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Arthur Seibold

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Reference Points for Retirement Behavior: Evidence from German Pension Discontinuities

Abstract

This paper documents and analyzes an important and puzzling stylized fact about retirement behavior: the large concentration of job exits at specific ages. In Germany, almost 30% of workers retire precisely in the month when they reach one of three *statutory retirement ages*, although there is often no incentive or even a disincentive to retire at these thresholds. To study what can explain the concentration of retirements around statutory ages, I use novel administrative data covering the universe of German retirees, and I exploit unique variation in financial retirement incentives as well as statutory ages across individuals in the German pension system. Measuring retirement bunching responses to 644 different discontinuities in pension benefit profiles, I first document that financial incentives alone fail to explain retirement patterns in the data. Second, I show that there is a large direct effect of "presenting" a threshold as a statutory retirement age. Further evidence on mechanisms suggests the framing of statutory ages as reference points for retirement as a potential explanation. A number of alternative channels including firm responses are also discussed but they do not seem to drive the results. Finally, structural bunching estimation is employed to estimate reference point effects. Counterfactual simulations highlight that shifting statutory ages via pension reforms can be an effective policy to increase actual retirement ages with a positive fiscal impact.

JEL-Codes: D030, H550, J260.

Keywords: retirement, reference points.

Arthur Seibold
University of Mannheim / Germany
seibold@uni-mannheim.de

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1 Introduction

For many countries, population aging poses looming questions over the fiscal sustainability of public pension systems. The average OECD country already spends 8% of GDP or 18% of total public expenditure on pensions (see OECD 2015). The old-age dependency ratio, measuring the number of individuals aged 65 and above relative to the working-age population, is projected to rise from currently 27% to 49% by 2050. In addressing these issues, a widely shared policy goal is to extend the working lives of the elderly population.

While standard economic models prescribe the design of appropriate financial incentives to influence labor supply at old age, much of the public debate on pension reform revolves around a different policy: *statutory retirement ages*. Such age thresholds are used by typical public pension systems to frame benefit rules. They may include an Early Retirement Age and a Normal Retirement Age, and they usually define retirement ages relative to which benefits are calculated. Figure 1 documents the prominent role of statutory ages for retirement behavior, showing that the distribution of job exits of German workers is strongly concentrated around them. There are sharp spikes in job exits at the main statutory ages 60, 63 and 65.[1] In total, 29% of job exits at age 55 and above occur precisely in the month when the worker reaches a statutory age.

The spikes in retirement at statutory ages are not only large, but also puzzling from the point of view of standard labor supply models. To preview this, consider the stylized lifetime budget constraint in figure 2. Most workers face a reduction in the marginal return to work, i.e. an incentive to stop working, at ages 60 and 63, but a disincentive to retire at age 65. Nevertheless, large bunching occurs at all three ages. Similarly, retirement bunching at statutory ages has been observed in countries including the U.S. and the U.K. (e.g. Mastrobuoni 2009; Cribb et al. 2016), and this phenomenon has been coined a “retirement puzzle” (Lumsdaine et al. 1996, Rust and Phelan 1997).

This paper asks what can explain the concentration of retirement around statutory ages. To address this question, I estimate bunching responses to more than 600 benefit discontinuities in the German public pension system, using administrative data on the universe of retirees. The analysis finds that financial incentives alone cannot explain retirement patterns, but there is a large direct effect of statutory ages. Moreover, I show evidence suggesting that this “statutory age effect” is driven by the framing of statutory ages as reference points for retirement. Using a model of retirement with reference points for counterfactual simulations, I demonstrate that shifting statutory ages can be an effective policy tool to influence retirement behavior and such reforms can generate a positive fiscal impact.

As the empirical setting, the German public pension system provides three key advantages. First, there is rich variation in financial incentives and in the location of statutory retirement ages arising due to two sources: There are six pathways into retirement entailing different benefit profiles, and a series of pension reforms provide additional cohort-based variation at the monthly

[1] Note that different statutory ages apply to workers depending on their birth cohort and characteristics such as gender and contribution histories.

level. This creates 644 discontinuities in pension benefits over the sample period, corresponding to kinks and notches in lifetime budget constraints. Discontinuities vary in the size of the local financial incentive, ranging from sizeable incentives for retirement to disincentives. The second advantage is that some discontinuities, namely statutory retirement ages, are framed as reference points for retirement, while others are "pure financial incentives". Statutory ages are linked to notions such as a "normal" retirement date, and losses and gains in pension benefits are defined relative to a reference level at statutory ages. Taken together, this independent variation allows me to disentangle responses to underlying financial incentives and the direct effect of presenting a threshold as a statutory age. In addition, discontinuities vary in the characteristics of affected workers and in their age locations, allowing to control for heterogeneity along these dimensions.

The third advantage of the empirical setting is that high-quality administrative data is available to exploit this fine-grained variation. The analysis is based on a novel data set provided by the German State Pension Fund, covering the universe of workers who retired between 1992 and 2014. The main sample contains 8.6 million individuals. The data includes a rich set of worker characteristics related to earnings careers and pension eligibility, based on which monthly job exits and individual lifetime budget constraints can be calculated.

I divide the analysis in the paper into three parts. The first part of the paper uses bunching methods to estimate retirement responses to the 644 benefit discontinuities. Two main results are established. First, financial incentives alone fail to explain retirement patterns. There are large responses to statutory ages even if there is a close to zero or negative financial incentive to retire at the discontinuity. Large differences in bunching responses across types of discontinuities can also not be explained by differences in financial incentives. Second, presenting a threshold as a statutory retirement age directly affects retirement behavior. At all types of statutory ages and irrespectively of kink sizes, large additional bunching occurs compared to pure financial incentive discontinuities.

These results emerge from two complementary approaches. In the first approach, I focus on a few cases of specific discontinuities that lend themselves to natural comparison. For instance, the same group of workers is shown to respond much more to an Early Retirement Age kink than to a pure financial incentive notch, although the notch entails a larger financial incentive to retire. Moreover, workers respond more strongly to a Full Retirement Age kink than to a pure financial incentive kink of similar size occurring at the same retirement age in a similar pathway. In the second approach, I use the full set of discontinuities to generalize the results. The average observed elasticity of the retirement age w.r.t. the net-of-tax rate across all 386 statutory age kinks in the data is 0.49, which is seven times larger than the average observed elasticity of 0.07 across the 258 pure financial incentive discontinuities.

I also propose a reduced-form strategy that combines the large number of bunching estimates in a regression to jointly estimate the response to financial incentives and the effect of statutory ages. The identification assumption is that responses to different types of discontinuities are driven by the same underlying parameters. Estimated statutory age effects are large and significant, and the net-of-tax elasticity of around 0.04 is modest. Results are robust to controlling for heterogeneity in observable characteristics in a variety of ways.

The second part of the paper explores mechanisms behind the reduced-form "statutory age effect", and argues that the framing of statutory ages as reference points for retirement provides a plausible mechanism. I begin by showing evidence from two reforms. The first reform increases the Full Retirement Age for women. Large bunching moves in lockstep with the statutory age while it is increased by one month for each month of birth over a five-year period. This indicates that the effect of statutory ages is indeed due to the government setting them at a certain age, and statutory ages can be effectively manipulated. In addition, I exploit a second reform where the frequency of information letters sent to workers is substantially increased. After the reform, more workers retire at a specific statutory age around which explanations in letters are framed, suggesting that framing can affect retirement behavior. On the contrary, information in the letters about benefit calculation does not seem to affect responses to financial incentives.

A number of potential alternative mechanisms are also discussed. To begin with, laying off older workers at statutory ages is sometimes cited as a way for firms to avoid firing costs. However, results from a number of checks suggest that such firm responses do not drive much of the results. For instance, self-employed workers and those in small firms below the employment protection threshold also bunch strongly at statutory ages. I also show that excluding those statutory ages where mandatory retirement is possible does not change the remaining results. Moreover, two patterns in the data speak against a different alternative mechanism driven by mistakes or inattention. First, retiring at statutory ages is positively associated with worker characteristics commonly used to proxy for financial literacy, including education, economic training and income. Second, the response to statutory ages is not diminished when a worker's stake in the retirement decision, e.g. measured by the size of their pension wealth relative to earnings, increases.

The third part of the paper turns to an interpretation of the empirical results in a simple model of retirement featuring statutory ages as reference points. As is commonly done in the literature, reference dependence is modeled as a discontinuity in marginal utility. More specifically, marginal disutility from continuing work changes at the reference point. This corresponds to a situation where workers perceive a statutory age as a reference point for their retirement age, for instance because it is framed as a "normal" time to retire. The framework predicts sharp retirement bunching at a reference point independently of financial incentives, and yields a straightforward relationship between the amount of bunching and underlying utility parameters governing reference dependence.

Based on the results from the theoretical framework, structural bunching estimation across multiple discontinuities can be employed to obtain estimates of the reference dependence parameters. The estimation exploits the same variation in statutory ages and financial incentives across discontinuities used in the reduced-form analysis. Estimated utility kinks are large and significant, with magnitudes equivalent to local changes in the implicit tax rate of between 44% and 113%. Furthermore, the estimates imply that least two thirds of actual statutory age retirements in the data are attributed to reference point effects.

Finally, the simulation of policy counterfactuals highlights an important policy implication: Reforms shifting statutory ages are effective in influencing retirement behavior and can generate a positive fiscal impact, but this would be more difficult to achieve via financial incentives. First, an increase in the Normal Retirement Age from 65 to 66 is predicted to lead to an increase in average actual retirement ages by 4 months. Second, I simulate the effect of a "delayed retirement credit" providing stronger financial incentives for late retirement. In order to match the average effect of the first scenario, rewards for late retirement would have to be more than doubled from their current level. Although both policies have the same effect on average retirement ages, the fiscal impact is very different: The increase in the Normal Retirement Age entails a net fiscal gain +€675m for one birth cohort, whereas the increase in financial rewards would lead to a net fiscal loss of -€465m. The difference in fiscal effects arises because workers pay pension contributions for longer in both scenarios, but in contrast to the second scenario, shifting statutory ages induces workers to retire later without having to increase pension benefits at older retirement ages.

This paper contributes to three strands of literature. First, I contribute to the empirical literature on retirement behavior. A number of studies estimate the effects of pension reforms involving statutory retirement ages, but evidence on the *direct* effect of statutory ages is scarce. For instance, Staubli and Zweimüller (2013) and Manoli and Weber (2018) find sizeable effects of an Early Retirement Age increase using Austrian administrative data. Importantly, this type of reform simultaneously changes statutory ages and the financial incentives linked to them, such that the total reform effect is a mix of the two.[2] Brown (2013) and Manoli and Weber (2016) analyze retirement responses to pure financial incentives. Conceptually, the most closely related work to this paper is by Behaghel and Blau (2012) who argue that the Full Retirement Age can induce loss aversion and document spikes in benefit claiming in U.S. survey data.[3] Relative to these complementary approaches, I leverage a unique setting combining rich, independent variation in statutory ages and financial incentives and full-population administrative data. To my knowledge, this paper is the first to systematically quantify the large, direct effect of statutory retirement ages on job exit behavior. Moreover, I present new evidence in favor of a behavioral mechanism and estimate corresponding reference point effects.

Second, I contribute to a growing literature on the role of reference points in field settings. Allen et al. (2017) investigate bunching at round numbers as reference points for marathon runners, and Rees-Jones (2018) studies bunching among loss averse tax filers. Building on these approaches, this paper takes the use of bunching methods further and estimates underlying reference dependence parameters by exploiting variation in financial incentives and statutory retirement ages across

[2]Similar recent studies estimating the total effects of pension reforms involving statutory ages and financial incentives include Mastrobuoni (2009), Lalive and Staubli (2015), Cribb et al. (2016), and Fetter and Lockwood (2018).

[3]In addition, some studies present survey and experimental evidence in favor of framing effects or reference dependence in intended retirement behavior, including Brown et al. (2013), Merkle et al. (2017) and Shoven et al. (2017).

multiple discontinuities.[4] The bunching approach is complementary to full structural approaches such as DellaVigna et al. (2018) who study reference-dependent job search, and Thakral and Tô (2019) who analyze adaptive reference points of taxi drivers. Moreover, while existing studies tend to focus on "natural" reference points such as the status quo and round numbers, this paper highlights that reference points can be induced or affected by policy.

Third, this paper builds on and contributes to the literature on bunching methods (Saez 2010; Chetty et al. 2011; Kleven 2016). Studies such as Kleven and Waseem (2013), Bastani and Selin (2014) and Gelber et al. (2019) emphasize the importance of contextual factors in determining responses, mostly focusing on optimization frictions. Estimating bunching at many discontinuities, this paper shows that reference points can magnify bunching responses and highlights that bunching methods can be used to estimate related preference parameters.

The remainder of this paper is organized as follows. Section 2 outlines context and data, section 3 describes the empirical methodology, section 4 presents reduced-form evidence, section 5 explores mechanisms behind the statutory age effect, section 6 develops the conceptual framework, section 7 presents the estimation and counterfactuals, and finally, section 8 concludes.

2 Context and Data

2.1 The German Public Pension System

Germany has a pay-as-you-go pension system that covers the vast majority of workers in the country (86% of the labor force in 2014). Enrolment is mandatory for private-sector employees, but most self-employed workers and civil servants are exempt. Contributions are levied as a payroll tax on gross earnings. Benefits are defined according to a pension formula based on a worker's lifetime contribution history.[5] Hence, pensions are roughly proportional to lifetime income and the system is characterized by relatively little redistribution. The average replacement rate is 50% (OECD 2015). Public pensions are the main source of income for most recipients.[6] Moreover, there is a relatively strict earnings test for pension recipients where earnings above €450 per month lead to reductions in benefit payments. Only 2.5% of workers in the data have any income from employment while receiving a pension, making retirement an absorbing state for most.

The system features three types of statutory retirement ages. First, the *Early Retirement Age (ERA)* is the earliest age from which a pension can be claimed. Second, the *Full Retirement Age*

[4] Existing bunching approaches including Allen et al. (2017) and Rees-Jones (2018) are unable to recover underlying reference dependence parameters, as suitable variation to estimate the curvature of the cost of effort function is not available in those settings (see DellaVigna 2018).

[5] Appendix B provides additional details on benefit calculation and other aspects of the institutional setting. See also Börsch-Supan and Schnabel (1999) and Börsch-Supan and Wilke (2004) for a more comprehensive overview.

[6] See Heien et al. (2005). In 2003, 11% of retirees reported to receive any income from employer pension schemes and only 1% had a private pension, and the average income from those sources is small relative to public pensions. Among retirees with any employer pension income, the employer pension amounts to 34% of their public pension on average. The corresponding figure for private pensions is 23%. The numbers seem to increase somewhat for younger cohorts, but remain small throughout the sample period.

(FRA) is the age from which workers can claim their *full pension*. Third, the *Normal Retirement Age (NRA)* is the age from which workers can get more than their full pension.[7]

Discontinuous Benefit Rules. The key advantage of the empirical setting is that there are more than 600 pension discontinuities. At their source lie three types of discontinuous pension benefit rules. First, pension adjustment changes discontinuously at statutory retirement ages. A full pension level is defined at the FRA, and there are permanent benefit reductions for workers claiming before the FRA as well as permanent benefit increases for claiming after the NRA. The adjustment function follows a kinked schedule, with a penalty of 0.3% for each month of retirement before the FRA, no adjustment between the FRA and the NRA, and a reward of 0.5% for each month of retirement after the NRA.

Second, workers become eligible for discontinuously higher pensions at some contribution thresholds, where they qualify for more generous "pathways" into retirement. Pathways are summarized in table 1. Receiving a pension from the regular pathway requires only 5 years of contributions. In order to qualify for a more generous pathway, workers must have contributed for longer and/or satisfy other requirements such as gender, disability and periods of unemployment. Specifically, at 15 and 35 years of contributions, workers become eligible for pathways with ERAs between 60 and 63, and FRAs between 60 and 65. Workers can receive a pension earlier (i.e. for more years) and their pension is higher at any given age due to more favorable adjustment, which implies a discontinuous increase in pension wealth. Finally, the third type of discontinuous pension rule occurs in a special pathway without statutory retirement ages where pensions can be claimed at any age. The disability pathway has a low contribution requirement of only 5 years, but a relatively strict disability requirement. In this pathway, benefits are increased by 0.3% per month for retiring between 60 and 63, with no further adjustment when claiming before 60 and after 63.[8]

Framing of Statutory Retirement Ages. Statutory ages are one source of pension discontinuities, but the way they are presented to workers differs fundamentally from "pure" financial incentives. Figure 3 provides an example of the framing of statutory ages from a leaflet designed to inform workers about a future pension reform that increases the NRA to 67. Two features stand out. First, statutory ages are more or less directly suggested as retirement dates. The title "retirement at 67" refers to the post-reform NRA at age 67 - this is in fact a commonly used nickname for this reform. Using a hypothetical worker ("Maria F."), readers are then told that if they want to retire "early" they can retire at the ERA, but if they wish a full pension, they should retire at the FRA. Second, workers are warned of losses if they retire before the FRA ("the penalty will remain for her entire retirement").

The example illustrates how statutory ages are *framed as reference points*. By invoking notions

[7] The distinction between a FRA and a NRA is somewhat peculiar to the German system. Essentially, the FRA allows some workers to claim a "full pension" before the NRA if they satisfy certain requirements. However, all workers can claim more than their full pension only after the NRA.

[8] Moreover, contribution points are credited in the disability pathway as if the individual had continued working until age 60, making benefits less dependent on their contribution history.

such as "early" and "normal" retirement ages, statutory ages are presented as regular times to retire. Moreover, pension adjustment is framed as a loss (penalty) or gain (reward) relative to a "full" reference level linked to a statutory age. In other words, statutory ages are presented as reference points in terms of retirement dates, and early and late retirement as well as losses and gains in benefits are defined relative to them.[9] This type of framing of retirement dates has been shown to affect reported retirement plans in experimental settings (e.g. Brown et al. 2013, Merkle et al. 2017).

2.2 Lifetime Budget Constraint Discontinuities

In order to see how the pension system affects incentives for the timing of retirement, the net present value of a worker i's net lifetime income can be written as a function of her retirement (job exit) age R_i:

$$NPV_i(R_i) = \sum_{t=0}^{R_i-1} \delta^t w_{it}(1-\tilde{\tau}_{it}) + \sum_{t=\max(R_i, ERA)}^{T_i} \delta^t B_i(R_i) \tag{1}$$

The worker earns a gross wage w from starting age 0 to the period before retirement, which is subject to income tax and social insurance contributions summarized in $\tilde{\tau}$. Pension benefits B depend on R both via contributions paid until retirement and via pension adjustment. Benefits can be claimed from the job exit age if the worker has already reached her ERA (and from the ERA otherwise) and are paid until time of death T.[10] Finally, all payments are discounted at factor $\delta = \frac{1}{1+r}$, where r is the interest rate.

To satisfy the lifetime budget constraint, lifetime consumption possibilities C equal net lifetime income. The slope of the budget constraint, that is the marginal gain in lifetime consumption from delaying retirement by one period, defines the implicit net wage $w^{net} = \frac{dC}{dR}$. Expressing the consumption gain as a fraction of gross earnings, the *implicit net-of-tax rate* can be calculated as $1 - \tau = \frac{w^{net}}{w}$. In general, delaying retirement affects consumption in three ways. First, the worker gains an additional period of wage earnings. Second, she sees a permanent change in her benefit eligibility $\frac{dB}{dR}$. In the German case $\frac{dB}{dR}$ is always strictly positive, since later retirement implies both more favorable pension adjustment and a larger sum of contribution points. Third, if she is already eligible to claim benefits, there is an opportunity cost of work in terms of foregoing one period of benefits.

Figure 2 shows a stylized version of the lifetime budget constraint. The discontinuous benefit rules described in section 2.1 introduce discontinuities into the budget constraint:

Kinks at Statutory Retirement Ages. There are convex kinks, i.e. reductions in the marginal net-of-tax rate, at the ERA and the FRA. Moreover, there is a non-convex kink, i.e. an

[9] More generally, statutory ages play a crucial role in the way pensions and retirement are presented to workers. While different pathways effectively entail different benefit levels for any given retirement age, the distinction between pathways is presented via different statutory ages rather than directly in terms of benefit levels. Major pension reforms are equally presented as changes to statutory ages rather than the changes to benefit levels that they effectively entail.

[10] For simplicity, T_i is assumed to be known.

increase in the marginal return to work, at the NRA.[11] The kinks at the FRA and NRA are a direct consequence of discontinuous pension adjustment, where marginal adjustment decreases from 3.6% p.a. to 0 at the FRA and increases from 0 to 6% p.a. at the NRA. The kink at the ERA arises due to a combination of pension adjustment and an additional opportunity cost of working, since workers start foregoing benefits from the ERA onwards.[12]

Pure Financial Incentive Discontinuities: Contribution Notches and Disability Kinks. There are two sources of *pure financial incentive discontinuities*. First, contribution requirements of different pathways create budget constraint discontinuities in the form of notches, i.e. jumps in the average net-of-tax rate. In figure 2, for instance, the worker reaches 35 years of contributions when working until age 58, where he becomes eligible for the long-term insured pathway with higher implied pension wealth. Similarly, workers face notches when they become eligible for other pathways at 5, 15 and 35 years of contributions.[13] Note that the age location of these notches is worker-specific since it depends on the individual career starting age. As a second source of pure financial incentive discontinuities, the kinks in the benefit schedule of the disability pathway imply budget constraint kinks, where the marginal net-of-tax rate changes due to changes in marginal pension adjustment.

2.3 644 Discontinuities

Two sources of variation generate more than 600 budget constraint discontinuities.[14] First, the six different pathways described in table 1 differ in statutory ages and contribution requirements. Second, a series of cohort-based pension reforms have been enacted since the early 1990s. Figure 4 shows the evolution of ERAs and FRAs for birth cohorts 1933 to 1949. In addition to cross-sectional variation, statutory ages were changed in different pathways at different times. For instance, the women's FRA was increased from 60 to 65 for cohorts 1940 to 1944. This was done gradually: the FRA increases by one month for each month of birth in the reform cohort window. Similar gradual changes to the ERA and FRA were also implemented in all other pathways.

In total, this yields 386 distinct budget constraint kinks linked to statutory ages. Contribution notches and disability kinks amount to a total of 258 pure financial incentive discontinuities. Combining variation across pathways, cohorts and age groups yields a total of 180 contribution notches. Including a gradual introduction period, there are 78 disability pension kinks. To illustrate the variation, appendix figure A2 provides some examples. In panel A, a female worker born in December 1942 faces an ERA at age 60, a FRA at 63, a NRA at 65 and a contribution notch at

[11] An exception is the regular pathway where the ERA coincides with the NRA. In this case, there is a convex kink at the ERA/NRA.

[12] The ERA kink could be smoothed out by actuarially fair adjustment of pensions. However, the actual adjustment of 3.6% annually is less than actuarially fair (see Börsch-Supan and Wilke 2004).

[13] The notches at 5 years of contributions are not used in this paper because the data on workers with less than 5 years of contributions is incomplete.

