21194.796	21207.709	21221.035	6362.769	6375.6802	6392.0907
AICc	21020.785	21020.832	21020.883	6188.7004	6188.7426	6192.2875
Controls	YES	YES	YES	YES	YES	YES
Cohort Fixed Effect	YES	YES	YES	YES	YES	YES
Obs.	4912	4912	4912	4912	4912	4912

Notes: Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Subsidy is measured in €100. The results are estimation results of Equation 4 with a bandwidth of 0.2 EP for a linear, a quadratic and a cubic specification. AIC is Aikake Information Criterion, BIC is Bayesian information criterion and AICc is AIC with a correction for small sample sizes.

Table A6: RKD estimates by bandwidth

	Age of claiming			Hazard rate at age 60		
			Bandwidth			
	(1)	(2)	(3)	(4)	(5)	(6)
	0.25	0.2	0.125	0.25	0.2	0.125
RKD estimator						
$\frac{dY}{dB}$ $\frac{(2)}{(1)}$	-0.6750***	-0.8556***	-1.2850**	0.1293 **	0.1710 **	0.2937**
	(0.1923)	(0.2436)	(0.4578)	(0.4415)	(0.0567)	(0.1092)
AIC	22521.89	21020.48	15536.50	6628.88	6188.40	4622.095
BIC	22698.12	21194.79	15702.76	6805.18	6362.76	4788.5138
AICc	22522.17	21020.78	15536.91	6629.16	6188.70	4622.498
Controls	YES	YES	YES	YES	YES	YES
Cohort Fixed Effect	YES	YES	YES	YES	YES	YES
Obs.	5048	4912	3490	5274	4912	3651

Notes: Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Subsidy is measured in €100. The results are obtained from linear specifications of Equation 4 for a bandwidth of 0.25, 0.2 and 0.125. AIC is Aikake Information Criterion, BIC is Bayesian information criterion and AICc is AIC with a correction for small sample size.)

Table A7: RKD Estimates of the effect of pension subsidies by cohort groups

	Pension claiming age				Hazard rate at age 60		
	(1)	(2)	(3)		(4)	(5)	(6)
	≤ 1940	1941-1944	≥ 1945		≤ 1940	1941-1944	≥ 1945
RKD estimator							
$\frac{dY}{dB}$	-0.5718	-0.6518	-1.2579*		0.1649*	0.1743*	0.1420
	(0.3187)	(0.4108)	(0.5670)		(0.0907)	(0.0986)	(0.1160)
Controls		YES	YES	YES		YES	YES
YES							
Cohort Fixed Effect	YES	YES	YES		YES	YES	YES
Obs.	1372	1574	1784		1390	1598	1792

Notes: Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Subsidy is measured in €100. The results are from local linear regressions with a bandwidth of 0.2 EP around the kink for the baseline specification. The standard error for RKD estimator is obtained from delta method.

Table A8: RKD Estimates of the effect of pension subsidies by sample construction

Panel A:

ΔB =€100	Pension claiming age					Hazard rate at age 60				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	from 60	from 61	from 62	from 63	from 64	from 60	from 61	from 62	from 63	from 64
$\frac{dY}{dB}$	-0.6318***	-0.6579***	-0.7582***	-0.8556***	-0.8513***	0.1509***	0.1544***	0.1623***	0.1714***	0.1667***
	(0.2690)	(0.2554)	(0.2499)	(0.2436)	(0.2475)	(0.0023)	(0.0506)	(0.0528)	(0.0568)	(0.0569)
Sample means										
outcomes	60.83	60.98	61.16	61.38	61.62	0.36	0.37	0.37	0.38	0.38
subsidy	81.26	81.64	83.34	82.95	83.71	81.26	81.64	83.34	82.95	83.71
Obs.	7382	6974	6389	4703	4630	9163	8241	7221	4912	4833
R^2	0.116	0.096	0.056	0.048	0.054	0.096	0.090	0.091	0.091	0.091

Panel B:

ΔB =€100	Adjusted pension claiming age					Adjusted Hazard rate at age 60				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	from 60	from 61	from 62	from 63	from 64	from 60	from 61	from 62	from 63	from 64
$\frac{dY}{dB}$	-0.4278***	-0.4598***	-0.6711***	-0.8570***	-0.8513***	0.1534***	0.1572***	0.1656***	0.1790***	0.1667***
	(0.2364)	(0.2332)	(0.2336)	(0.2436)	(0.2475)	(0.0513)	(0.0531)	(0.0538)	(0.0585)	(0.0569)
Sample means										
outcomes	60.83	60.98	61.16	61.38	61.62	0.36	0.37	0.37	0.38	0.38
subsidy	81.26	81.64	83.34	82.95	83.71	81.26	81.64	83.34	82.95	83.71
Obs.	9163	8241	7221	4912	4833	9146	8224	7204	4894	4815
R^2	0.116	0.096	0.056	0.048	0.054	0.096	0.090	0.091	0.091	0.091

Notes: Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.Subsidies are measured in €100. The results are from local linear regressions with a bandwidth of 0.2 EP around the kink for the baseline specification. The standard error for RKD estimator is obtained from delta method. Columns 1 to 5 are the impacts on retirement age for sample constructed for workers who are at least 60 at the survey year, at least 61, 62, 63 and 64. Columns 6 to 10 are the impacts on hazard rate of claiming pension at age 60. Panel B reports the results for adjusted retirement age and adjusted hazard rate at age 60.

Table A9: RKD Estimates using the legal kink

Panel A:						
ΔB =€100	Age of claiming			Hazard to claim at age 60		
	(1)	(2)	(3)	(4)	(5)	(6)
$\frac{dY}{dB}$	-0.4829	-0.5466†	-0.4001	0.0987	0.1177†	0.0919
	(0.2960)	(0.2843)	(0.2753)	(0.0712)	(0.0676)	(0.0665)
Controls	No	No	Yes	No	No	Yes
Cohort Fixed Effects	No	Yes	Yes	No	Yes	Yes
Obs.	4961	5367	5367	5367	5367	4961

Panel B:						
ΔB =€100	Age of exiting			Hazard to exit at age 60		
	(1)	(2)	(3)	(4)	(5)	(6)
$\frac{dY}{dB}$	-0.3614	-0.4446	-0.2913	0.05138	0.0828	0.0874
	(0.9367)	(0.9176)	(0.8042)	(0.0946)	(0.0853)	(0.0826)
Controls	No	No	Yes	No	No	Yes
Cohort Fixed Effects	No	Yes	Yes	No	Yes	Yes
Obs.	5367	5367	4961	5315	5315	4919

Notes: Standard errors in parentheses sym† $p < 0.10$ * $p < 0.05$ .Subsidies are measured in €100. The results are from local linear regressions with a bandwidth of 0.2 EP around the $aep_{92} = 0.5$ for the baseline specification. The standard error for RKD estimator is obtained from delta method.