[14] See appendix D.2 for the a complete list of all discontinuities used. This paper refers to both kinks and notches as budget constraint discontinuities. Of course, kinks are discontinuities in the marginal net-of-tax rate, but notches are discontinuities in the average net-of-tax rate.

age 58. In panel B, a male worker born in March 1939 faces a notch at the age of 61 years and 4 months, and statutory ages at 63 and 65. In panel C, a worker born in January 1946 who satisfies a disability requirement faces a pure financial incentive kink at age 63.

Table 2 summarizes the 644 budget constraint discontinuities. At statutory retirement ages, there is strong heterogeneity in underlying kink sizes. At ERAs and FRAs, the average kink size is between 0.22 and 0.25, i.e. the net-of-tax rate decreases between 22% and 25% at the threshold. On the other hand, NRAs feature sizeable non-convex kinks of average size -0.50. The average kink size is across all statutory ages is 0.04. Across the 258 pure financial incentive discontinuities, the average change in the net-of-tax rate is 0.42, where the contribution notches entail a slightly larger average kink size of 0.44. A further advantage of the setting is that there is substantial variation in kink sizes across discontinuities of a given type. For instance, the standard deviation of kink sizes at FRAs is 0.23. There is also some within-group variation in effective kink sizes due to different individual earnings histories, but the within-group standard deviations are small.

2.4 Data

The analysis is based on a novel set of administrative data covering the universe of retirees who claim a public pension between 1992 and 2014. The main data set is assembled from 23 single-year cross sections provided by the German State Pension Fund.[15] The sample is limited to workers in the six main pathways who claim a pension for the first time between ages 55 and 67, have earned at least 5 contribution points from at least 5 years of contributions and do not continue work after retirement. Moreover, East Germans retiring in 1995 and earlier are excluded since their pension was calculated under a particular set of post-reunification rules. In order to have sufficient parts of each cohort's retirement age distribution available, the analysis focuses on workers born between 1933 and 1949. After applying those restrictions, the *individual sample* contains around 8.6 million observations.

The data includes all variables necessary for the pension fund to determine a worker's pension eligibility as well as a number of socioeconomic characteristics. Monthly benefit claims and last contributions can be directly observed. The month of job exit can be inferred from the time of the last contribution for most of the sample. For those workers where the last contribution does not coincide with employment, the time of job exit is imputed using additional information on the insurance status in the last three years before retirement. Lifetime earnings and average annual earnings are backed out using information on contribution periods and contribution points,[16] and a pension benefit simulator is built to calculate each individual's benefit eligibility across possible retirement ages. Lifetime budget constraints are simulated as a version of equation (1) with a 3% discount rate and heterogeneous life expectancies by gender and year of birth. In order to account for the fact that observed take-up of pathways may reflect workers' choices, pathways are assigned

[15]See appendix C for details of the data, key variables and other definitions.

[16]Contribution points are generally proportional to gross earnings. The only caveat is top-coding of earnings above the contributions cap.

in terms of eligibility as far as possible.

In addition, survey data from the German Socioeconomic Panel (SOEP) is used for part of the analysis. SOEP is an unbalanced panel of around 1.4 million individual-year observations spanning the period 1984 to 2013. It contains a wide range of socioeconomic variables including labor market outcomes. Variables of interest are collapsed at the three-digit occupation level and merged with the main data where occupation can be observed from 2000 onwards. This sample is referred to as the *occupation-matched sample*.

As explained in section 2.3, pension discontinuities differ across pathways and cohorts. In practice, workers can be grouped by pathway and year of birth to capture this variation. Workers born during reform periods where policy varies at the monthly level are grouped by pathway and month of birth instead. The sample split yields 375 groups each of whom faces a distinct set of statutory ages and lifetime budget constraint discontinuities. When analyzing contribution notches, groups by pathway and year of birth are further divided into those retiring at ages 55 to 60 and 60 to 65 in order to capture variation of notch sizes with retirement age. For the analysis across discontinuities, bunching observations are collected in the *bunching sample*, where each of the 644 observations represents a discontinuity faced by a particular group of workers. Table 3 shows summary statistics for the individual sample in column (1), for the occupation-matched sample in column (2) and for the bunching sample in column (3). The average job exit age is around 61, and the time between the first and last contribution is around 44 years. Just below half of the sample are female and three quarters are married. These and other key observables are relatively balanced across the different samples.

3 Empirical Methodology

3.1 Basic Bunching Method

The first step of the empirical analysis is to measure retirement responses at each discontinuity. The bunching method developed by Saez (2010) and Chetty et al. (2011), which can be applied to the retirement age distribution,[17] provides a way of detecting such responses. A bunching strategy is naturally suited to the context of this paper, since excess retirements can measure both responses to budget constraint discontinuities and any other impact of certain thresholds on retirement. The bunching mass B at an age threshold $\hat{R}$ can be measured as the observed local spike in the density of retirement ages above a counterfactual density $h_0(\hat{R})$. The standard approach to estimate $h_0(\hat{R})$ is to fit a flexible polynomial to the observed density excluding the threshold. The excess mass $b = B/h_0(\hat{R})$ is computed as the bunching mass relative to the counterfactual. While B measures the absolute number of excess retirements at $\hat{R}$, b expresses bunching in multiples of the counterfactual and can be compared across thresholds.

Assuming that the density would have been smooth in the absence of the threshold,[18] bunching

[17]See e.g. Brown (2013) and Manoli and Weber (2016) for previous work on retirement bunching.

[18]The empirical implementation allows for round number effects at the threshold in addition. See appendix D.1

can be interpreted in terms of a local retirement response. A standard approach focused only on responses to financial incentives then computes an elasticity by relating the excess mass to the kink size $\frac{\Delta\tau}{1-\tau}$, defined as the local percentage change in the implicit net-of-tax rate. The elasticity of the retirement age with respect to the net-of-tax rate can be calculated as

$$\hat{\varepsilon} = \frac{b/\hat{R}}{\Delta\tau/(1-\tau)} \tag{2}$$

The formula is based on the insight that the excess mass is directly related to the labor supply response of the marginal bunching individual (Saez 2010), i.e. $b \approx \Delta R$. Elasticities computed according to (2) are referred to as *observed elasticities* for the remainder of the paper.

3.2 Estimation Using Multiple Bunching Observations

The observed elasticity $\hat{\varepsilon}$ corresponds to a structural labor supply elasticity in a frictionless model without any responses to non-price factors. In such a model, bunching is only a function of the elasticity and a vector of observable variables x related to the threshold, including the counterfactual density and the kink size. Following the notation of Kleven (2016), $B = B(\varepsilon, x)$, and ε can be estimated from bunching at a single discontinuity as above. However, recent literature has moved towards estimating additional parameters to explain differences in bunching across kinks. Writing bunching at threshold i as $B_i = B(\varepsilon, \omega, x_i)$, where ω is a vector of k additional parameters, identification requires observing $n \geq k+1$ bunching moments. If $n = k+1$, the implied system of n equations has an exact solution given the set of observed bunching moments. In this paper, bunching is observed at many discontinuity, such that $n > k+1$ and parameters can be estimated across "bunching observations" B_i.

Specifically, this paper is interested in estimating the direct effect of statutory ages on bunching, which is later interpreted in terms of reference dependence. Denoting D_i an indicator for the presence of a statutory age at threshold i,

$$B_i = B(\varepsilon, \omega(D_i), x_i) \tag{3}$$

Hence, statutory ages directly affect bunching via ω. Parameters can be identified when bunching is observed at sufficiently many thresholds that vary in D_i and x_i under the following assumption:

ASSUMPTION A. $E(\varepsilon_i | D_i) = \varepsilon$. *That is, structural elasticities do not vary systematically between statutory retirement ages and pure financial incentive discontinuities.*

Intuitively, the assumption rules out that stronger responses to financial incentives are falsely interpreted as statutory age effects. Note that the assumption is concerned with underlying structural elasticities, which differ from observed elasticities estimated according to (2) in the presence of statutory age effects. Indeed, equations (2) and (3) imply differences in observed elasticities across

for details of bunching estimation in practice.

types of discontinuities as a corollary. An observed elasticity at a statutory age overestimates the true elasticity if some of the bunching occurs due to non-financial factors.[19] It is also important to note that the bunching approach generally allows for heterogeneity in underlying elasticities (and other parameters). In this case, bunching identifies an average retirement response, and local average parameter values at the threshold (Kleven 2016).

Within-Group Estimation. For part of the analysis, parameters can be estimated within groups indexed by g:

$$B_{ig} = B(\varepsilon_g, \omega_g(D_{ig}), x_{ig}) \tag{4}$$

This requires observing bunching both at statutory ages and pure financial incentive discontinuities for the same group of workers g. Restricting the analysis to groups of workers facing both types of discontinuities allows for identification under a weaker assumption.

ASSUMPTION B. $E(\varepsilon_{ig}|D_{ig}) = \varepsilon_g$. *That is, a given group of workers g exhibits the same structural elasticity at statutory retirement ages and pure financial incentive discontinuities.*

Hence, elasticities can vary across groups in unrestricted ways, but a given group of workers are required to respond to all financial incentives in the same manner.

Optimization Frictions. Evidence from previous work indicates that optimization frictions seem to play a relatively minor role for the timing of retirement (e.g. Manoli and Weber 2018). More generally, extensive margin responses are less subject to frictions than intensive margin responses (Chetty 2012). These findings are also mirrored by the sharp retirement responses documented in this paper. However, it is not necessary to assume that there are no frictions for the purpose of the above analysis. Denoting a vector of friction parameters by ϕ, if $B_i = B(\varepsilon, \omega(D_i), \phi, x_i)$, the additional assumption necessary to identify statutory age effects is that frictions do not vary systematically with D_i. In other words, if frictions attenuate responses to different thresholds in the same way, the relative magnitude of the effects of interest can still be identified.[20]

4 Reduced-Form Evidence

4.1 Basic Bunching Analysis

4.1.1 Bunching at Specific Discontinuities: Some Cases

I begin by presenting some cases of bunching at specific discontinuities in order to illustrate the variation in the data. In particular, this section focuses on cases that lend themselves to two natural comparisons between statutory retirement ages and pure financial incentive discontinuities.

[19] Existing studies estimating additional parameters from bunching focus mostly on optimization frictions, such as a fraction of workers unable to adjust or a fixed cost of adjustment (e.g. Chetty et al. 2011, Kleven and Waseem 2013, Gelber et al. 2019). In a situation with optimization frictions, the observed elasticity underestimates the true elasticity.

[20] For instance, this would be given if there was a constant share of non-optimizers, leading to a proportional attenuation of bunching as in Kleven and Waseem (2013).

Statutory Retirement Age vs. Contribution Notch Within Group. First, panels A1 and A2 of figure 5 show that the same group of workers respond more strongly to a discontinuity linked to a statutory age than to pure financial incentives. Panel A1 plots the job exit age distribution of women born in 1945 and 1946 around their ERA of 60. The average kink size is 0.07, implying a 7% reduction in the implicit net-of-tax rate at the threshold. There is large excess mass of 12.3 and the observed retirement age elasticity calculated according to equation (2) is 1.46. Panel A2 shows the distribution of years of contributions of women in the same birth cohorts around the threshold of 15 years required for the women's pathway. At 14 years and 11 months of contributions, women face a notch of size 0.007, i.e. they gain an average of 0.7% of net lifetime income from working an additional month. Following Kleven and Waseem (2013), the notch can be approximated as a kink for the marginal buncher. Here, the notch corresponds approximately to a kink of size 0.28. Indeed, there is sharp bunching at 15 years and some missing mass to the left of the notch. However, the excess mass of 1.32 is significantly less than that at the ERA in panel A1 where workers face a smaller kink. The observed elasticity of 0.04 is much smaller than that of the same group at the ERA. Note that an observed elasticity calculated from a notch represents an upper bound (Kleven and Waseem 2013), which makes the difference even starker.

Statutory Retirement Age vs. Pure Financial Incentive Kink. For the second comparison, panels B1 and B2 show bunching at two very similar kinks, with and without a statutory retirement age. Panel B1 shows bunching around the FRA at 63 for cohorts 1945 and 1946 in the invalidity pathway. The kink size is 0.33 and the excess mass is estimated at 10.5, which implies an observed elasticity of 0.20. Panel B2 shows the distribution of job exit ages for workers born between 1938 and 1946 in the disability pathway. They face a pure financial incentive kink of size 0.26 at age 63. Consequently, workers in panels B1 and B2 face similar kinks at the same age, but the threshold is not presented as a full retirement age in the disability pathway. Indeed, responses are very different. In contrast to the large excess mass at the FRA, bunching is hardly visible and the excess mass is only 0.08 at the disability kink. Consequently, the observed elasticity of 0.002 is far below the estimate at the FRA.

4.1.2 Bunching Across All 644 Discontinuities

Table 4 summarizes bunching responses across all 644 discontinuities in the data. In column (1), the average excess mass of 19.8 across the 386 kinks linked to statutory ages is very large. Columns (2) to (4) show that it is driven by large responses to all three types of statutory ages, with the largest excess mass at NRAs. Attributing all bunching to the discontinuity in the implicit net-of-tax rate implies an average observed elasticity of 0.49. Again, elasticities are large across all types of statutory ages.[21] Next, columns (5) to (7) report bunching responses to the 258 pure financial incentive discontinuities. The average excess mass is 3.81. The average observed elasticity is 0.08 at

[21]Non-convex NRA kinks are not included in the elasticity estimation since bunching in response to those would imply a negative elasticity.

pure financial incentive notches, and 0.01 at kinks.[22] Averaging across all pure financial incentive discontinuities yields an elasticity of 0.07.

The difference in observed elasticities suggests that, conditional on kink size, the response to statutory ages is about seven times larger than that to pure financial incentives. This is even more marked than the difference in absolute excess mass, reflecting that kink sizes are larger at pure financial incentives on average. The observed elasticity at statutory ages is also an order of magnitude above previous estimates of around 0.01 to 0.04 by Brown (2013) and Manoli and Weber (2016) from pure financial incentives. Moreover, a first indication that bunching at statutory ages seems to occur somewhat irrespectively of the financial incentive is given by the large excess mass at non-convex NRA kinks, where there is a disincentive to bunch.

To further investigate to what extent differences in bunching are driven by differences in financial incentives, figure 6 shows binned scatterplots of the excess mass at a discontinuity against kink size. Two main insights emerge from the figure. First, financial incentives alone cannot explain the bunching patterns. In panel A, there is large excess mass at statutory ages independently of the underlying financial incentive. There is large bunching across all kink sizes, even when there is a zero or negative incentive to retire. The second insight is that statutory ages seem to matter directly for bunching. There are much larger responses at statutory ages in panel A than at pure financial incentives in panel B for any given kink size. Even at the largest pure financial incentive discontinuities there is less bunching than at statutory ages. Note that this does not necessarily imply that there is no response at all to financial incentives. Both panels A and B show a modest, but significantly positive relationship between excess mass and underlying kink size. The estimated slopes correspond to difference-in-bunching elasticities of 0.08 and 0.05, respectively.

4.2 Reduced-Form Estimation

The analysis so far suggests a large amount of additional bunching at discontinuities linked to statutory retirement ages. In order to quantify the importance of this "statutory age effect", the following regression specification is used:

$$\frac{b_i}{\hat{R}_i} = \varepsilon \, \frac{\Delta\tau_i}{1-\tau_i} + \sum_s \beta^s D_i^s + Z_i'\gamma + \nu_i \tag{5}$$

where an observation indexed by i corresponds to a discontinuity in the bunching sample. D_i^s is an indicator for a statutory age of type $s \in \{ERA, FRA, NRA\}$ linked to discontinuity i, and the coefficients β^s measure the reduced-form effect of the respective statutory age type. Finally, Z_i is a vector of control variables, and ν_i is an error term.

[22] The larger observed elasticities at notches could be driven by several factors. First, kinks apply to the disability pathway where workers may display a lower true elasticity than in other pathways. Second, observed elasticities measured at notches represent an upper bound: Kleven and Waseem (2013) point out that the approximation of the notch as a kink for the marginal buncher in order to compute a reduced-form elasticity undestimates the size of the discontinuity since everyone between the marginal buncher and the notch faces a larger change in the marginal tax rate. Third, additional months of contributions could come from some non-work periods such that workers may have additional margins of adjustment to bunch at contribution notches.

Equation (5) may be a natural way to detect a reduced-form statutory age effect, but it can be also be interpreted as a simple, linear version of the bunching equation (3), where the parameter vector ω consists of a set of linear regression coefficients on the dummies D_i^s. The empirical setting provides many more bunching observations than parameters in the equation, which has two advantages. First, additional regressors can be included, allowing to control for a number of group-level characteristics and fixed effects in a flexible way. Second, rather than finding a solution to an exactly identified system of bunching equations, the equation can be estimated via OLS, combining the information provided by all available bunching moments. Intuitively, statutory age effects are identified from the difference in bunching *between* statutory ages and pure financial incentive discontinuities while the elasticity is identified from variation in kink size *within* each type of discontinuity. Standard errors are obtained via bootstrap by re-sampling bunching observations.[23]

The key identification assumption for this specification is assumption A. To see this, consider a case where true elasticities vary across discontinuities with $D_i = 0$ and $D_i = 1$. Then $E(\nu_i|D_i) \neq 0$, since ν_i contains some residual bunching not captured by the average elasticity ε, and this would introduce bias into the estimation of β. In practice, including control variables and fixed effects somewhat weakens the required assumption, such that elasticities should be independent of D_i conditional on these controls. Note that direct empirical support for assumption A is lent by the results from figure 6: The estimated slopes are similar in panels A and B, i.e. the responsiveness to differences in financial incentives is similar at statutory ages and pure financial incentive discontinuities.

Table 5 reports results from regressions based on equation (5). To begin with, column (1) shows results from a basic specification without controls. This yields large and significant statutory age effects and an elasticity of 0.04. Next, column (2) adds interactions between different statutory age types in order to account for the fact that more than one type is present at some discontinuities. Column (3) adds a set of worker characteristics including gender, marital status, income and education as controls, as well as pathway and year-of-birth fixed effects accounting for the dimensions along which groups are defined. Column (4) adds the maximum set of group fixed effects, controlling for pathway times year-of-birth fixed effects. Finally, column (5) controls for occupation-level characteristics including firm size and unionization rates. In spite of the varying set of controls and fixed effects, the estimated statutory age effects remain large and highly significant. With a coefficient of 0.16 to 0.23, the NRA has the largest reduced-form effect on bunching, while the FRA effect is 0.06 to 0.08 and the ERA effect is 0.04 to 0.07. Point estimates of the elasticity range between 0.02 and 0.05, but they are only significantly different from zero in columns (1) and (2).

4.3 Heterogeneity

An important advantage of the empirical setting is that the large number of discontinuities allows for exploring heterogeneity in bunching responses along a number of dimensions. The main finding

[23] This corresponds to re-sampling blocks of individual-level data, where blocks are defined by groups of workers facing the same discontinuity.

is that the “statutory age effect” found in the previous section is not confounded by differences in observables across groups. Moreover, results from an additional estimation strategy are presented, where parameters are allowed to vary across groups.

Heterogeneity in Bunching Responses. Figure 7 shows average observed bunching elasticities at statutory ages and pure financial incentive discontinuities by a range of observables.[24] First, panels A and B sort bunching observations by birth cohort and the retirement age at the discontinuity. Responses are substantially larger at statutory ages for each birth cohort and across the available range of retirement ages. Panels C to E focus on worker characteristics, namely lifetime income (panel C), years of education (panel D), and health status proxied by sick leave periods (panel E). Bunching observations are grouped by quintiles of each variable. Groups with higher lifetime income and higher education seem to respond less strongly to statutory ages, but more strongly to pure financial incentives. Groups in worse health, on the other hand, are less responsive to both statutory ages and pure financial incentives. However, the difference in observed elasticities remains significant for all groups. Panels F to H sort bunching observations by some occupation-level characteristics, in particular firm size (panel F), unionization rate (panel G) and tenure in the firm (panel H). Recall that these characteristics are obtained by matching the individual data with SOEP data at the 3-digit occupation level. Again, the observed elasticities vary somewhat across groups. Overall, bunching responses are significantly larger at statutory ages than at pure financial incentives in each quintile of each variable in panels C to H.

Explanatory Power of Observed Characteristics. In order to quantify the explanatory power of observable characteristics, appendix table A1 reports results from a Oaxaca-Blinder decomposition. Bunching observations are grouped into statutory retirement ages and pure financial incentive discontinuities. The decomposition attributes differences in excess mass across groups to a component explained by differences in observables and an unexplained component. Since results vary with the choice of reference group, the table reports results using statutory ages as the reference group in column (1), pure financial incentive discontinuities as the reference group in column (2) and an average of the two in column (3). Results confirm that most of the additional bunching at statutory ages cannot be explained by observable factors. Financial incentives account for a maximum of 3% of observed differences, while worker and firm variables including those discussed above explain up to 11% and 5%, respectively. Between 92% and 109% of the additional bunching at statutory ages cannot be explained by differences in observable characteristics.

Estimation with Heterogeneous Parameters. In the main reduced-form estimation, a concern for identification arises if parameters are heterogeneous across workers facing different types of discontinuities. Adding controls and fixed effects may somewhat alleviate this concern. However, a more direct way to address this is to allow for heterogeneous parameters in the following

[24] Each panel in figure 7 shows observed elasticities for groups defined by a sample split along a single dimension of heterogeneity. See section 5.3 for a multivariate analysis of the correlates of bunching at the individual level.

specification:

$$\frac{b_{ig}}{\hat{R}_{ig}} = \varepsilon_g \frac{\Delta \tau_{ig}}{1-\tau_{ig}} + \sum_s \beta_g^s D_{ig}^s + \nu_{ig} \tag{6}$$

where g indexes groups. Since the main potential issue with the baseline specification from equation (5) is heterogeneity in elasticities correlated with statutory retirement ages, a natural solution is to allow for heterogeneous parameters at the level where statutory ages are determined, namely pathway and year of birth. This strategy corresponds to a linear version of the within-group bunching equation (4). The specification requires identification assumption B, which is weaker than assumption A. Assumption B states that the same group of workers exhibits the same elasticity at different types of discontinuities, while true elasticities can vary arbitrarily across groups.

Table 6 reports results from estimating equation (6) with varying group definitions. Note that the table reports weighted averages of coefficients, while selected pathway- and cohort-specific estimates are shown in appendix table A2. Overall, results remain very similar to the baseline estimation. First, column (1) estimates a specification with pathway-specific coefficients, and column (2) repeats the exercise with groups defined by birth cohorts. In both specifications, statutory age effects are highly significant and increase slightly to between 0.06 and 0.24 compared to table 5. The estimated elasticity is between 0.05 and 0.08. Column (3) reports estimates with groups defined by pathway and birth cohort. In the spirit of the comparison presented in figure 5, this specification estimates elasticities and statutory age effects within narrowly defined groups such as women born in 1945. The estimates in column (3) are similar to columns (1) and (2). Appendix table A2 suggests some parameter heterogeneity across pathways, and little heterogeneity across birth cohorts. However, the fact that average parameters in table 6 change little when allowing for more heterogeneity indicates that there is little bias in the basic specification with homogeneous coefficients.

5 Mechanisms

This section discusses mechanisms behind the reduced-form "statutory age effect", and argues that the framing of statutory ages as reference points for retirement is a plausible mechanism. First, I show evidence from two reforms, suggesting that workers respond strongly to the government changing statutory ages, and that the framing of statutory ages can affect retirement behavior. Second, potential alternative mechanisms including firm responses and mistakes by workers are discussed.

5.1 Can the Government Effectively Change Statutory Retirement Ages?

This paper argues that the strong response to statutory retirement ages is due to the government setting those at a certain age. In this section, I show that workers' retirement decisions react directly to a change in statutory ages, which indicates that the government can effectively set and manipulate statutory ages. To this avail, I exploit a part of the variation in statutory retirement ages that is due to cohort-based reforms (see figure 4). One prominent reform enacted over the sample period is the increase in the FRA in the women's pathway from age 60 to 65 for birth cohorts 1940 to 1945. The reform creates fine-grained variation, as the increase is implemented gradually such that each monthly birth cohort faces a FRA that is one month higher than that of the previous cohort.

Figure 8 shows the effect of the change in the FRA on retirement behavior. Panel A displays the average job exit age in the women's pathway by month of birth around the reform. Among the pre-reform cohorts 1935 to 1939, the average job exit age is around 61 and exhibits no clear trend, besides some seasonal fluctuations. Starting with January 1940, there is a remarkably linear upward trend in job exit ages among the cohorts affected by the gradual FRA increase. For the post-reform cohorts, the average job exit age is just below 63 and remains stable. A before-after estimate of the reform effect indicates an increase in average job exit ages of 1.78 years, corresponding to a 4.3 months increase in actual retirement ages per one-year increase in the FRA.[25]

Panel B shows job exit age distributions of the pre-reform birth cohort 1939, the post-reform cohort 1945, as well as selected monthly birth cohorts during the transition period. The graphs indicate that the increase in the average job exit age is largely driven by a shift in the retirement spike from the pre-reform FRA to the post-reform FRA. Among the last pre-reform cohort born in 1939, there is a large job exit age spike at age 60 and a relatively small spike at age 65. Among the first post-reform cohort 1945, a large spike at age 65 emerges. Since the women's ERA remains at age 60 after the reform, there is still a spike in job exits at this age, but its magnitude is greatly reduced. In addition, job exit age distributions among selected transition cohort are shown, namely workers born in June 1940, February 1941, April 1942, and July 1943 who face a FRA of ages 60 and 6 months, 61 and 2 months, 62 and 4 months, and 63 and 7 months, respectively. For each cohort, there is large bunching precisely in the month of the FRA, even though the policy changes at a high frequency and FRAs are located at non-round ages. Appendix figure A4 shows the complete set of job exit age distributions for the 60 monthly birth cohorts during the transition period. Across all cohorts, the spike in retirement moves in lockstep with the monthly change in the FRA.

5.2 The Effect of Framing

Does the framing of statutory ages affect retirement behavior? The impact of this framing is difficult to test directly, as it is ubiquitous and there has been no change to the way statutory ages are presented per se over the last decades to my knowledge. To obtain suggestive evidence, I exploit a reform affecting the intensity of framing instead. In the early 2000s, the state pension fund drastically increased the frequency of information letters sent to workers (see Dolls et al. 2018). Before June 2002, workers received a letter only once in their lifetime, when they turned 55. Under the new regime phased in between June 2002 and December 2003, letters are sent annually to all workers. The stated goal of the reform was to better inform workers about benefits and retirement.

[25] Manoli and Weber (2018) use a regression kink design to analyze an ERA increase in Austria and find effects of similar magnitude on average job exit ages.

Appendix figure A5 shows an example of a letter, and appendix B.4 provides further explanation of the letter content. Letters provide detailed, personalized information on the worker's contributions so far, pension benefit calculation, and some guidance on making intertemporal decisions. Projected benefit amounts at different hypothetical retirement ages are also shown. However, letters emphasize statutory ages, in particular the NRA, as reference dates. For instance, the first paragraph shows the exact, individual date when the worker will reach the NRA. Moreover, two out of three benefit scenarios in the letter use the NRA as the hypothetical retirement date.

Panel A of figure 9 shows the fraction of workers bunching at different types of discontinuities by calendar quarter around the reform.[26] Two main results emerge. First, there is no visible change in the response to pure financial incentives, in spite of the goal of providing more information. Second, there is an increase in the probability of bunching at statutory ages, which is driven by a significant increase in the probability of bunching at the NRA. The post-reform coefficient in the figure and panel A of appendix table A4 indicates a 3pp increase in the probability of bunching at the NRA.

In addition, variation in the number of letters across birth cohorts can be exploited. During the phase-in period, letters are sent to cohorts 1939 and older, and cohorts 1940 and younger receive letters annually. Since the NRA is 65 during the period, this implies that workers born in 1938 to 1940, as well as some workers born in the second half of 1937, receive exactly one letter before they reach the NRA. Workers born from 1941 onwards receive more than one letter before the NRA, and the number of letters increases with each year of birth. Panel B of figure 9 shows the fraction bunching at the NRA by quarterly birth cohort. For cohorts 1941 onwards, there is a gradual increase in the probability of retiring at the NRA as they receive more letters, while the effect is less clear for those cohorts who receive only one letter. Overall, there is a significant post-reform increase of 2pp in the probability of bunching at the NRA.

5.3 Alternative Mechanisms

5.3.1 The Role of Firms

In the German labor market, laying off workers at statutory ages is sometimes cited as a way for firms to avoid costs of firing older workers. In particular, "mandatory retirement" clauses linked to workers' NRA can be specified in collective industry agreements or in individual contracts. It is important to note that there is no possibility for mandatory retirement at the other statutory age types, the ERA and FRA. This section presents a number of additional checks, suggesting that firm responses are not the main driver of statutory age retirements.

Self-Employed and Small Firms. To begin with, I show that there is bunching at statutory ages among two subgroups where firm incentives play no role at all, or a smaller role. First, although limited, there are a number of self-employed individuals enrolled in the public pension

[26] The series excludes the two retirement pathways where reforms to statutory ages were implemented at the same time.

system.[27] Second, small firms with less than 10 employees are exempt from employment protection, which implies that there should be little need for employers to somehow use statutory ages to lay off older workers. Figure 10 shows job exit age distributions among the full occupation-matched sample (panel A), self-employed workers enrolled in the public pension system (panel B), and the 20 occupations most frequently in small firms, including medical receptionists, hairdressers, pharmacists, florists, and dental technicians (panel C). There are sharp spikes among the self-employed at the main statutory ages and the fraction bunching of 28% is only marginally smaller than in panel A. Hence, much of the bunching at statutory ages seems to persist in the absence of possible firm responses. Moreover, although the majority of contracts falls below the employment protection threshold, there are also sharp spikes among those most frequently in small firms, 30% of whom bunch at statutory ages.

Mandatory Retirement. The most direct way for firms to induce retirements at statutory ages is through mandatory retirement clauses linked to the NRA. A natural way to check whether this drives the results is to exclude all statutory ages from the analysis where mandatory retirement is possible. Column (2) of appendix table A5 shows results from a specification analogous to table 6, but excluding all discontinuities linked to a NRA. The remaining results are virtually unchanged, with an elasticity estimate of 0.04, and highly significant statutory age effects at the ERA and FRA similar in magnitude to those in table 6. Thus, even in the unlikely case that all NRA job exits were driven by mandatory retirement, this would not affect the results regarding the other statutory ages.

Proxying for Firm Incentives. To shed light on the role of firms more generally, bunching at statutory ages can be related to a number of variables proxying for firms' incentives to lay off workers at statutory ages. First, firing frictions are more severe for larger firms since employment protection becomes stricter at larger firm sizes. Second, firing costs may change when workers are more unionized. Third, firing costs are higher for workers with longer tenure since employment protection increases as a function of tenure thresholds. Fourth, some workers are in contracts that end automatically after a term limit. Finally, in a tighter labor market it may be more valuable to firms to keep older workers beyond statutory retirement ages.

Appendix figure A6 shows binned scatterplots of the fraction of workers bunching at statutory ages against the above proxies. Panels A to D include firm size, unionization, tenure and the frequency of unlimited contracts at the occupation level. Labor market tightness in panel E is constructed from annual vacancy and unemployment data at the state level. The fraction bunching at statutory ages is large in all bins of the explanatory variables and the estimated slopes are relatively flat. While there seems to be no effect of unionization, the fraction bunching is indeed increasing in firm size, average tenure and the fraction of workers in unlimited contracts. Somewhat

[27] Self-employed individuals can be enrolled in the public pension system for two reasons. First, there is a small set of self-employed occupations where enrollment is mandatory. This includes mainly craftspersons, workmen, self-employed teachers and educators, nurses and artists. Second, self-employed workers can voluntarily enrol in the public scheme.

surprisingly, there seem to be more statutory age job exits in tighter labor markets.

Appendix table A6 shows results from corresponding individual-level regressions, controlling for worker characteristics as well as pathway and year-of-birth fixed effects. In column (1), the probability of bunching at statutory ages increases with firm size, but the effects of unionization, tenure and unlimited contract turn negative. Overall, the probability that a worker retires at a statutory age is only weakly related to firm incentives. Larger firms may induce some additional statutory age retirements, but the magnitude of the effect is limited. This is consistent with section 4, where the main results are robust to controlling for firm-related variables, and those explain only a small share of differences in bunching across types of discontinuities.

5.3.2 Other Checks

Mistakes and Inattention. An alternative explanation for the statutory age effect may be mistakes, for instance because workers misperceive the incentives linked to statutory ages. First, one can examine how bunching at statutory ages correlates with some proxies for financial literacy. Table 7 shows regressions of dummies for bunching at different types of discontinuities on individual-level characteristics.[28] In column (1), workers retiring at statutory ages have *higher* education and are *more* likely to be economically trained. They also have higher lifetime income and higher last earnings before retirement. Hence, there is no indication that higher financial literacy diminishes bunching at statutory ages. For comparison, column (2) repeats the exercise with pure financial incentive discontinuities. Bunching at those is positively associated with education and economic training, but negatively with lifetime earnings.

Relatedly, could some form of inattention explain statutory age retirements? In this case, one might expect that workers with a higher stake in the retirement decision should be more likely to pay attention and optimize their retirement decision. Of course, retirement is a high-stake decision with large consequences in terms of lifetime consumption possibilities for most workers, but stakes vary to some extent. Table 7 shows that workers with higher stakes seem to be, if anything, more likely to bunch at statutory ages. The ratio of pension wealth to annual earnings, which proxies for the relative importance of public pensions for the worker, is positively related to the probability of bunching at statutory ages. Married females, who are less likely to be the main household earner and thus their own retirement decision should entail a relatively smaller financial stake, are less likely to bunch at statutory ages. Thus, higher stakes do not seem to diminish the response to statutory ages. Finally, another measure of stakes could be the size of the local incentive. For instance, if a kink is very small, choosing a "wrong" retirement age may not be very costly. This would imply that observed elasticities are increasing in kink sizes because it is more worthwhile to optimize at larger kinks. Appendix figure A7 shows binned scatterplots of observed elasticities vs. kink sizes. There is no evidence of a larger responsiveness at large kinks: across all types

[28] While the heterogeneity analysis in section 4.3 tests whether differences in responses across discontinuities can be explained by differences in observables, the individual-level regressions here aim at exploring which workers are more likely to be among the bunchers.

of discontinuities observed elasticities are flat or even decreasing with kink size. Column (1) of appendix table A5 confirms that there is no significant effect of kink size on observed elasticities.

Salience of Incentives. Could it be that statutory ages make underlying financial incentives more salient? In other words, there could be more bunching at statutory ages than at pure financial incentive discontinuities because workers are more aware of the underlying budget constraint kink. A priori evidence against this hypothesis is provided by the results from figure 6, where large bunching at statutory ages occurs at all kink sizes, including negative ones. If financial incentives were made more salient by statutory ages, one would expect a different pattern, where bunching is more steeply increasing in kink size than at pure financial incentives. Columns (3) and (4) of appendix table A5 provide a further test, repeating the analysis of table 6 with additional interactions of kink size with statutory age dummies. Interaction effects are insignificant or even negative, implying that workers do not respond more to underlying financial incentives at statutory ages.

Liquidity Constraints. Since pension benefits can only be claimed from the ERA onwards, liquidity constraints may provide a potential reason to retire at the ERA (but not at the FRA/NRA). In the presence of liquidity constraints, workers may not be able to smooth lifetime consumption throughout the gap between job exit and ERA to the desired extent. This channel is hard to check directly in the absence of data on assets. However, recent evidence by Goda et al. (2018) suggests that liquidity constraints are not the main driver of ERA retirements in the U.S. In addition, table 7 shows no indication of workers retiring at statutory ages being liquidity constrained, as they have both higher lifetime incomes and higher last earnings before retirement.

Default Options. In the German context, retirement requires an active choice in the form of an application by workers to claim benefits. This is in contrast to the Swiss setting in Lalive et al. (2017), where statutory retirement ages serve as default options for retirement.

Health Insurance. Finally, health insurance availability has been suggested in the U.S. context as a potential driver of retirements at the NRA. However, in Germany there is public health insurance that covers workers as well as pensioners. Hence, the availability of health insurance does not depend on age and should not drive retirement at specific ages.

6 Retirement Bunching and Reference Points in a Simple Model

This section incorporates reference points into a simple model of retirement decisions. The approach is guided by the institutional setting and the evidence from the previous section where the framing of statutory retirement ages as reference points is suggested as a plausible explanation for the "statutory age effect". It is arguably natural that workers perceive a salient benchmark presented by government policy as a "normal" time to retire as a reference point, in particular given that retirement is a one-off decision where other potential reference points such as previous outcomes or a status quo are not available. Evidence from surveys and experiments additionally supports this view. For instance, Merkle et al. (2017) find experimental support for framing effects and behavior consistent with statutory ages as reference points.

In this section, I show that incorporating a standard formulation of reference dependence into a bunching framework yields predictions consistent with the empirical patterns, namely sharp bunching at a reference point. Moreover, the magnitude of observed bunching can be related to parameters governing the strength of reference dependence, and these parameters can be recovered via simple structural bunching estimation. Note that the purpose of the framework is to quantify bunching responses to a fixed, exogenous reference point, rather than explaining the formation of reference points.[29]

6.1 Basic Setup and Bunching at a Budget Constraint Kink

Consider a simple static model of retirement decisions[30] where workers maximize lifetime utility

$$U = u(C) - v(R, n)$$

C is lifetime consumption, R is the worker's retirement age relative to a career starting age normalized to 0, and n is a parameter capturing earnings ability at old age. Utility is increasing and concave in consumption and disutility from lifetime labor supply is strictly convex such that $u'(C) > 0$, $u''(C) \leq 0$, $v_R > 0$, and $v_{RR} > 0$. Moreover, low ability increases disutility from postponing retirement such that $v_{Rn} < 0$. The lifetime budget constraint expresses consumption C as a function of R as in equation (1). The slope of the budget constraint is given by $w(1-\tau) = \frac{dC}{dR}$, which defines the implicit net-of-tax rate $1-\tau$.

Consider first the case of a linear budget constraint $C = w(1-\tau)R$, and assume, as is standard in the bunching literature, that utility is quasi-linear in consumption and iso-elastic in labor supply such that

$$U = w(1-\tau)R - \frac{n}{1+\frac{1}{\varepsilon}}\left(\frac{R}{n}\right)^{1+\frac{1}{\varepsilon}}$$

where ε is the elasticity of the retirement age with respect to the implicit net-of-tax rate. Workers' utility maximization yields

$$R = n\left[w(1-\tau)\right]^{\varepsilon}$$

[29]In this sense, a reference point, i.e. a discontinuity in preferences, provides a convenient modelling tool to quantify preference-driven bunching at statutory ages. A preference discontinuity induces bunching, which could encompass a number of potential sources including framing effects. Ultimately, the goal is to draw conclusions about the effects of statutory retirement ages as policy tools, and it is not within the scope of this paper to pin down the origin or formation of individual reference points.

[30]The static model considered in this section corresponds to the "lifetime budget constraint" model of retirement suggested by Burtless (1986). Similar static models are used in recent retirement bunching applications such as Brown (2013) and Manoli and Weber (2018) in order to quantify the factors leading to bunching at local discontinuities and reference points. Section 6.3 provides an outlook on the relationship with dynamic models.

If the distribution of ability $F(n)$ is smooth, this implies a smooth distribution of retirement ages with density $h_0(R)$.

Bunching at a Budget Constraint Kink. Suppose now that there is a kink in the lifetime budget constraint such that the marginal implicit tax rate increases by $\Delta\tau$ at some retirement age threshold $\hat{R}$. Appendix figure A8 illustrates the effect of the kink in a budget set diagram and density diagram following Saez (2010) and Kleven (2016). In the absence of the kink, individuals locate along the budget line according to their abilities. Whilst an individual with ability $\hat{n}$ initially retires at $\hat{R}$, there is a marginal buncher with ability n^* whose indifference curve is tangent to the initial budget set at R^* and to the upper part of the new budget set at $\hat{R}$. All workers initially located between $\hat{R}$ and R^* bunch at the kink, while all individuals initially to the left of the kink leave their retirement age unchanged and all individuals initially to the right of R^* stay above the kink.

The bunching mass B is given by

$$B = \int_{\hat{R}}^{R^*} h_0(R)dR \approx h_0(\hat{R})(R^* - \hat{R}) \tag{7}$$

where $h_0(R)$ is the pre-kink density and the approximate equality holds if $h_0(R)$ is constant on $[\hat{R}, R^*]$. With quasi-linear utility, the two tangency conditions for the marginal buncher imply $R^* = n^*[w(1-\tau)]^{\varepsilon}$ and $\hat{R} = n^*[w(1-\tau-\Delta\tau)]^{\varepsilon}$ and thus

$$\frac{R^*}{\hat{R}} = \left(\frac{1-\tau}{1-\tau-\Delta\tau}\right)^{\varepsilon} \tag{8}$$

Now define $\Delta R^* = R^* - \hat{R}$ such that bunching is $B = h_0(\hat{R})\Delta R^*$. Suppose $\Delta\tau$ is small and hence ΔR^* is small, such that $\log(R^*/\hat{R}) \approx \Delta R^*/\hat{R}$, and $\log(1-\tau-\Delta\tau)/(1-\tau)) \approx -\Delta\tau/(1-\tau)$. Then equation (8) implies

$$\frac{b}{\hat{R}} \approx \varepsilon\frac{\Delta\tau}{1-\tau} \tag{9}$$

where $b = B/h_0(\hat{R})$ is the excess mass. This corresponds to the Saez (2010) bunching formula applied to the context of retirement. Note that equation (2), which is used to calculate observed elasticities, is a direct implication of this formula.

6.2 Bunching at a Reference Point

A reference point captures the notion that workers evaluate their retirement age relative to a threshold $\hat{R}$. In the present context, the interest is in a fixed reference point set by policy in the form of a statutory retirement age. Such reference dependence can be modeled via a discontinuity in marginal utility, where preferences of a reference dependent agent are:[31]

$$U = u(C) - v(R, n) - \mathbb{1}(R \geq \hat{R}) \cdot \widetilde{\lambda}(R - \hat{R}) \tag{10}$$

The last term in equation (10) introduces a discontinuity in marginal disutility from continuing work at $\hat{R}$, i.e. a kink in utility. Marginal disutility from increasing labor supply beyond the reference point $\hat{R}$ is greater than marginal disutility from approaching $\hat{R}$ from the left, where the parameter $\widetilde{\lambda} > 0$ captures this change in marginal disutility. This is consistent with an interpretation where workers perceive postponing retirement as a loss relative to a "normal" time to retire. Choosing this formulation of reference dependence is guided for two considerations. First, similar utility kink formulations are commonly used in the literature.[32] Second, as I show below, it entails the advantage that bunching responses are analogous to those at a budget constraint kink, and underlying parameters can be estimated in a straightforward way.

Figure 11 illustrates bunching responses to the reference point. Initially, indifference curves are smooth and an individual with ability $\hat{n}$ is located at $\hat{R}$, while n^* is located at R^*. When the reference point is introduced, indifference curves rotate counter-clockwise above $\hat{R}$ and now exhibit a convex kink at $\hat{R}$. The individual whose indifference curve was initially tangent to the budget line at R^* is now tangent at $\hat{R}$. This individual is the marginal buncher: All workers initially located between $\hat{R}$ and R^* bunch at the reference point, while all individuals initially to the left of the reference point leave their retirement age unchanged and all individuals initially to the right of R^* stay above the reference point. Like a kink in the budget constraint, the reference point does not produce a hole in the density of retirement ages, since workers initially above R^* also retire earlier, causing a leftward shift in the density above $\hat{R}$ that fills the hole.

As in equation (7), bunching at the reference point is $B \approx h_0(R)(R^* - \hat{R})$. The two tangency conditions for the marginal buncher imply $R^* = n^*[w(1-\tau)]^\varepsilon$ and $\hat{R} = n^*[w(1-\tau) - \widetilde{\lambda})]^\varepsilon$. Hence

$$\frac{R^*}{\hat{R}} = \left(\frac{1-\tau}{1-\tau-\lambda}\right)^\varepsilon \tag{11}$$

where $\lambda = \widetilde{\lambda}/w$ expresses the reference dependence parameter relative to the gross wage w. Equation (11) implies that a kink in disutility from work has a bunching effect equivalent to a budget constraint kink. Workers respond *as if* there was a local change in the implicit net-of-rax rate of

[31] A previous version of this paper considered reference dependence in terms of both the retirement age and consumption. This version focuses on a simplified model with a single reference dependence parameter, which makes similar predictions in terms of bunching at a reference point, and is better suited in terms of transparent identification of the key parameters.

[32] See for instance Rees-Jones (2018) and DellaVigna et al. (2018). The utility kink functional form corresponds to the "loss aversion" property from prospect theory, where the choice set is divided into two domains, gains and losses. Instead, reference dependence could also be modeled as a discontinuity in utility (a utility notch) or a discontinuity in the second derivative (diminishing sensitivity). Allen et al. (2017) show that all these types lead to bunching at the reference point. Note that there are two additional, implicit modeling choices in equation (10). First, loss aversion enters utility linearly, following Tversky and Kahneman (1991). Alternatively, loss aversion could be defined in terms of utility levels as in Köszegi and Rabin (2006), which would yield parameters on a different scale. Second, the formulation abstracts from gain utility.

size λ. This result has two important implications. First, a natural interpretation of the magnitude of λ arises, as it can be scaled equivalently to kink size, a standard measure used in the bunching literature. Second, λ could be estimated given bunching observed at a reference point, but one also needs to know or estimate the elasticity ε for this purpose. Intuitively, ε plays a role for the amount of bunching in response to a given λ, as it governs the utility cost to workers of adjusting their retirement age towards the reference point.

Combining Financial Incentives and Reference Points. At a statutory retirement age, a potential reference point coincides with a change in financial incentives. In order to compute total bunching at such a threshold, an initial situation without any discontinuity needs to be compared to a situation with the budget set kink and reference point. Appendix figure A9 illustrates bunching due to the combination of the budget set kink and the retirement age reference point. One can identify a marginal buncher whose original indifference curve is tangent to the original budget set at R^* and whose kinked indifference curve is tangent to the upper part of the kinked budget set at $\hat{R}$. Hence, all individuals initially located between $\hat{R}$ and R^* bunch at the threshold.

The total bunching mass is $B \approx h_0(\hat{R})(R^* - \hat{R})$. The two tangency conditions for the marginal buncher imply $R^* = n^*[w(1-\tau)]^\varepsilon$ and $\hat{R} = n^*[w(1-\tau-\Delta\tau-\lambda)]^\varepsilon$. Hence

$$\frac{R^*}{\hat{R}} = \left(\frac{1-\tau}{1-\tau-\Delta\tau-\lambda}\right)^\varepsilon$$

The total excess mass $b = B/h_0(\hat{R})$ is

$$\frac{b}{\hat{R}} = \left(\frac{1-\tau}{1-\tau-\Delta\tau-\lambda}\right)^\varepsilon - 1 \tag{12}$$

Thus, if a retirement age reference point is at the same location as a budget constraint kink $\Delta\tau$, the additional bunching effect due to the reference point is as if the size of the kink increases by λ.

6.3 Extensions

A number of extensions to the framework above can be incorporated into the analysis. First, parameters such as ε and λ may be heterogeneous across workers. With parameter heterogeneity, the bunching method identifies parameters among the average responding individuals (Kleven 2016). Appendix E.1 discusses how this standard argument of the bunching literature can be applied to a model with reference points. Second, income or wealth effects may be present at larger kinks. In this case, bunching identifies a mixture of compensated and uncompensated parameters (see appendix E.2).

Third, retirement decisions are dynamic problems and often modeled as such. Appendix E.3 shows that the static model can be viewed as a reduced form of a richer dynamic model under two assumptions: First, all uncertainty in earnings capacity is realized at the "beginning" of old age when the retirement age is decided, and second, there are no liquidity constraints. This paper focuses on the static model for several reasons. First, simple and transparent bunching equations can be derived from the static version. Second, the static model is directly analogous to a standard labor supply model and thus results can be easily compared to those from existing bunching models. Third, the sharp bunching responses documented in this paper may indicate that dynamic uncertainty does not play a large role for retirement responses to different discontinuities. Fourth, as long as uncertainty attenuates responses to statutory ages and pure financial incentives in the same way, the relative magnitude of the parameters of interest can still be identified.

7 Structural Bunching Estimation and Counterfactuals

7.1 Structural Bunching Estimation

The previous section establishes a straightforward link between the amount of bunching at a reference point and the parameters governing the strength of reference dependence. Equations (8) and (12) imply that bunching observed at different discontinuities provides "sufficient statistics" to estimate these parameters. In particular, the variation across discontinuities in the presence of statutory ages and in kink sizes used for the reduced-form estimation can be exploited to identify ϵ and λ. Similarly to the reduced-form analysis, the estimation can be implemented at the discontinuity level, without having to estimate a full model of retirement decisions at the individual level. The availability of independent variation in statutory ages and financial incentives presents a crucial advantage, as existing bunching approaches to reference dependence are unable to estimate λ or similar parameters in the absence of an estimate of the cost of adjusting the relevant behavioral margin.[33]

Taking the model to the discontinuity-level data in the bunching sample, bunching at discontinuity i can be written as

$$\frac{b_i}{\hat{R}_i} = \left(\frac{1-\tau_i}{1-\tau_i-\Delta\tau_i-\Lambda(D_i)}\right)^{\varepsilon} - 1 + \xi_i \tag{13}$$

where D_i is a vector of indicators for statutory ages, $\Lambda(D_i)$ denotes reference point effects as a function of statutory ages, and ξ_i is an error term. Reference point effects are then written as a simple linear combination of the different types of statutory ages:

$$\Lambda(D_i) = \sum_s \lambda^s D_i^s$$

where λ^s is a parameter governing reference point effects of statutory age type s. Thus, the specification allows for the degree of reference dependence to vary with the type of statutory age, which may be natural given that the reduced-form effects of statutory ages differ across types.

Table 8 reports results from a corresponding non-linear least squares estimation at the discon-

[33] See DellaVigna 2018. For instance, in Rees-Jones (2018) the cost of effort to change one's tax liability is not known. Similarly, in Allen et al. (2017), the cost of running effort is unknown.

tinuity level. The baseline specification estimates λ^s by type of statutory age, and also includes interaction effects between types of statutory ages in order to account for the fact that statutory ages can coincide. The estimated λ^s parameters are positive and highly significant, with magnitudes of 0.34 at the ERA, 0.23 at the FRA and a particularly large NRA effect of 0.38. The estimates imply that disutility from working an additional period changes by between 23% and 38% of a worker's gross wage due to reference point effects at the different types of statutory ages. In addition, the parameters can be scaled in terms of budget constraint kink equivalents, i.e. the percent decrease in the implicit net-of-tax rate at the discontinuity $\Delta\tau/(1-\tau)$ that would produce an equivalent bunching response. The second row of the table shows the parameters scaled as such kink equivalents. The estimated magnitude of reference dependence at the ERA corresponds to a 54% kink, 44% at the FRA and 113% at the NRA. Intuitively, the large estimate at the NRA is due to the fact that there is large bunching in spite of non-convex kinks. Finally, the elasticity of 0.05 is precisely estimated and similar to the reduced-form results.[34]

Alternative Specifications. Appendix table A8 shows parameter estimates from a range of alternative specifications of reference point effects. First, reference dependence parameters can be directly estimated in terms of kink size equivalents, rather than estimating the λ^s parameters and then scaling by the implicit net-of-tax rate $1-\tau$. The resulting estimates of 0.59, 0.54 and 1.32 are slightly larger than the baseline estimates. The second alternative specification estimates λ^s parameters like in the baseline specification, but without interaction effects between different types of statutory ages. Here, the effect of the NRA remains the same, but the effects of the ERA and FRA are somewhat smaller. This suggests that the main effects of the ERA and FRA can be underestimated without including interactions. The third set of alternative estimates is obtained from three separate specifications for each type of statutory age. The results remain very similar to the baseline estimation. Finally, a single reference dependence parameter can be estimated by setting $\Lambda(D_i) = \lambda D_i$, where D_i is an indicator for any statutory age. The resulting estimate of λ is 0.24, corresponding to a kink size equivalent of 51%.

7.2 Counterfactual Simulations

Finally, counterfactual scenarios with respect to parameters and policy variables can be simulated based on the estimates.

Financial Incentives vs. Reference Points. A first, natural question may be how much bunching at statutory retirement ages would prevail in the absence of reference points. Panel A of table 9 shows results from a simulation of bunching at statutory ages under such a scenario. Column (1) reports the actually observed fraction of job exits and average excess mass at statutory

[34] Appendix table A7 additionally shows estimated interaction effects between types of statutory ages. Interaction effects are significantly negative across the board. This suggests that reference point effects of different types of statutory ages do not simply "add up". For instance, the interaction effect of a FRA coinciding with a NRA is -38% in kink size equivalent, reducing the total effect to roughly the magnitude of a NRA alone.

ages, while column (2) shows simulated figures under the counterfactual scenario without reference point effects. Over the entire sample period, 29% of workers actually retire at statutory ages. In the counterfactual with all λ^s set to zero, this fraction is estimated to decrease to only 6.8pp, corresponding to a 76% reduction. The average excess mass at statutory ages is predicted to decrease even more dramatically from 19.8 to 1.3. This sharp drop is partly a consequence of the simulation predicting negative excess mass (holes) in the job exit age distribution at non-convex NRA kinks. In addition, columns (3) and (4) of the table show results from simulations based on alternative elasticity estimates. Instead of the structural elasticity, column (3) takes the smallest significantly estimated reduced-form elasticity of 0.03, and column (4) allows for heterogeneous elasticities with an average of 0.08. The fraction of retirements at statutory ages is estimated to decrease to between 5.8pp and 9.4pp. In other words, between 67% and 84% of statutory age retirements would disappear in the absence of reference point effects.

Policy Reforms. Next, the effects of counterfactual policy scenarios can be simulated. I focus on two policies often considered as options for pension reform. The first reform increases the NRA, as a number of countries are in the process of doing.[35] In the simulation, the NRA is raised from 65 to 66, leaving financial incentives unchanged. The second reform increases financial rewards for late retirement similarly to the U.S. "Delayed Retirement Credit", while the NRA remains at 65. Figure 12 and panel B of table 9 summarize the effects of both scenarios simulated for one birth cohort. With the NRA increase, there is un-bunching of the spike at age 65, and the density above 65 increases.[36] A new, large job exit spike emerges at the post-reform NRA of 66. The average retirement age increases by around 4 months, and the increase among individuals who retire at 65 and above is 10 months. The key implicit assumption behind this simulation is that the NRA shifted to the new location is perceived by workers as a reference point similarly to the previous NRA. Support for this assumption is provided by the evidence from section 5.1, where bunching moves in lockstep with the legislated statutory ages during a reform period. Moreover, it is reassuring that the change in average retirement ages in the simulation is similar to estimated reform effects in section 5.1.

In the second scenario, the increase in delayed retirement rewards is calibrated to match the effect on the average retirement age in the first scenario. In order to yield the same effect, financial rewards have to be more than doubled from currently 6% p.a. to 12.6%. In figure 12, providing stronger financial incentives for late retirement leads to a drop in the excess mass at the NRA by more than half, and the former bunchers disperse along the density above age 65. Hence, both types of policies could achieve an increase in average actual retirement ages. However, the estimated fiscal impact of the two scenarios is very different. The NRA increase has a positive net fiscal effect of +€675m per year. This is due to the additional contributions of affected workers postponing

[35] For example, the NRA will be increased to age 67 in the U.S. by 2027, to 67 in Germany by 2031, and to 68 in the U.K. by 2046.

[36] A small spike remains at age 65 after the reform due to round-number bunching taken into account in the counterfactual distribution.

retirement, combined with the shorter duration for which they receive pension benefits. On the contrary, the net fiscal effect of increased financial rewards is negative at –€465m. Workers also contribute longer in this scenario, but this is more than offset by the large increase in pension benefits at older retirement ages necessary to induce workers to postpone retirement. These results further highlight that statutory retirement ages can be an effective policy tool for the government to influence retirement decisions. For instance, if the government's goal is to improve the fiscal balance of the pension system, increasing statutory ages is an effective policy. On the other hand, this would be more difficult to achieve using pure financial incentives such as a delayed retirement credit.

8 Conclusion

Recent years have seen a surge of interest in retirement decisions and their responsiveness to pension system features. While there have been studies on some individual policies and reforms, the overall evidence is somewhat inconclusive. This paper aims at filling this gap by providing a comprehensive analysis of the effect of two key features of pension systems, namely statutory retirement ages and financial incentives. The results highlight the important direct role of statutory ages: around 29% of job exits occur at a statutory age, and at least two thirds of those are estimated to be driven by reference point effects. The response to financial incentives is modest in comparison. Retirement age elasticities w.r.t. the net-of-tax rate are similar to those found in previous studies, with estimates around 0.05.

There are implications for the design of pensions and reform options. Having established their direct impact on behavior, statutory retirement ages can be viewed as policy tools in their own right. Policy simulations suggest that shifting statutory retirement ages can be an effective way to increase actual retirement ages with a positive fiscal effect. Hence, such reforms can help adapt pension systems to demographic change.

Two limitations of the analysis may be worth pointing out. First, this paper is agnostic about the welfare consequences of policies that set or manipulate statutory retirement ages. Such an evaluation would require a normative stance on the extent to which reference point effects enter welfare calculations. Studying these questions may be a promising avenue for future research. Second, this paper presents evidence that the framing of policies can induce reference dependence, and reference points can be shifted by policy, but future work could dig deeper into the formation of individual reference points around government policies.

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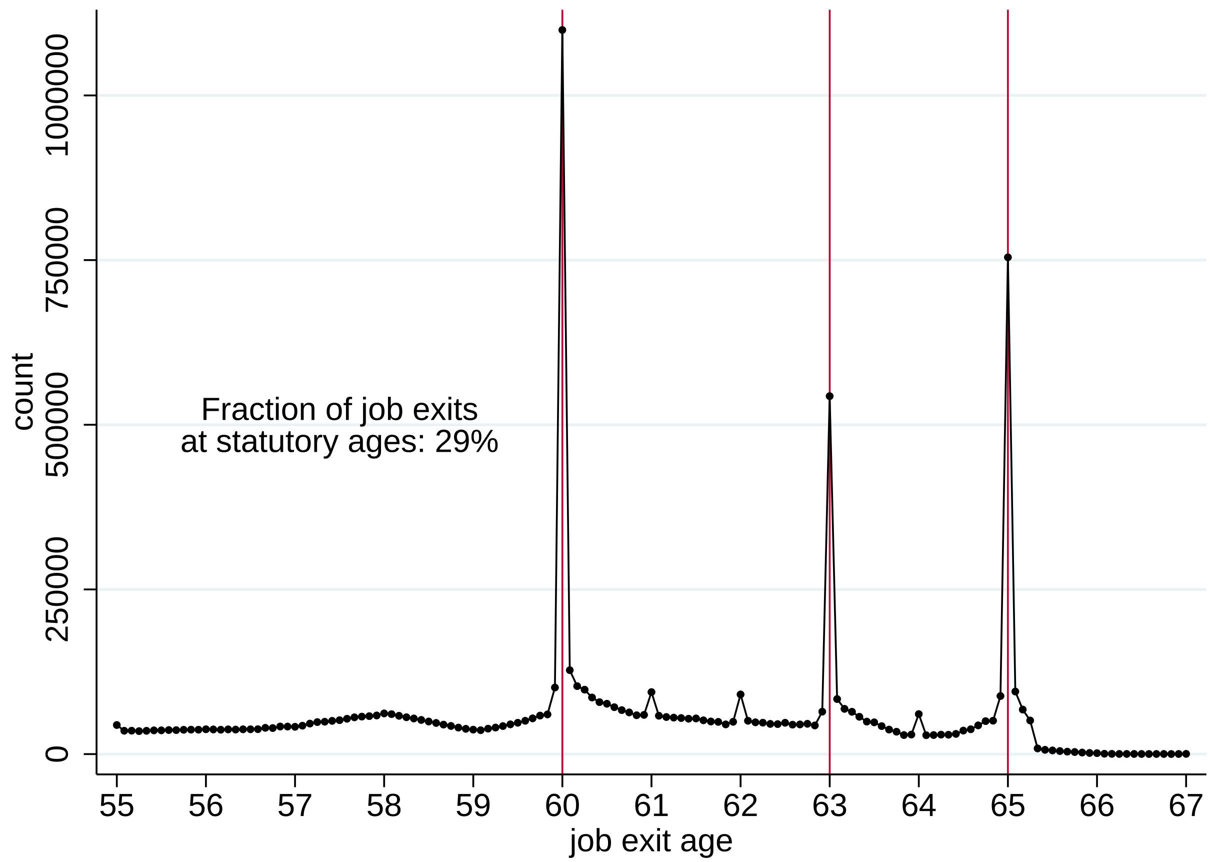
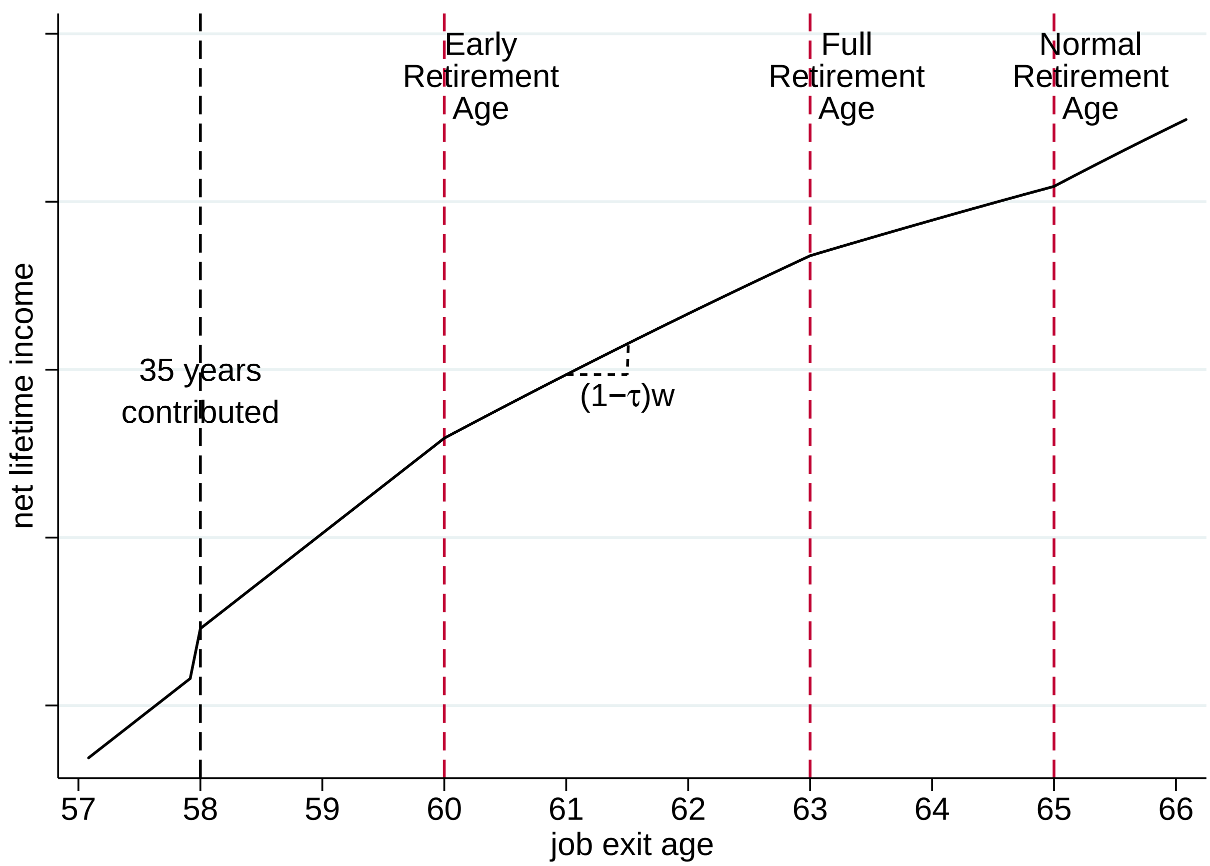
Figure 1: Job Exit Age Distribution (Full Sample)



Note: The figure shows the pooled distribution of retirement (job exit) ages for the full individual sample, i.e. for all workers born between 1933 and 1949. The connected dots show the count of job exits within monthly bins. Vertical red lines indicate the location of main statutory ages throughout the sample period. "Fraction of job exits at statutory ages" refers to the fraction of job exits at ages 55 to 67 that occur in the month when the workers reaches a statutory retirement age.
Data source of all figures and tables: *FDZ-RV - Themenfile SUFRTZN1992-2014XVSBB_Seibold*

Figure 2: Stylized Lifetime Budget Constraint



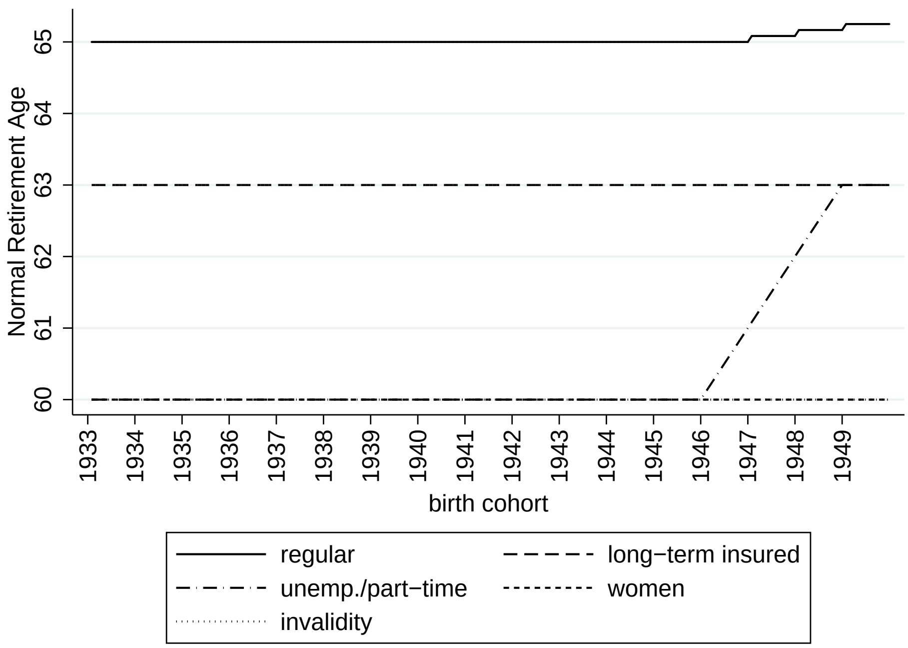
Note: The figure shows a stylized lifetime budget constraint for a worker who faces an Early Retirement Age of 60, a Full Retirement Age of 63 and an Normal Retirement Age of 65, and who becomes eligible for a more generous pathway into retirement requiring 35 years of contributions at age 58. The slope of the budget constraint is the implicit net wage defined as $w_i^{net} = (1 - \tau_i)w_i$, which captures the marginal gain in net lifetime income from postponing retirement by one month as shown in section 2.2. The stylized shape of the constraint corresponds to incentives faced by the average worker: On average, workers face a 22% reduction in the implicit net wage (i.e. a 22% kink size) at age 60, a 28% reduction at age 63%, and a 32% increase in the implicit net wage at age 65.

Figure 3: Framing

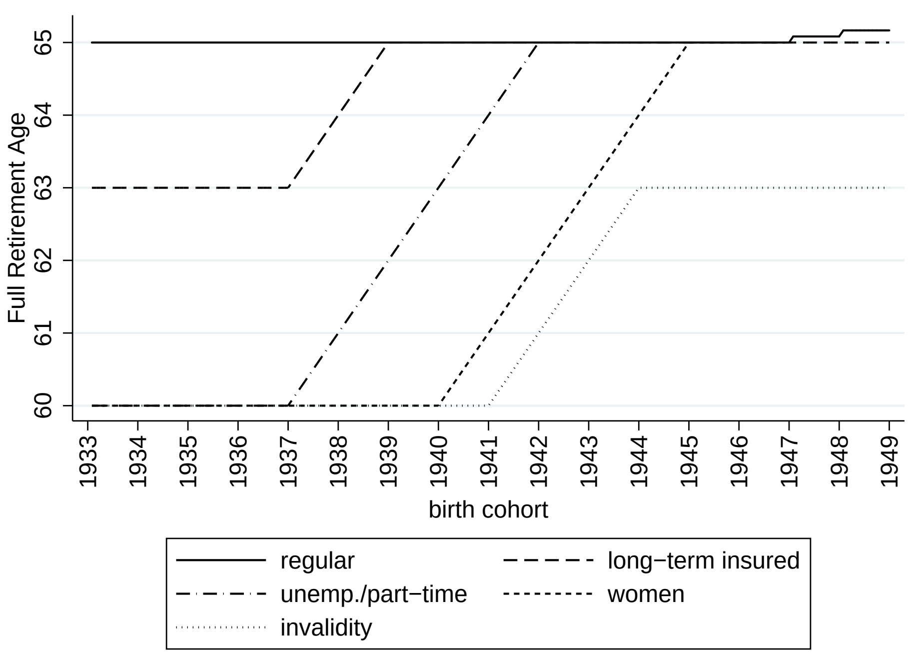
Note: The figure shows excerpts of an information leaflet that informs workers about a future pension reform. Explanation of the main points is provided in the red boxes on the right. See appendix figure A1 for full brochure. Note that some of the pension rules in the leaflet can differ from those described in section 2, as the leaflet describes future pension rules. Source: `http://www.deutsche-rentenversicherung.de/cae/servlet/contentblob/232636/publicationFile/49694/rente_mit_67.pdf`

Figure 4: Statutory Retirement Ages across Pathways and Birth Cohorts

Panel A: Early Retirement Ages (ERA)



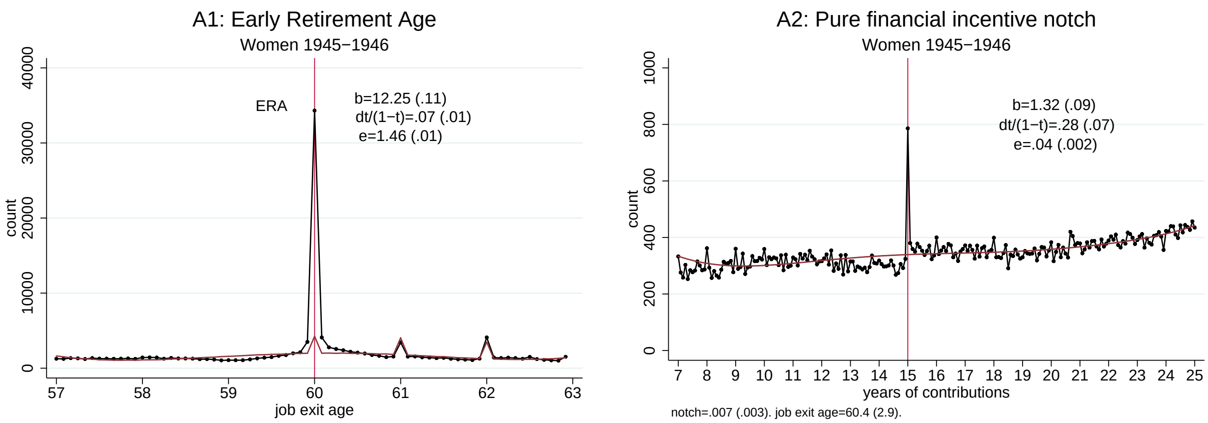
Panel B: Full Retirement Ages (FRA)



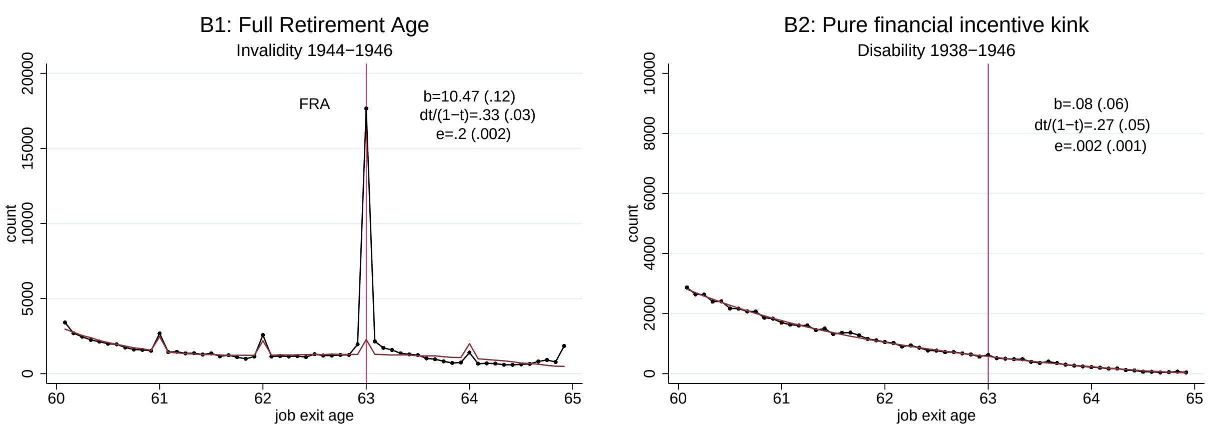
Note: The figures show the evolution of Early Retirement Ages (ERA) and Full Retirement Ages (FRA) of different pathways across monthly birth cohorts. In Panel A, the regular ERA is increased from 65 to 65/3 between 1947 and 1949 and the unemployed/part-time ERA is gradually increased from 60 to 63 between 1946 and 1948. In Panel B, the long-term insured FRA is increased from 63 to 65 between 1937 and 1938 and from 65 to 65/3 for cohort 1949, the women's FRA from 60 to 65 between 1940 and 1944, the unemployed/part-time FRA from 60 to 65 between 1937 and 1941, the invalidity FRA from 60 to 63 between 1941 and 1943, and the regular FRA 65 to 65/3 between 1947 and 1949. See table 1 for an overview of pathways.

Figure 5: Bunching at Specific Discontinuities

Panel A: Statutory Age vs. Pure Financial Incentive Notch

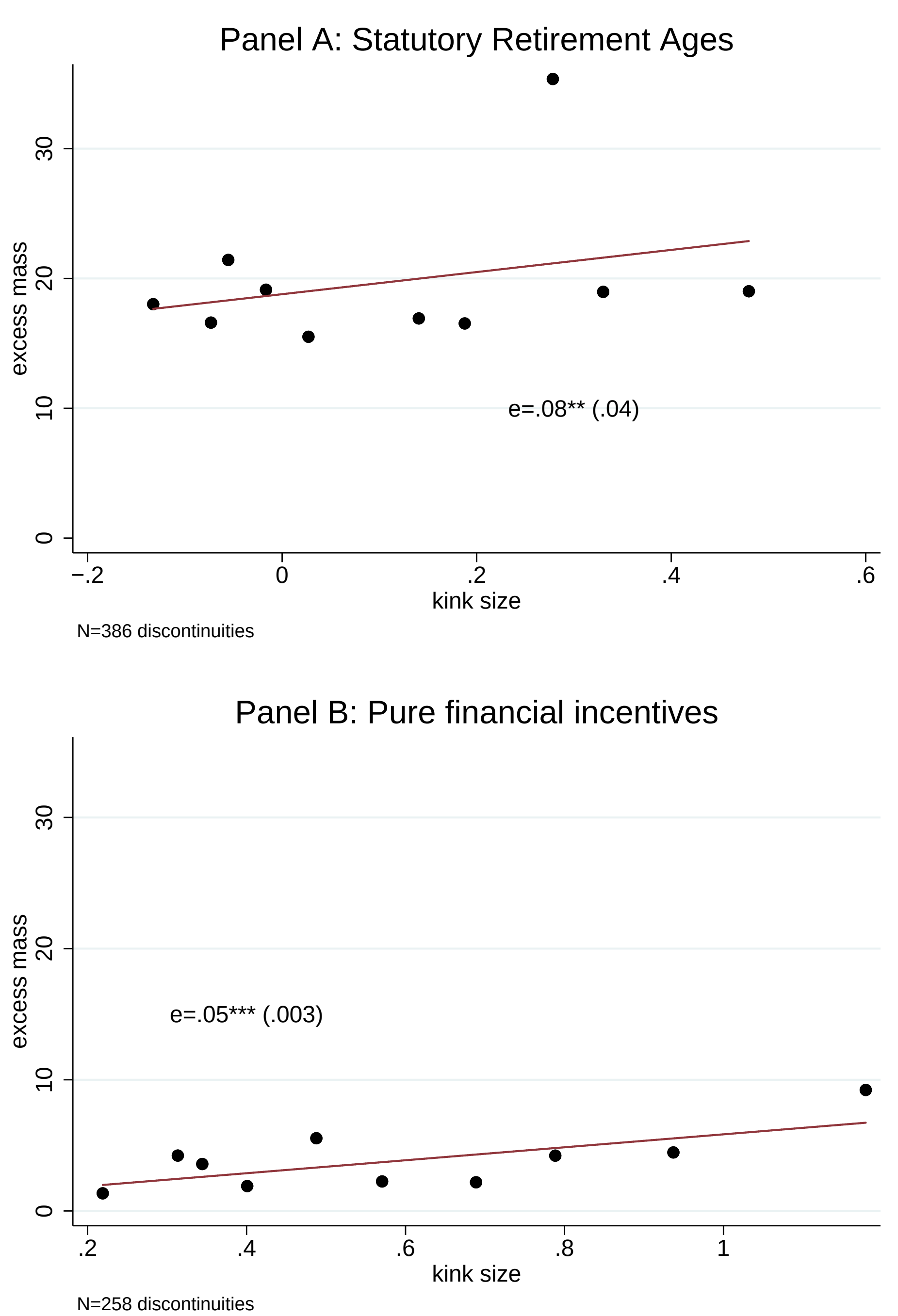


Panel B: Statutory Age vs. Pure Financial Incentive Kink



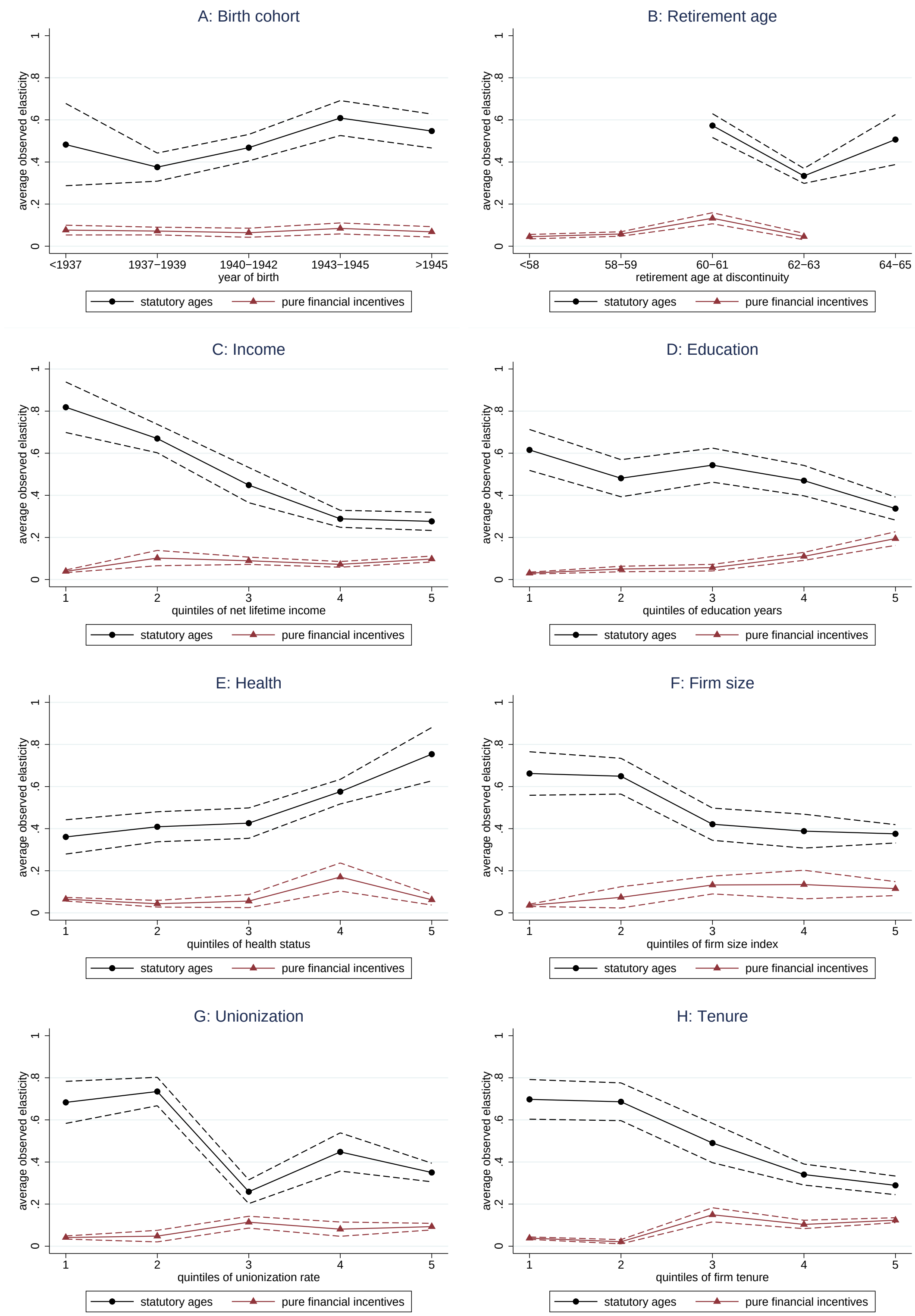
Note: The figure shows bunching at some cases of specific discontinuities. Panel titles indicate the type of discontinuity and panel subtitles indicate pathways and birth cohorts used. In panels A1, B1 and B2, the connected black dots show counts of job exit ages in monthly bins for the group indicated by the respective panel title. In panel A2, the black dots show counts of years of contributions instead. In all panels, the red line shows the counterfactual distribution estimated as a 7th-order polynomial, including round-age dummies in panels A1 and B1. Vertical red lines indicate the location of the discontinuity. b is the excess mass, $d\tau/(1-\tau)$ is the change in the implicit net-of-tax rate at the discontinuity (kink size), and ε is the observed elasticity of the retirement age w.r.t. the implicit net-of-tax rate. In panel A2, the footnote shows the notch size, i.e. the percentage change in net lifetime income, and the average job exit age at the notch in addition. For the excess mass and observed elasticity, bootstrapped standard errors are in parantheses. For the kink size, notch size and average job exit age, standard deviations are in parantheses.

Figure 6: Bunching and Financial Incentives



Note: The figure shows binned scatterplots of the retirement response (excess mass) vs. the underlying financial incentive (kink size) at a discontinuity, separately for statutory retirement ages (panel A) and pure financial incentive discontinuities (panel B). In panel A, the type of statutory ages (Early, Full or Normal Retirement Age) is controlled for. Each panel also includes the coefficient from a discontinuity-level regression of normalized excess mass $b/\hat{R}$ on kink size, which can be interpreted as a difference-in-bunching elasticity, with bootstrapped standard error in parantheses. Appendix figure A3 shows additional plots separately by statutory age types.

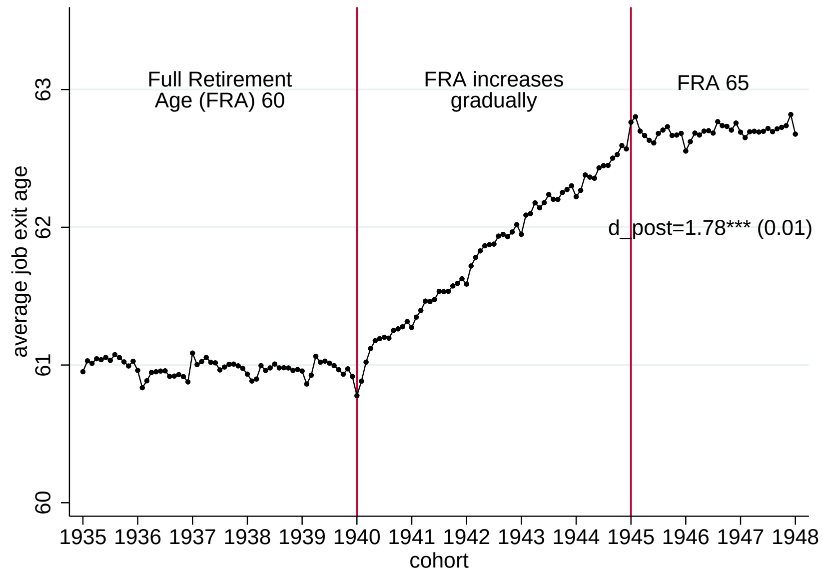
Figure 7: Heterogeneity in Bunching Responses



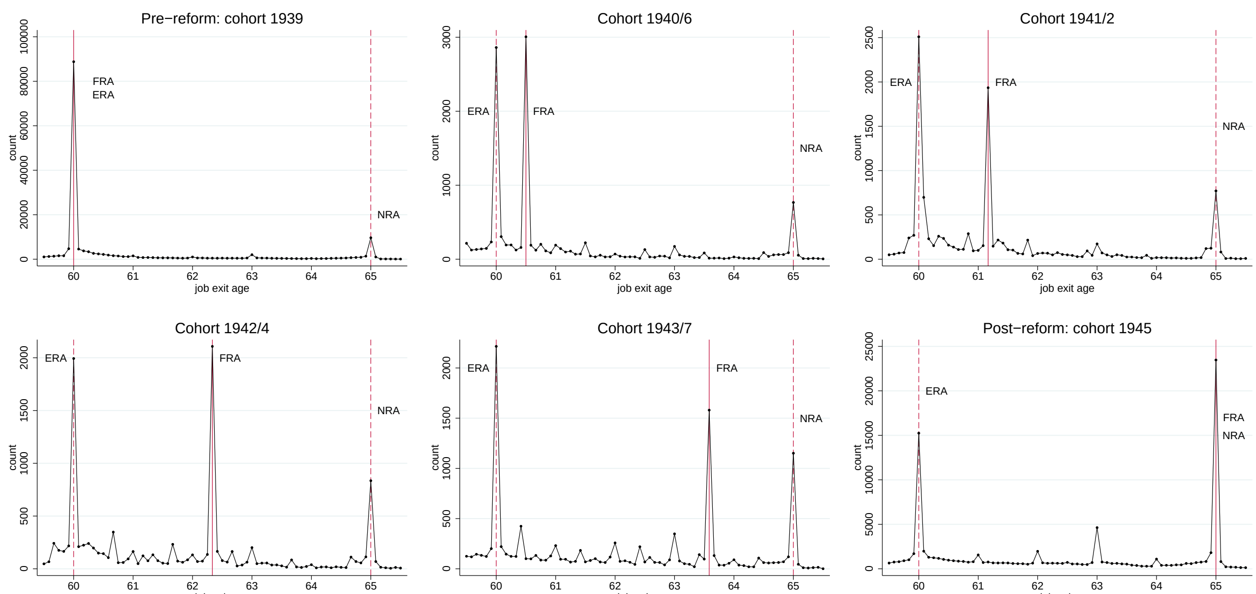
Note: The figure shows average observed bunching elasticities by birth cohort, the retirement age at the discontinuity, and quintiles of worker and firm-related characteristics, namely net lifetime income, education periods, health status (5=healthiest), a firm size index computed from discrete size categories, unionization rate and tenure. Black dots indicate bunching at statutory ages, and red triangles are for bunching at pure financial incentive discontinuities. The dashed lines around the point estimates mark 95% confidence intervals based on bootstrapped standard errors.

Figure 8: The Effect of Increasing the Full Retirement Age

Panel A: Average Job Exit Age



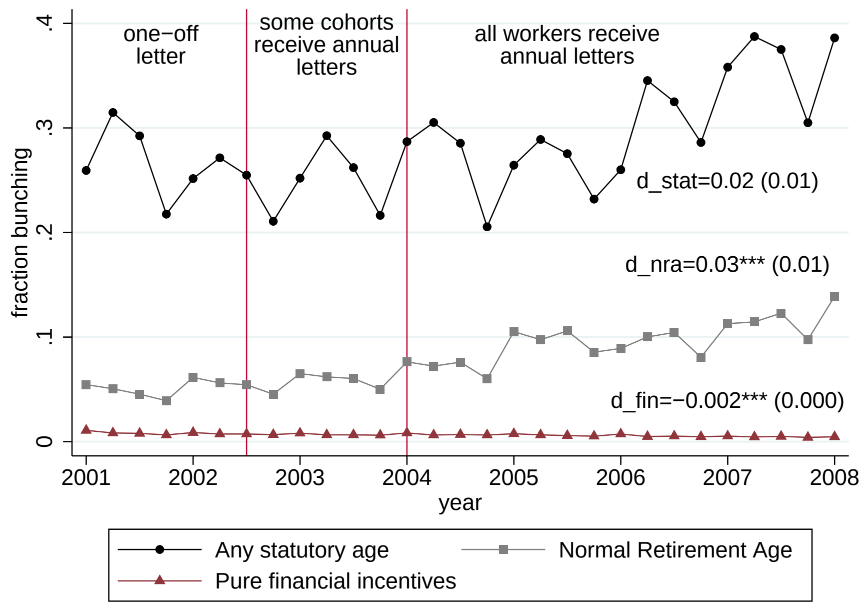
Panel B: Job Exit Age Distribution among Selected Cohorts



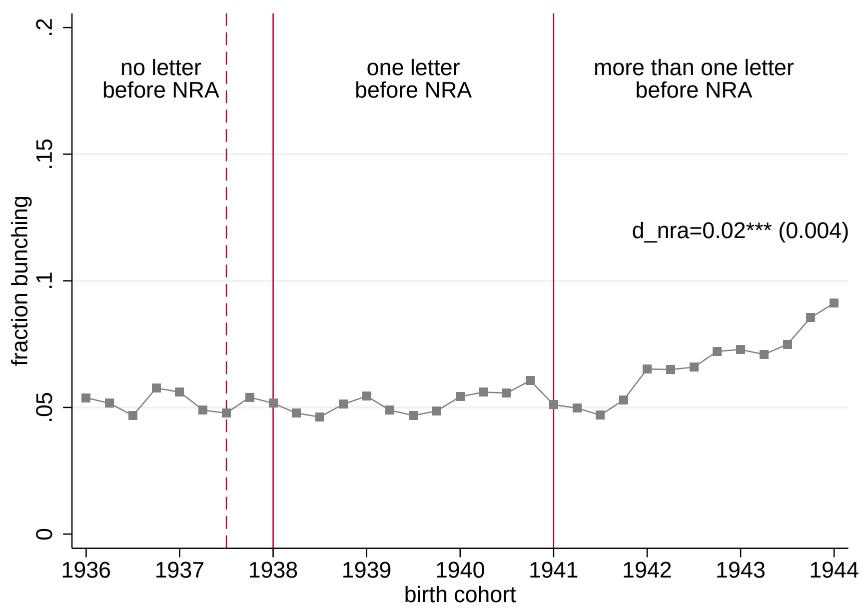
Note: The figure shows the effect of a reform that increases the Full Retirement Age (FRA) in the women's pathway. For birth cohorts 1939 and older, the FRA is 60 and from cohort 1945 onwards the FRA is 65. For the 60 monthly birth cohorts born between 1940 and 1944, the FRA increases by one month for each month of birth. Panel A displays the average job exit age among workers in the women's pathway retiring at age 60 and above. The graph also includes the coefficient from an individual-level before-after regression, see appendix table A3 for details. Panel B shows selected job exit age distributions throughout the reform. The first and last graph are for the last pre-reform cohort 1939 and the first post-reform cohort 1945, respectively. The remaining graphs show distributions among selected monthly cohorts during the transition period where the FRA increases on a monthly basis. In each graph, the connected dots show the count of job exits within monthly bins. The solid vertical red line indicates the location of the FRA, and dashed vertical red lines indicate other statutory retirement ages. Appendix figure A4 shows the full set of monthly job exit age distributions during the transition period.
Data source: FDZ-RV - Themenfile SUFRTZN1992-2014XVSBB_Seibold

Figure 9: The Effect of Information Letters

Panel A: By Calendar Year

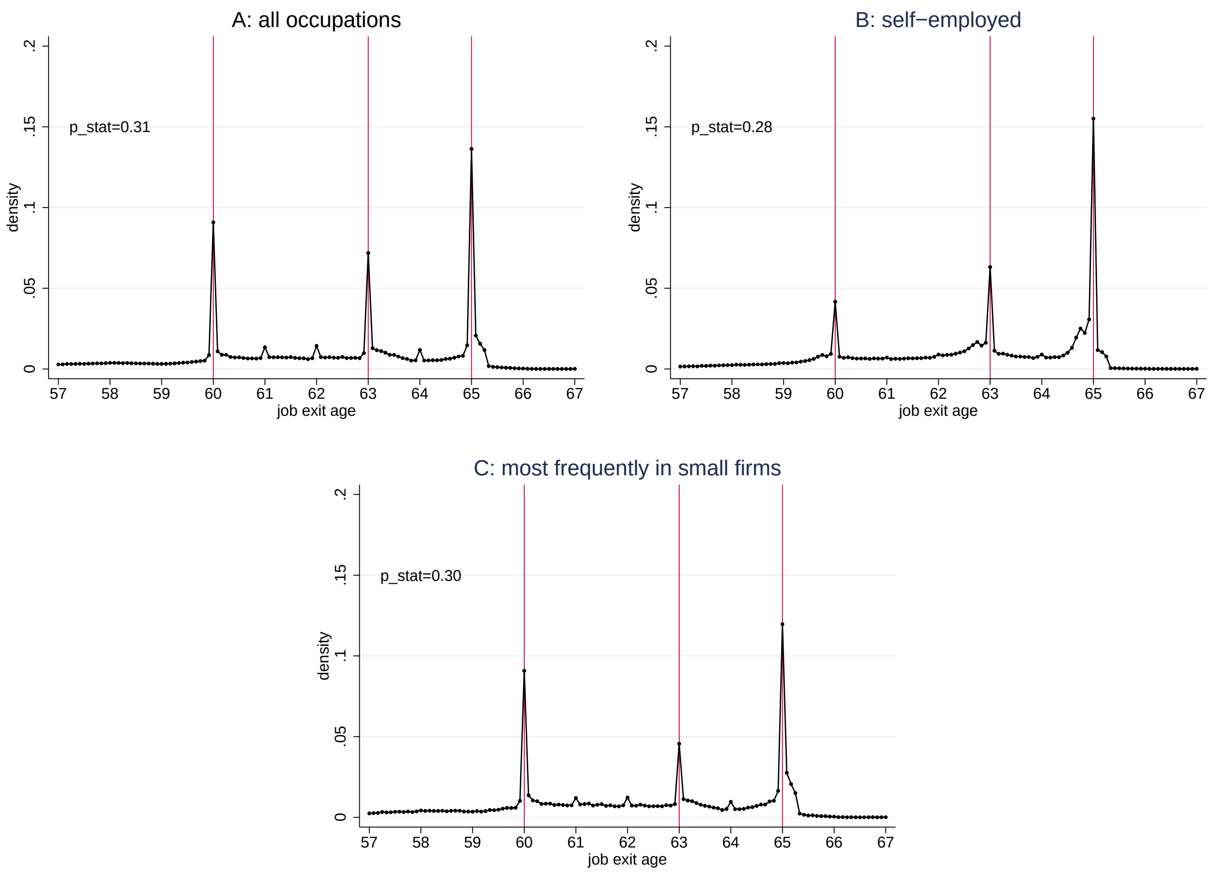


Panel B: By Birth Cohort



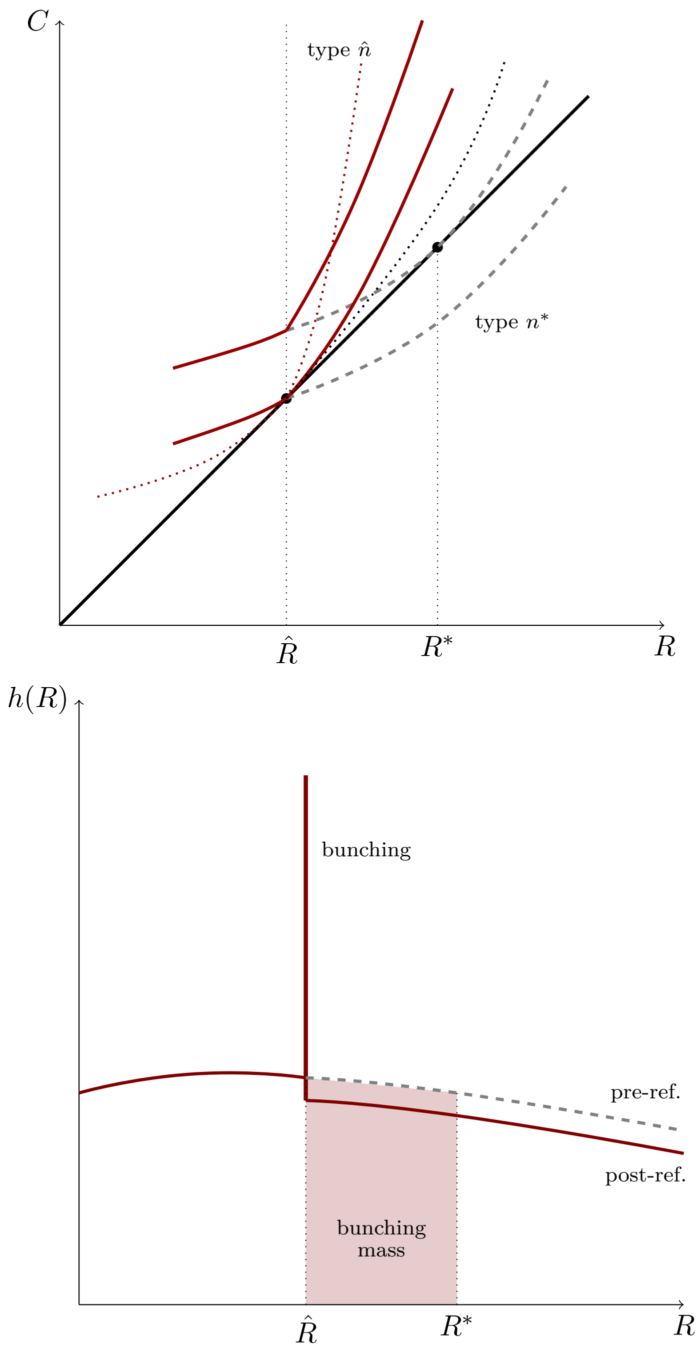
Note: The figure shows the fraction of workers bunching at at different types of discontinuities throughout a reform period, where the pension fund increased the number of information letters sent to workers. Panel A shows the fraction bunching at any statutory age (black dots), the Normal Retirement Age (gray squares), and pure financial incentive discontinuities (red triangles) by calendar quarter. Before mid-2002, workers receive only one letter in their lifetime. The first vertical line marks the beginning of the phase-in period in June 2002, where some birth cohorts start receiving letters annually. The second vertical line marks the beginning of full implementation, when all workers receive annual letters. Panel B shows the fraction of workers bunching at the Normal Retirement Age (NRA) by quarter of birth. Cohorts born before mid-1937 receive no letter for ten years before they reach the NRA. The dashed vertical line indicates that some workers born in the second half of 1937 may receive a letter in the year before the NRA. The first solid vertical line marks the first cohorts who receive exactly one letter in the years before the NRA. The second solid vertical line marks the beginning of cohorts who receive more than one letter before the NRA, where the number of letters increases linearly with year of birth. The graphs also show coefficients from individual-level before-after regressions, see appendix table A4 for details. Workers in the long-term insured and unemployed/part-time pathways are excluded from all series as these pathways are subject to statutory age reforms during the period.

Figure 10: Self-Employed and Small Firms



Note: The figure shows the pooled distribution of job exit ages for all workers in the occupation-matched sample (panel A), self-employed workers (panel B), and the 20 occupations most frequently in small firms with less than 20 employees (panel C). The connected dots show the count of job exits within monthly bins. Vertical red lines indicate the location of main statutory ages throughout the sample period. *p_stat* indicates the fraction of workers bunching at statutory ages among the group in each panel.

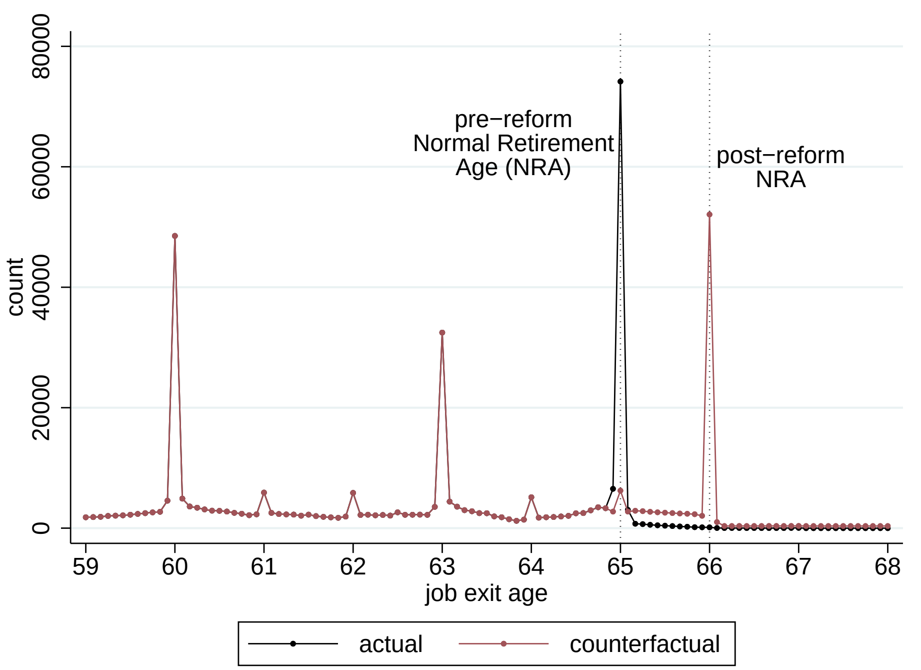
Figure 11: Retirement Bunching at a Reference Point



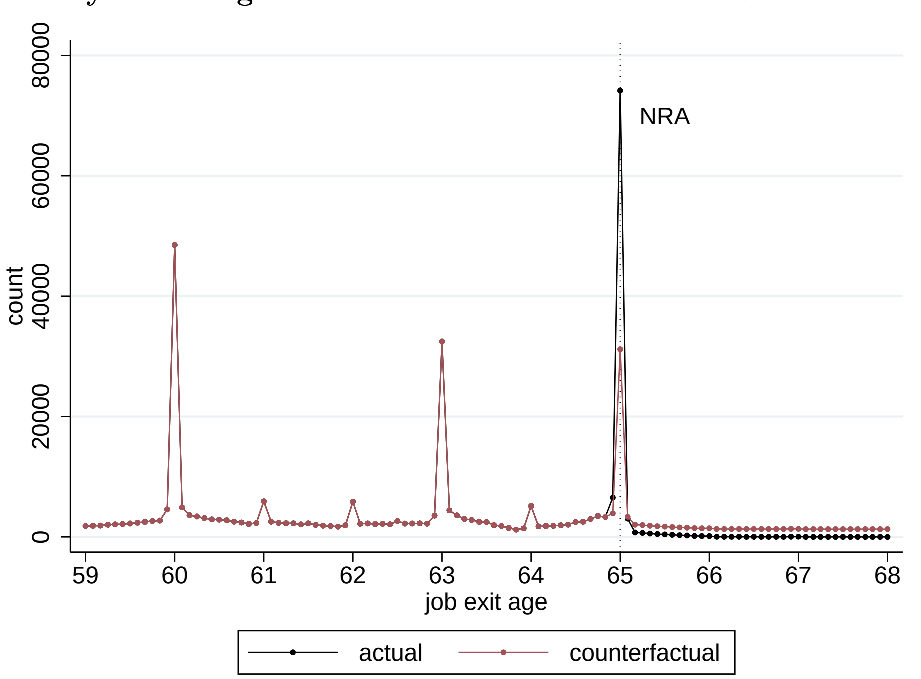
Note: The figure shows bunching responses to a retirement age reference point in an indifference curve diagram (top panel) and density diagram (bottom panel). In the top panel, the dashed gray curves are the initial (pre-ref.) indifference curves of the marginal buncher with ability n^*, whereas the solid red curves are her indifference curves with the reference point (post-ref.). The dotted curves are indifference curves pre-ref. (gray) and post-ref. (red) of an individual with ability $\hat{n}$ who retires at $\hat{R}$ before and after the change. The marginal buncher is tangent at R^* in the absence of the reference point, and tangent at $\hat{R}$ with the reference point. In the bottom panel, the solid red line denotes the post-ref. density, whereas the dashed gray line denotes the pre-ref. density. The red shaded area is the initial location of the mass of workers bunching in response to the reference point.

Figure 12: Counterfactual Simulations

Policy 1: Normal Retirement Age Increase from 65 to 66



Policy 2: Stronger Financial Incentives for Late Retirement



Note: The figure shows the the job exit age distribution simulated in two counterfactual policy scenarios vs. the actual job exit age distribution. In both panels, the black connected dots show the actual distribution of job exit ages for all workers born in 1946, and the dotted vertical line marks the actual NRA of 65 for this cohort. The red connected dots show the distribution of job exits among the same workers, simulated under a counterfactual scenario with an increase in the NRA from 65 to 66 (upper panel), and an increase in financial rewards for late retirement from 6% to 12.6% p.a. (lower panel). In the upper panel, the second dotted vertical line marks the post-reform NRA. See panel B of table 9 for quantitative results of the simulation.

Table 1: Pathways into Retirement

Pathway	Required contributions	Other requirements	Statutory Retirement Ages (Cohort 1941)		
			Early	Full	Normal
Regular	5 years	-	65	65	65
Long-term insured	35 years	-	63	65	65
Women	15 years 10 years full	female	60	61	65
Unemployed/part-time	15 years 8 years full	unemployed or in part-time work before retirement	60	64	65
Invalidity	35 years	disability status	60	60	65
Disability	5 years 3 years full	stricter disability status	-		

Note: The table presents an overview of pathways into retirement and associated eligibility requirements. For each pathway, statutory retirement ages are shown for a worker born in January 1941. Note that statutory ages vary over the sample period as shown in figure 4. The disability pathway does not have any statutory ages. For the unemployed/part-time pathway, unemployment for at least 1 year or old-age part-time work for at least 2 years after age 58 is required. For the invalidity pathway, an officially recognized disability of a certain degree is required; the disability pathway entails a stricter disability requirement such that the worker is not able to work more than 3 hours a day in any job. Full contribution years excludes periods where contributions are paid voluntarily.

Table 2: 644 Discontinuities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Statutory Retirement Ages				Pure Financial Incentives		
	all	Early	Full	Normal	all	kinks	notches
Mean kink size $\frac{\Delta\tau}{1-\tau}$	0.04	0.22	0.25	-0.50	0.42	0.31	0.44
s.d. across discontinuities	0.39	0.14	0.23	0.30	0.16	0.12	0.15
s.d. within discontinuity	0.05	0.02	0.04	0.12	0.08	0.05	0.08
Obs. (discontinuities)	386	117	257	93	258	78	180

Note: The table shows summary statistics of discontinuities in the bunching sample by type of discontinuity. Kink size is the percentage reduction in the net-of-tax rate at the discontinuity. "s.d. across discontinuities" is standard deviations of kink size across discontinuities of a given type. "s.d. within discontinuity" is standard deviation of kink size within a group of workers facing the same discontinuity. Note that the number of discontinuities in columns (2) to (4) are larger than the total in column (1) because some kinks are linked to more than one type of statutory age. All statistics weighted by group size.

Table 3: Summary Statistics

	(1) individual sample	(2) occupation-matched sample	(3) bunching sample
job exit age	60.85	61.89	61.11
	(2.80)	(2.67)	(1.54)
benefit claiming age	62.02	62.80	62.39
	(2.35)	(2.13)	(1.41)
career length	43.57	44.18	43.70
	(6.54)	(6.94)	(2.66)
contribution points	36.98	38.99	37.06
	(17.20)	(18.08)	(11.37)
net lifetime income	1,082,966	1,120,269	1,077,502
	(420,224)	(434,974)	(277,333)
female	0.46	0.45	0.45
	(0.50)	(0.50)	(0.43)
east	0.18	0.20	0.18
	(0.38)	(0.40)	(0.09)
married	0.76	0.76	0.77
	(0.42)	(0.43)	(0.06)
sick leave (years)	0.074	0.056	0.07
	(0.25)	(0.21)	(0.04)
education (years)	10.61	10.74	10.68
	(1.58)	(1.79)	(0.30)
small firm		0.27	
		(0.18)	
large firm		0.44	
		(0.18)	
tenure		8.95	
		(2.80)	
unlimited contract		0.83	
		(0.09)	
Obs. (individuals)	8,637,698	3,955,473	
Obs. (discontinuities)			644

Note: The table presents summary statistics for the samples used. The individual and occupation-matched samples are at the worker level, while the bunching sample is at the discontinuity level. Job exit and benefit claiming ages are in years. Career length is time between first and last contribution. Contribution points are collected from pension contributions, where one point corresponds to earning the population average gross income for one year. Net lifetime income is in net present value terms as in equation (1). "East" is a dummy for residence in East Germany. "Small firm" and "large firm" are indicators for firms with less than 20 employees and more than 200 employees, respectively. Firm size, tenure and fraction in unlimited contract are at the occupation level. Standard deviations in parantheses. See appendix C.2 for further details of variable definitions.

Table 4: Bunching across All Discontinuities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Statutory Retirement Ages				Pure Financial Incentives		
	all	Early	Full	Normal	all	kinks	notches
Excess mass b	19.8	14.1	21.5	32.7	3.81	0.10	4.31
	(0.80)	(0.98)	(0.85)	(1.77)	(0.28)	(0.04)	(0.34)
Observed	0.49	0.56	0.44	1.02	0.07	0.01	0.08
elasticity $\hat{\varepsilon}$	(0.02)	(0.03)	(0.02)	(0.14)	(0.01)	(0.002)	(0.01)
Obs. (discontinuities)	386	117	257	93	258	78	180

Note: The table summarizes bunching responses by type of discontinuity in the bunching sample. Excess mass and observed elasticities are computed as described in section 3 and appendix D. All statistics are weighted by group sizes. Standard errors in parantheses. Observed elasticities are only calculated only at convex kinks, that is excluding non-convex NRA kinks.

Table 5: Reduced-Form Estimation

	(1)	(2)	(3)	(4)	(5)
	Dependent variable: Excess mass $b/\hat{R}$				
kink size $\frac{\Delta\tau}{1-\tau}$	0.04***	0.03***	0.02	0.03	0.05
	(0.004)	(0.004)	(0.02)	(0.02)	(0.03)
Statutory age at kink:					
Early Retirement Age	0.07***	0.05***	0.04**	0.06**	0.07**
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
Full Retirement Age	0.07***	0.06***	0.06***	0.08***	0.08***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
Normal Retirement Age	0.16***	0.19***	0.18***	0.20***	0.23***
	(0.02)	(0.02)	(0.03)	(0.04)	(0.06)
Observations (discontinuities)	644	644	644	644	583
R-squared	0.68	0.71	0.87	0.89	0.87
Statutory age interactions	no	yes	yes	yes	yes
Worker controls	no	no	yes	yes	yes
Pathway FE, year-of-birth FE	no	no	yes	yes	yes
Pathway × year-of-birth FE	no	no	no	yes	yes
Occupation-level controls	no	no	no	no	yes

Note: The table shows results from discontinuity-level regressions of normalized excess mass $b/\hat{R}$ on kink size as well as dummies for the presence of statutory age types $s \in \{ERA, FRA, NRA\}$ based on equation (5), using the bunching sample. Statutory age interactions are interactions between dummies for each statutory age type. Worker controls include dummies for female, married and East Germany, last earnings before retirement, net lifetime income, career length, sick leave years and education years. Occupation-level controls include firm size index, unionization rate, active union member rate, tenure in the firm, fraction in unlimited contracts, fraction receiving severance pay, fraction of involuntary job exits. The number of observations is smaller in column (5) because occupation-level controls are only available for the occupation-matched sample, and discontinuities corresponding to too few individual observations are dropped. Regressions weighted by group size. Bootstrapped standard errors in parantheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Reduced-Form Estimation: Heterogeneous Coefficients

	(1)	(2)	(3)
	Dependent variable: Excess mass $b/\hat{R}$		
kink size $\frac{\Delta\tau}{1-\tau}$	0.08***	0.05***	0.09***
	(0.01)	(0.01)	(0.01)
Statutory age at kink:			
Early Retirement Age	0.06***	0.07***	0.08***
	(0.004)	(0.01)	(0.01)
Full Retirement Age	0.07***	0.08***	0.10***
	(0.01)	(0.01)	(0.01)
Normal Retirement Age	0.24***	0.23***	0.24***
	(0.02)	(0.02)	(0.02)
Observations (discontinuities)	627	627	627
R-squared	0.91	0.82	0.95
Heterogeneous coefficients:			
by pathway	yes	no	yes
by year of birth	no	yes	yes
by pathway × year of birth	no	no	yes

Note: The table shows results from discontinuity-level regressions of normalized excess mass $b/\hat{R}$ on kink size as well as dummies for the presence of statutory age types $s \in \{ERA, FRA, NRA\}$ based on equation (6), using the bunching sample. Weighted averages of heterogeneous coefficients estimated according to equation (6) are reported, where column (1) defines groups by pathway, (2) defines groups by year of birth, and (3) by pathway × year of birth. Groups with no variation in D^s are excluded from the within-group estimation since group-specific coefficients cannot be estimated in this case, such that the number of observations is slightly smaller than the full bunching sample used in table 5. Interactions between statutory age dummies are included in all specifications. Regressions weighted by group size. Bootstrapped standard errors in parantheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Individual-Level Correlates of Bunching

	(1)	(2)
	Dependent variable: Indicator for bunching at...	
	Statutory Retirement Age	pure financial incentive discontinuity
education	0.01***	0.0001***
	(0.001)	(0.0000)
economic training	0.01***	0.001***
	(0.002)	(0.0002)
lifetime earnings	0.27***	-0.02***
	(0.01)	(0.001)
last earnings before retirement	0.08***	0.001***
	(0.002)	(0.0001)
pension wealth/annual earnings	0.04***	-0.0004***
	(0.001)	(0.0000)
female	-0.02***	-0.004***
	(0.01)	(0.0004)
married	-0.17***	0.005***
	(0.003)	(0.0003)
female × married	-0.01**	0.0004**
	(0.002)	(0.0002)
Mean dependent variable	0.31	0.004
Observations	3,932,038	3,932,038
R-squared	0.15	0.02
Additional worker controls	yes	yes
Occupation-level controls	yes	yes
Year of birth & pathway FE	yes	yes

Note: The table shows results from an individual-level regression of dummies for job exits at different types of discontinuities on worker characteristics. Economic training is defined as working in an economically trained occupation, such as economists, bankers and insurance specialists. Pension wealth/annual earnings denotes the ratio between a worker's pension wealth and their average annual earnings. Additional worker controls include dummy for East Germany, career length, sick leave years. Occupation-level controls include firm size index, unionization rate, active union member rate, tenure in the firm, fraction in unlimited contracts, fraction receiving severance pay, fraction of involuntary job exits. Standard errors clustered at the pathway × month of birth level. *** p<0.01, ** p<0.05, * p<0.1.

Table 8: Parameter Estimates

	(1)	(2)	(3)
	Statutory Retirement Ages:		
	Early	Full	Normal
Reference dependence λ^s	0.34***	0.23***	0.38***
	(0.02)	(0.01)	(0.01)
Kink size equivalent	0.54***	0.44***	1.13***
	(0.03)	(0.02)	(0.05)
Elasticity ε	0.05*** (0.003)		

Note: The table presents parameter estimates from a non-linear least squares estimation based on equation (13), using the bunching sample. The first row displays estimates of the λ^s parameters governing reference point effects of statutory retirement age type s. The second row shows reference point effects scaled as kink size equivalents obtained by dividing λ^s by the implicit net-of-tax rate $1-\tau$ at each statutory age discontinuity. The third row displays ε, the estimated elasticity of the retirement age w.r.t. to the net-of-tax rate. Bootstrapped standard errors in parantheses. *** p<0.01, ** p<0.05, * p<0.1. The estimation also allows for interaction effects between different types of statutory ages, which are shown in appendix table A7.

Table 9: Counterfactual Simulations

Panel A: No Reference Point Effects

	(1)	(2)	(3)	(4)
	actual	counterfactuals		
		$\varepsilon = 0.05$	$\varepsilon = 0.03$	$\bar{\varepsilon}_g = 0.08$
Percentage of job exits at statutory ages	28.7	6.80	5.77	9.39
% explained (of actual)		23.7%	20.0%	32.7%
Excess at mass at statutory ages	19.8	1.27	0.88	2.36
% explained (of actual)		6.41%	4.45%	11.9%

Panel B: Policy Counterfactuals

	(1)	(2)	(3)
	actual	counterfactuals	
Policy		Normal Retirement Age increase from 65 to 66	increase in rewards for late retirement from 6% to 12.6%
Average job exit age (65 and above)	65.0	65.9	65.9
change (months)		+10	+10
Average job exit age (60 and above)	62.8	63.1	63.0
change (months)		+4	+3
Excess mass at NRA	29.9	21.2	11.3
change		-8.1	-17.7
Net fiscal effect (NPV)		+€675m	-€465m
contributions collected		+€277	+€277m
benefits paid		-€398m	+€741m

Note: The table shows results from counterfactual simulations. Panel A shows a counterfactual scenario where there are no reference point effects of statutory retirement ages, i.e. workers respond only to financial incentives. Column (1) shows figures from the actual data, whereas columns (2) to (4) show figures from the counterfactual with varying retirement age elasticities. $\varepsilon = 0.05$ is the structural elasticity from table 8, $\varepsilon = 0.03$ is the lower estimate among the reduced-form estimation (column (2) of table 5), and $\bar{\varepsilon}_g = 0.08$ refers to a scenario with heterogeneous elasticities (column (1) of table 6). Panel B shows results from a simulation of two counterfactual policies: an increase in the NRA (column 1) and an increase in financial rewards for late retirement (column 2). The size of rewards in column (2) is calibrated to match the effect on the average job exit age in the first row of panel B. Fiscal effects are calculated in 2012 Euros. All excess mass figures weighted by group size.

Online Appendix

A Appendix Figures and Tables

Figure A1: Framing

Note: The figure shows excerpts of an information leaflet that informs workers about a future pension reform where the Normal Retirement Age will be increased to 67. Explanation of the main points is provided in the red boxes on the right. Note that some of the pension rules in the leaflet can differ from those described in section 2, as the leaflet describes future pension rules. Source: `http://www.deutsche-rentenversicherung.de/cae/servlet/contentblob/232636/publicationFile/49694/rente_mit_67.pdf`

Figure A1: Framing (continued)

Beispiel:

Hubert K. ist Jahrgang 1953. Er feiert am 23. Juli 2018 seinen 65. Geburtstag. Seine Regelaltersrente erhält er erst ab dem 1. März 2019.

Example: Hubert K. was born in 1953. He will celebrate his 65th birthday on 23 June 2018. He can get his regular pension from 1 March 2019. (Note: This is his NRA.)

Aber auch die Altersgrenzen der vorgezogenen Altersrenten werden weiter angehoben. Bis die neuen Altersgrenzen erreicht sind, vergehen oft viele Jahre, denn auch hier werden die Altersgrenzen nur um ein oder zwei Monate pro Geburtsjahr angehoben.

Anhebung der Altersgrenzen

Altersrente	stufenweise Anhebung	erster betroffener Geburtsjahrgang
Regelaltersrente	von 65 auf 67 Jahre	1947
Altersrente für besonders langjährig Versicherte	von 63 auf 65 Jahre	1953
Altersrente für langjährig Versicherte	von 65 auf 67 Jahre	1949
Altersrente für schwerbehinderte Menschen	von 63 auf 65 Jahre	1952
Altersrente für langjährig unter Tage beschäftigte Bergleute	von 60 auf 62 Jahre	1952

Overview of Normal and Full Retirement Ages

Für die Geburtsjahrgänge 1964 und jünger gelten dann grundsätzlich die neuen Altersgrenzen.

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Früher in Rente – mit Abschlägen möglich

Die Altersgrenzen der meisten Altersrenten sind fließend. Wer früher in Rente gehen will, muss aber mit Abschlägen rechnen.

Der Abschlag beträgt 0,3 Prozent für jeden Monat, den Sie vorzeitig in Rente gehen. Vorzeitig bedeutet, dass Sie die Rente bereits vor der abschlagsfreien Altersgrenze bekommen.

For each month of retirement before the FRA, the penalty is 0.3 percent.

Die Abschläge wirken sich während der gesamten Laufzeit der Rente aus. Wird im Anschluss an Ihre Rente später einmal eine Hinterbliebenenrente gezahlt, gilt der Abschlag auch für diese Rente weiter.

Altersrente für langjährig Versicherte
Die Altersrente für langjährig Versicherte kann mit Abschlägen ab dem 63. Geburtstag beginnen.

Altersrente für schwerbehinderte Menschen
Die Mindestaltersgrenze für die Altersrente für schwerbehinderte Menschen wird ab

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dem Geburtsjahrgang 1952 stufenweise von 60 auf 62 Jahre angehoben und ist für jeden Geburtsjahrgang individuell.

Beispiel:

Josef N. ist Jahrgang 1954 und wird am 14. Juli 2018 64 Jahre alt. Er erfüllt die Voraussetzungen für eine Altersrente für langjährig Versicherte. Beansprucht Josef N. seine Altersrente mit 64 Jahren, muss er dafür Abschläge in Kauf nehmen. Die Höhe des Abschlags richtet sich nach dem Zeitraum, der zwischen Josef N.s individuellem Rentenbeginn und der zu diesem Zeitpunkt gültigen abschlagsfreien Altersgrenze liegt.

Der Jahrgang 1954 darf ohne Abschläge mit 65 Jahren und acht Monaten in Rente gehen. Zwischen Rentenbeginn (64 Jahre) und der abschlagsfreien Altersgrenze liegen damit bei Josef N. 20 Monate. Die Summe seiner Abschläge beträgt 6 Prozent (20 × 0,3 Prozent).

Erfüllt Josef N. auch die Voraussetzungen für eine Altersrente für besonders langjährig Versicherte, kann er ebenfalls mit 64 Jahren in Rente gehen. Hier muss er aber keine Abschläge in Kauf nehmen, da diese Rente bereits mit 63 Jahren und vier Monaten abschlagsfrei gezahlt werden kann.

Example: Josef N. was born in 1954 and he will turn 64 on 14th July 2018. [...] If he retires at 64, he has to incur a penalty. The penalty amount depends on his retirement age relative to the Full Retirement Age. [...] The total penalty would be 6 percent (20 x 0.3 percent). [...]

Weitere Informationen zum Thema Abschläge finden Sie in der Broschüre „Die richtige Altersrente für Sie".

You can find further information on pension adjustment in the brochure "The right pension for you".

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Rente bei voller Erwerbsminderung

Ein Versicherter mit ... Versicherungsjahren*	hat Anspruch auf diese Monatsrente** bei einem insgesamt unterdurchschnittlichen Verdienst (70 % vom Durchschnitt = 0,7 EP***)	bei einem insgesamt durchschnittlichen Verdienst (100 % vom Durchschnitt = 1,0 EP***)	bei einem insgesamt überdurchschnittlichen Verdienst (130 % vom Durchschnitt = 1,3 EP***)
alte Bundesländer			
25	532,88 Euro	761,25 Euro	989,63 Euro
30	639,45 Euro	913,50 Euro	1 187,55 Euro
35	746,03 Euro	1 065,75 Euro	1 385,48 Euro
40	852,60 Euro	1 218,00 Euro	1 583,40 Euro
45	959,18 Euro	1 370,25 Euro	1 781,33 Euro
neue Bundesländer			
25	501,55 Euro	716,50 Euro	931,45 Euro
30	601,86 Euro	859,80 Euro	1 117,74 Euro
35	702,17 Euro	1 003,10 Euro	1 304,03 Euro
40	802,48 Euro	1 146,40 Euro	1 490,32 Euro
45	902,79 Euro	1 289,70 Euro	1 676,61 Euro

Disability pension benefits by contribution years and previous earnings.

Die Werte sind bis zum 30. Juni 2017 gültig. Die ermittelten Beträge basieren auf dem aktuellen Rentenwert von 30,45 EUR beziehungsweise von 28,66 EUR Rentenwert (Ost). Sie vermindern sich bei einem Rentenbeginn vor Vollendung des 65. Lebensjahres mit einer gleitenden Übergangsregelung um einen individuellen Abschlag (maximal 10,8 %). Bitte lesen Sie hierzu die Seiten 16 bis 17.

Note that benefits will be gradually adjusted by an individual penalty if claiming before age 65 (max. 10.8%). Please see pages 16 and 17.

* Inklusive Zurechnungszeit. Bitte lesen Sie auch Seite 15.
** Bei der Berechnung sind individuelle Abschläge nicht berücksichtigt.
*** EP = Entgeltpunkt. Einen Entgeltpunkt erhalten Sie für ein Jahr Beitragszahlung nach dem statistischen Jahresdurchschnittsverdienst (vorläufiger Wert für 2016 = 36 267 EUR).

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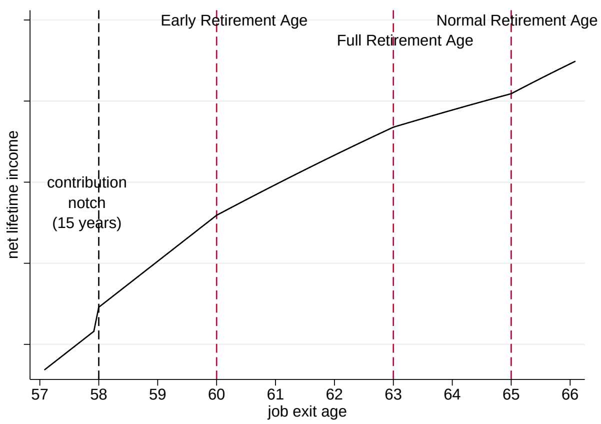
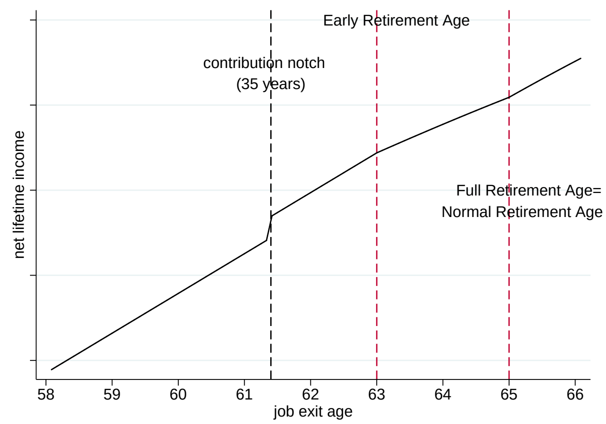
Note: The figure shows excerpts of an information leaflet that informs workers about a future pension reform where the Normal Retirement Age will be increased to 67. Explanation of the main points is provided in the red boxes on the right. The bottom right panel is taken from an information leaflet on disability pensions. Note that some of the pension rules in the leaflet can differ from those described in section 2, as the leaflet describes future pension rules. Sources: http://www.deutsche-rentenversicherung.de/cae/servlet/contentblob/232636/publicationFile/49694/rente_mit_67.pdfhttp://www.deutsche-rentenversicherung.de/cae/servlet/contentblob/232616/publicationFile/49858/erwerbsminderungsrente_das_netz_fuer_alle_faelle.pdf

Figure A2: Lifetime Budget Constraints: Some Examples

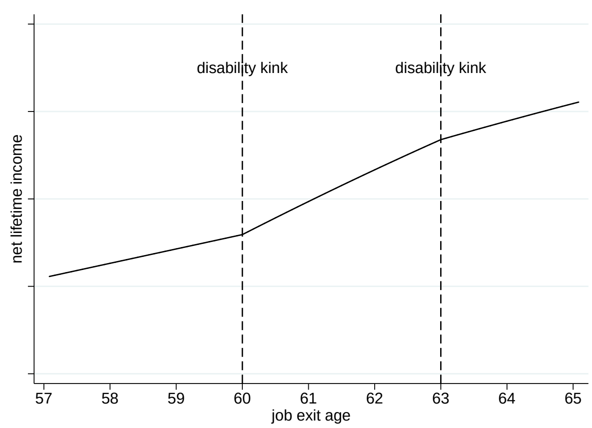
Panel A: Female, born December 1942



Panel B: Male, born March 1939

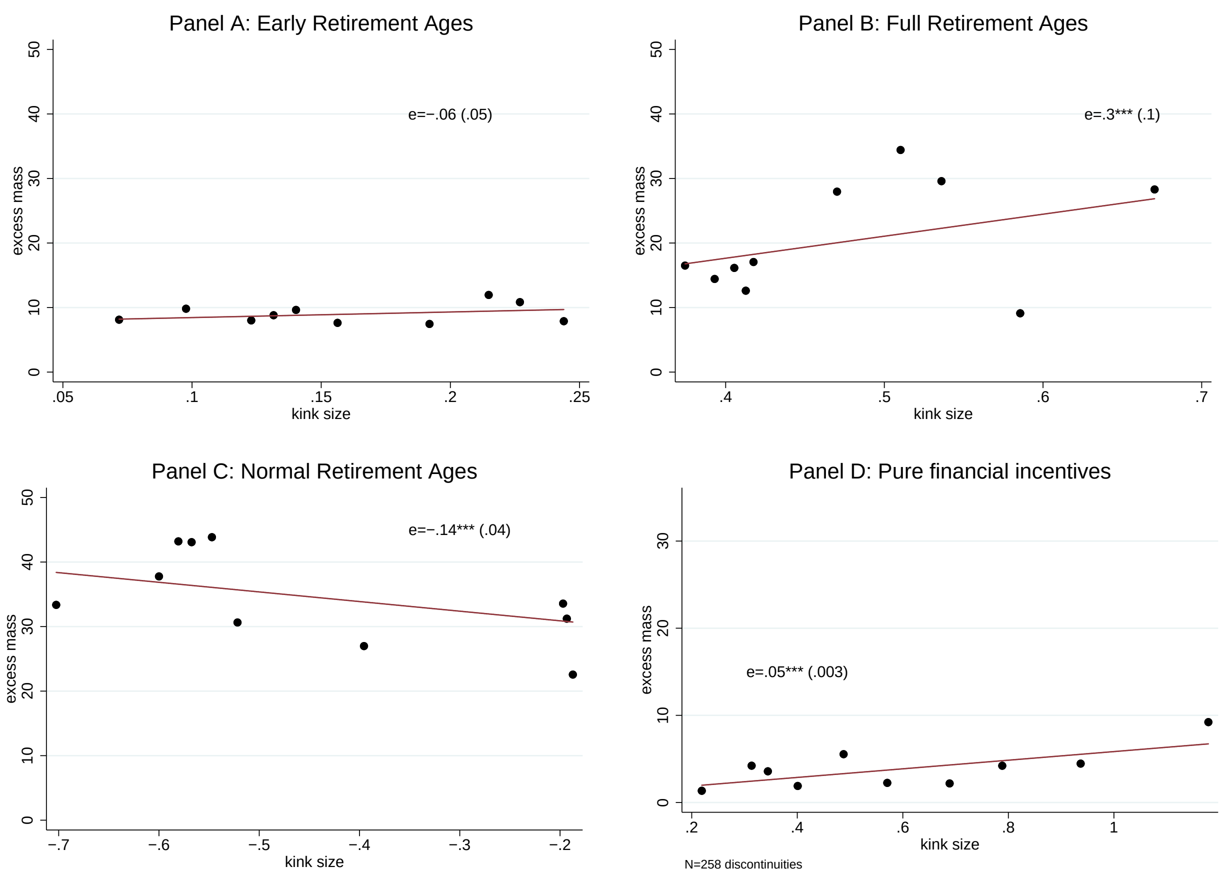


Panel C: Male, born January 1946, satisfies disability requirement



Note: The figure shows some examples of lifetime budget constraints to illustrate the variation across pathways and birth cohorts. In panel A, a female born in December 1942 becomes eligible for the women's pathway after 15 years of contributions, where she faces an Early Retirement Age (ERA) of 60, a Full Retirement Age (FRA) of 63 and a Normal Retirement Age (NRA) of 65. There are convex kinks at the ERA and FRA, and a non-convex kink at the NRA. The pure financial incentive notch due to the contribution requirement is reached at age 58 in the example. In panel B, a male worker born in March 1939 becomes eligible for the long-term insured pathway after 35 years of contributions, where he faces an ERA at 63 and a joint FRA/NRA at 65. There is a convex kink at the ERA and anon-convex kink at the FRA/NRA. The contribution notch is reached at age 61 and 4 months in the example. In panel C, a male worker born in January 1946 who satisfies the medical requirement for the disability pathway faces pure financial incentive kinks at ages 60 and 63, where marginal pension adjustment changes.

Figure A3: Bunching and Financial Incentives



Note: The figure shows binned scatterplots of the retirement response (excess mass) vs. the underlying financial incentive (kink size) at a discontinuity, separately for Early Retirement Ages (panel A), Full Retirement Ages (panel B), Normal Retirement Ages (panel C), and pure financial incentive discontinuities (panel D). Each panel also includes the coefficient from a discontinuity-level regression of normalized excess mass $b/\hat{R}$ on kink size, which can be interpreted as a difference-in-bunching elasticity, with bootstrapped standard error in parantheses.
Data source of all figures and tables: *FDZ-RV - Themenfile SUFRTZN1992-2014XVSBB_Seibold*

Figure A4: The Effect of Increasing the Full Retirement Age

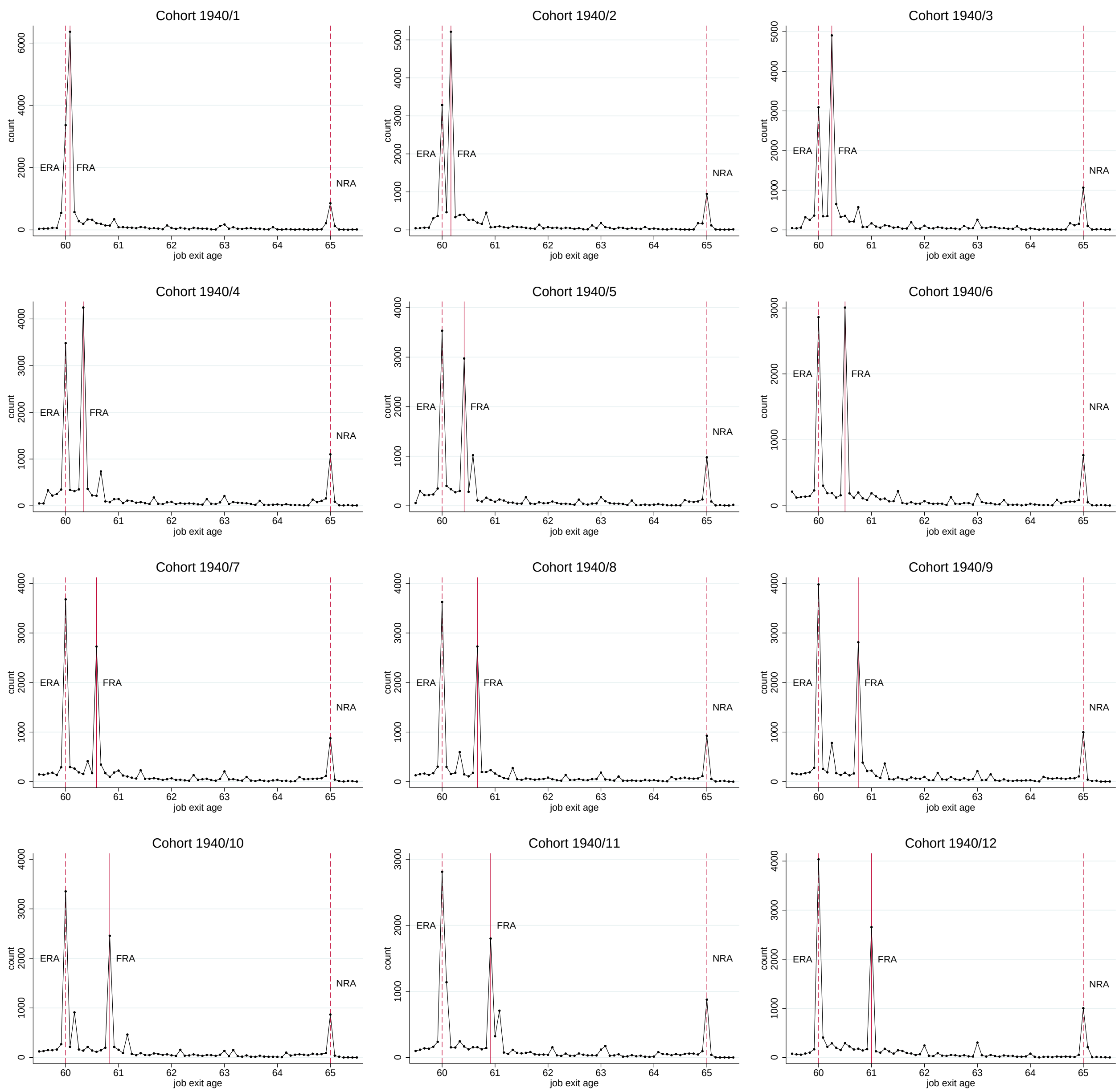


Figure A4: The Effect of Increasing the Full Retirement Age (continued)

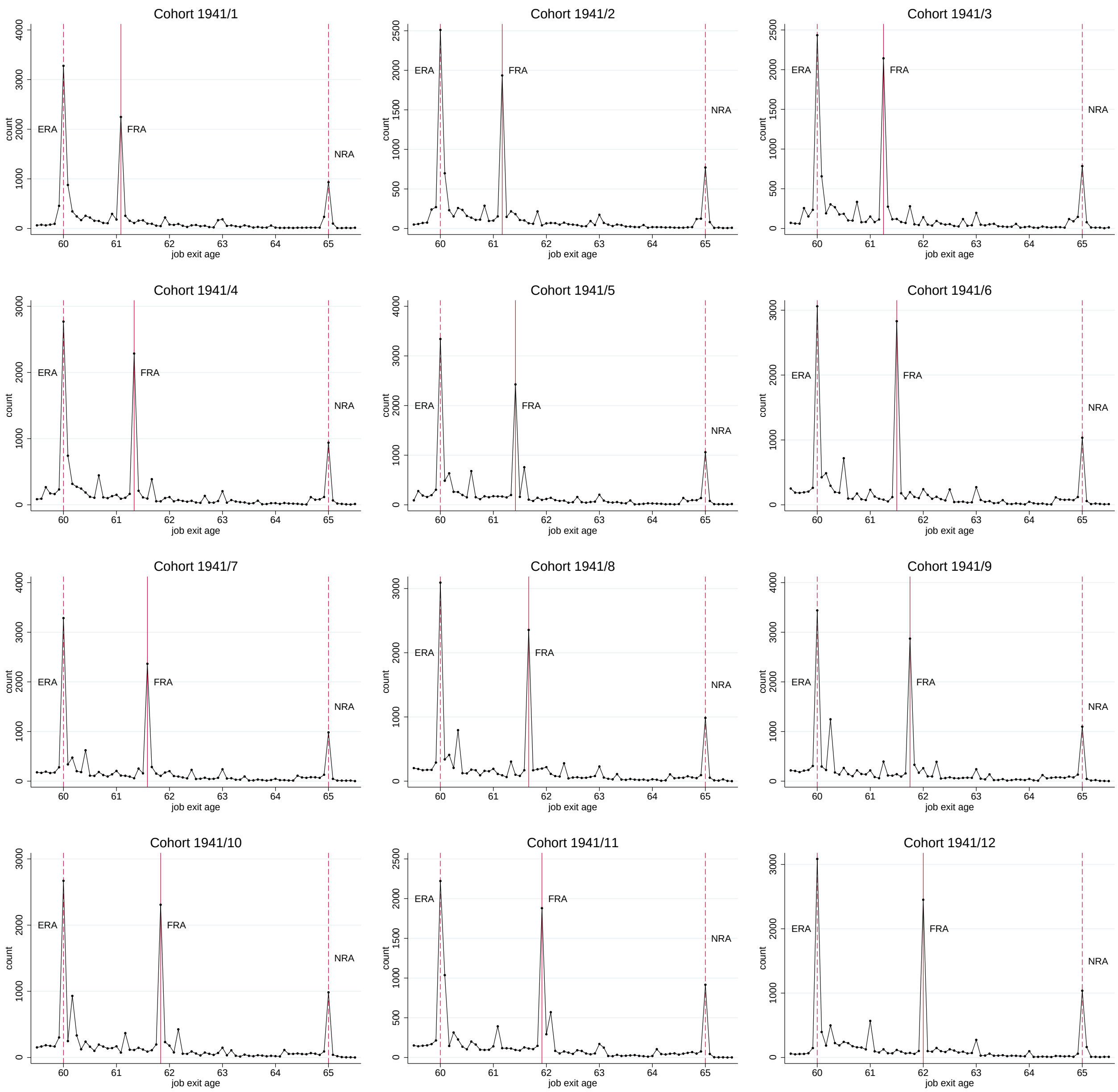


Figure A4: The Effect of Increasing the Full Retirement Age (continued)

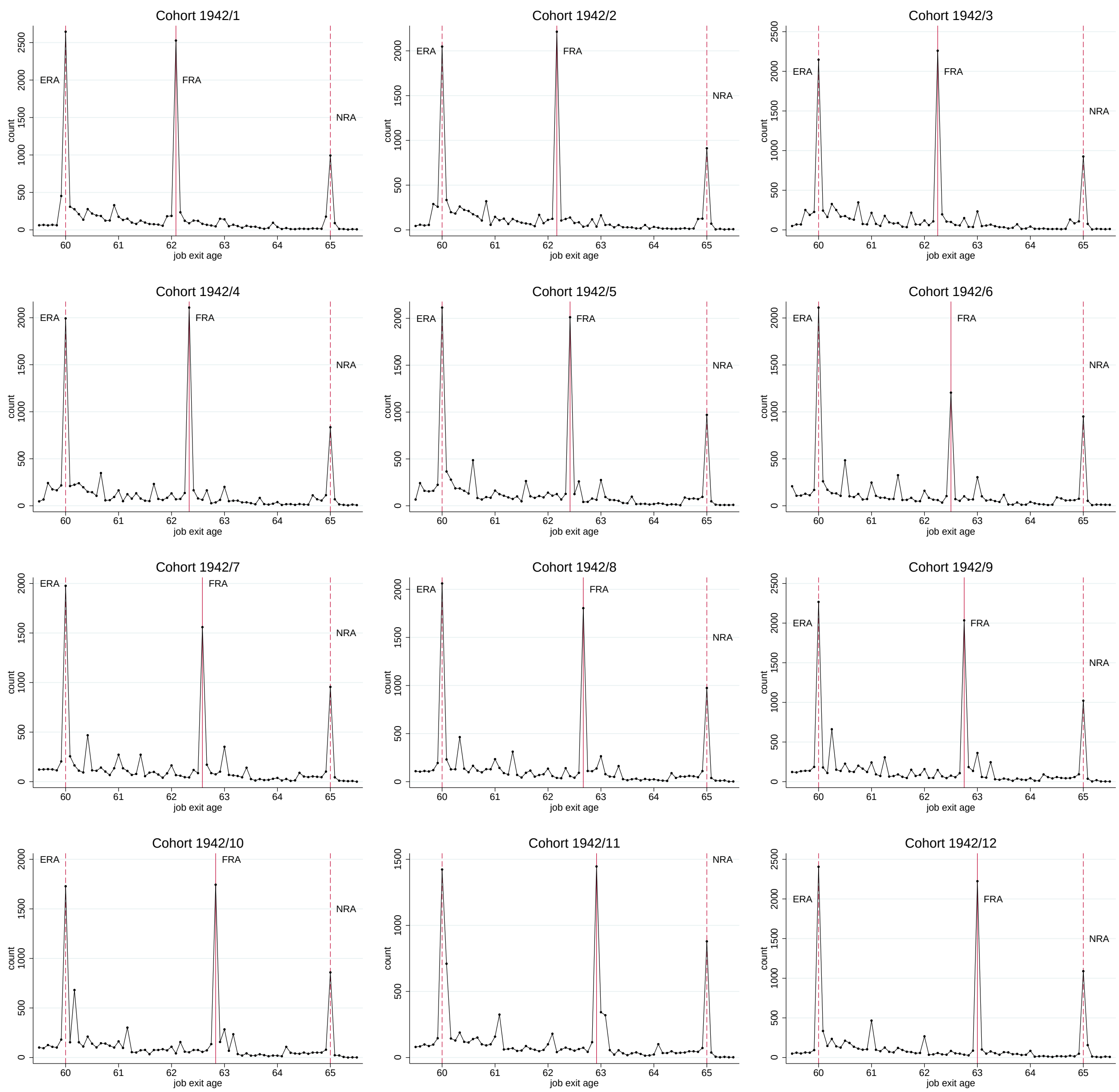


Figure A4: The Effect of Increasing the Full Retirement Age (continued)

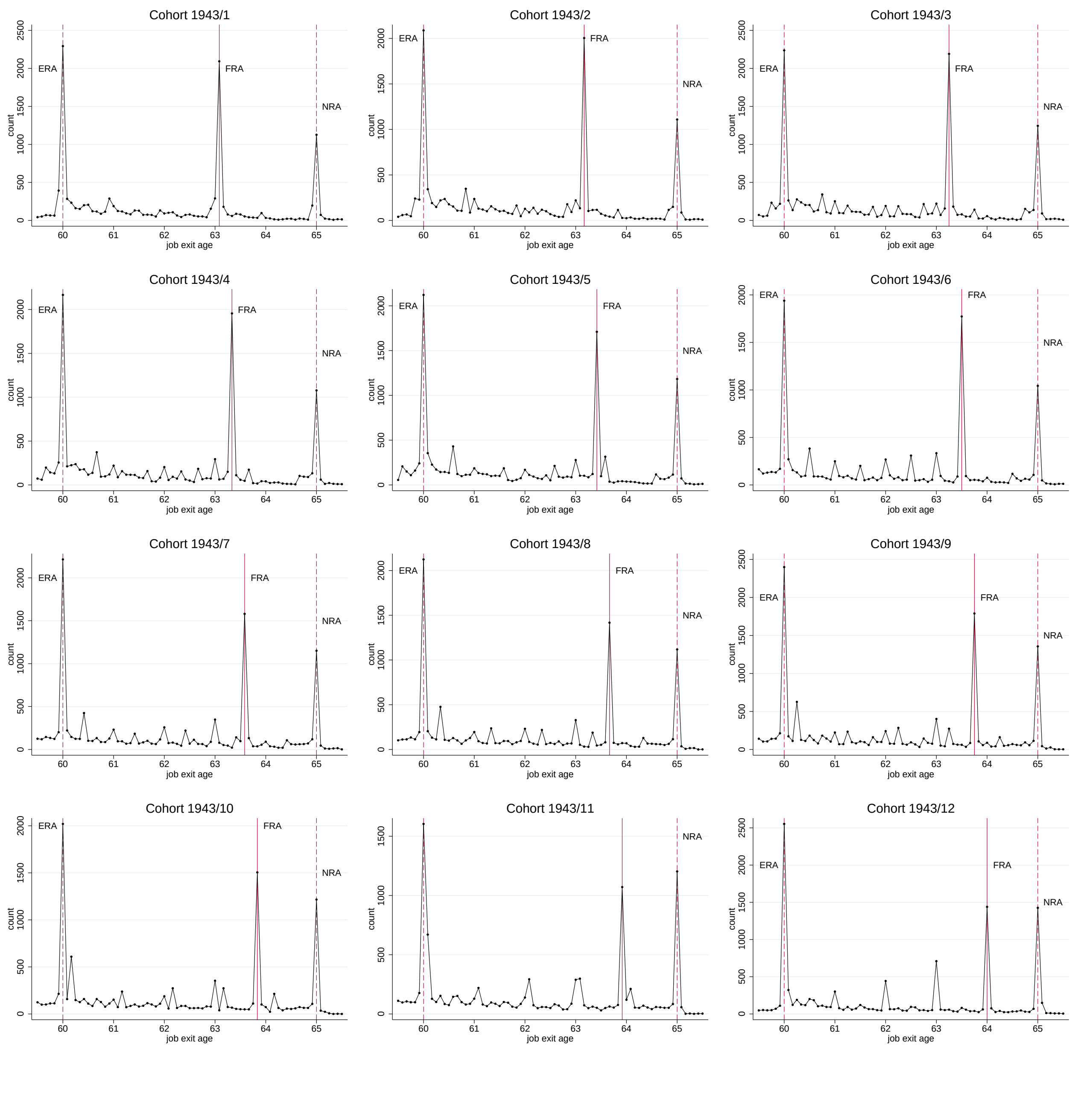
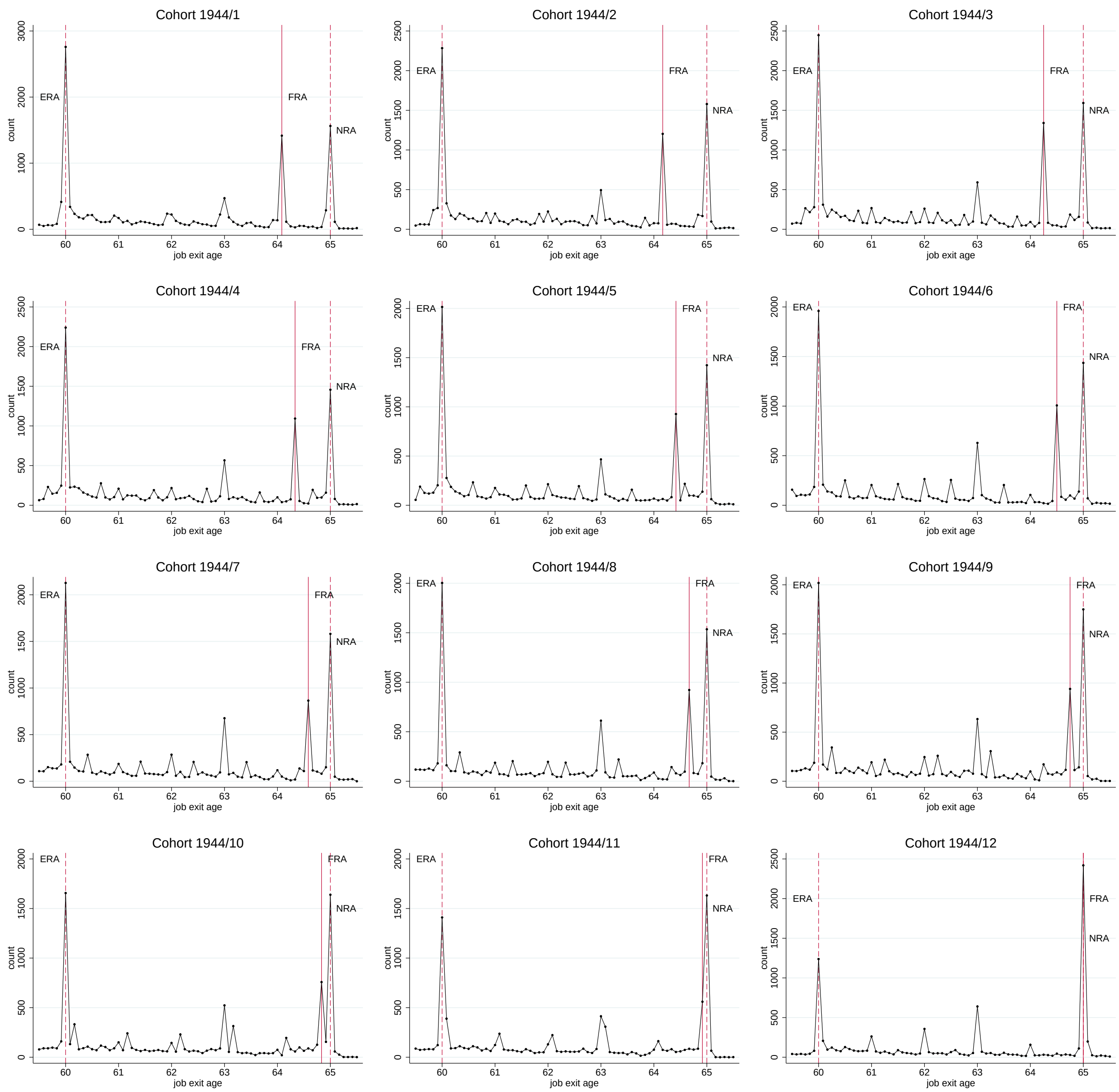
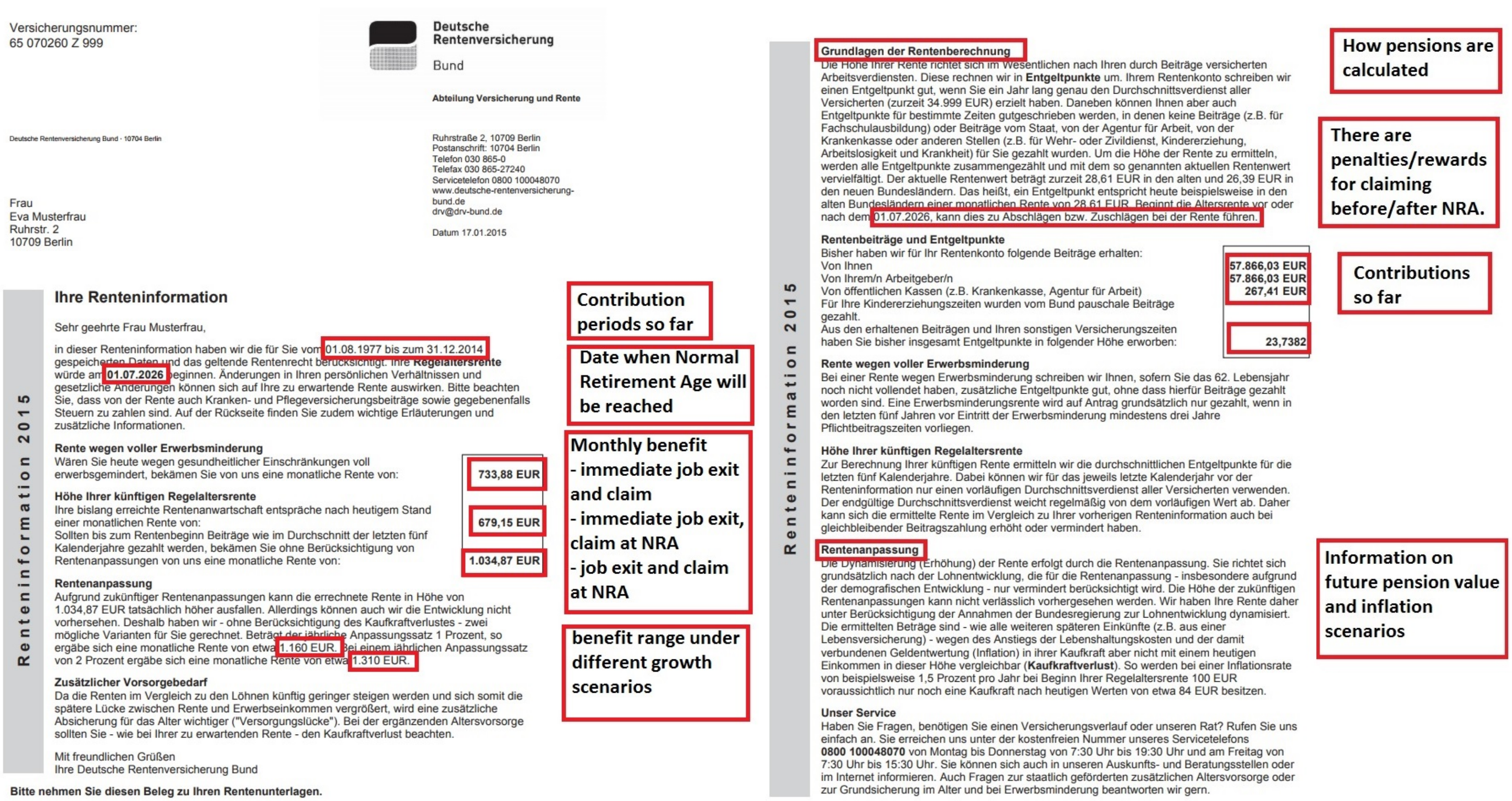


Figure A4: The Effect of Increasing the Full Retirement Age (continued)



Note: The figure shows job exit age distributions throughout a reform that increases the Full Retirement Age (FRA) from 60 to 65 in the women's pathway. For cohorts 1940 1944, the FRA increases by one month for each month of birth. Each graph shows the job exit age distribution among the monthly birth cohort indicated in the graph title. The connected dots show the count of job exits within monthly bins. The solid vertical red line indicates the location of the FRA, and dashed vertical red lines indicate other statutory retirement ages. The figure complements main text figure 8 which shows selected monthly birth cohorts.

Figure A5: Information Letters



Versicherungsnummer:
65 070260 Z 999

Deutsche Rentenversicherung
Bund

Abteilung Versicherung und Rente

Deutsche Rentenversicherung Bund · 10704 Berlin

Ruhrstraße 2, 10709 Berlin
Postanschrift: 10704 Berlin
Telefon 030 865-0
Telefax 030 865-27240
Servicetelefon 0800 100048070
www.deutsche-rentenversicherung-bund.de
drv@drv-bund.de

Frau
Eva Musterfrau
Ruhrstr. 2
10709 Berlin

Datum 17.01.2015

Renteninformation 2015

Ihre Renteninformation

Sehr geehrte Frau Musterfrau,

in dieser Renteninformation haben wir die für Sie vom 01.08.1977 bis zum 31.12.2014 gespeicherten Daten und das geltende Rentenrecht berücksichtigt. Ihre **Regelaltersrente** würde am **01.07.2026** beginnen. Änderungen in Ihren persönlichen Verhältnissen und gesetzliche Änderungen können sich auf Ihre zu erwartende Rente auswirken. Bitte beachten Sie, dass von der Rente auch Kranken- und Pflegeversicherungsbeiträge sowie gegebenenfalls Steuern zu zahlen sind. Auf der Rückseite finden Sie zudem wichtige Erläuterungen und zusätzliche Informationen.

Rente wegen voller Erwerbsminderung
Wären Sie heute wegen gesundheitlicher Einschränkungen voll erwerbsgemindert, bekämen Sie von uns eine monatliche Rente von: **733,88 EUR**

Höhe Ihrer künftigen Regelaltersrente
Ihre bislang erreichte Rentenanwartschaft entspräche nach heutigem Stand einer monatlichen Rente von: **679,15 EUR**
Sollten bis zum Rentenbeginn Beiträge wie im Durchschnitt der letzten fünf Kalenderjahre gezahlt werden, bekämen Sie ohne Berücksichtigung von Rentenanpassungen von uns eine monatliche Rente von: **1.034,87 EUR**

Rentenanpassung
Aufgrund zukünftiger Rentenanpassungen kann die errechnete Rente in Höhe von 1.034,87 EUR tatsächlich höher ausfallen. Allerdings können auch wir die Entwicklung nicht vorhersehen. Deshalb haben wir - ohne Berücksichtigung des Kaufkraftverlustes - zwei mögliche Varianten für Sie gerechnet. Beträgt der jährliche Anpassungssatz 1 Prozent, so ergäbe sich eine monatliche Rente von etwa 1.160 EUR. Bei einem jährlichen Anpassungssatz von 2 Prozent ergäbe sich eine monatliche Rente von etwa 1.310 EUR.

Zusätzlicher Vorsorgebedarf
Da die Renten im Vergleich zu den Löhnen künftig geringer steigen werden und sich somit die spätere Lücke zwischen Rente und Erwerbseinkommen vergrößert, wird eine zusätzliche Absicherung für das Alter wichtiger ("Versorgungslücke"). Bei der ergänzenden Altersvorsorge sollten Sie - wie bei Ihrer zu erwartenden Rente - den Kaufkraftverlust beachten.

Mit freundlichen Grüßen
Ihre Deutsche Rentenversicherung Bund

Bitte nehmen Sie diesen Beleg zu Ihren Rentenunterlagen.

Renteninformation 2015

Grundlagen der Rentenberechnung
Die Höhe Ihrer Rente richtet sich im Wesentlichen nach Ihren durch Beiträge versicherten Arbeitsverdiensten. Diese rechnen wir in **Entgeltpunkte** um. Ihrem Rentenkonto schreiben wir einen Entgeltpunkt gut, wenn Sie ein Jahr lang genau den Durchschnittsverdienst aller Versicherten (zurzeit 34.999 EUR) erzielt haben. Daneben können Ihnen aber auch Entgeltpunkte für bestimmte Zeiten gutgeschrieben werden, in denen keine Beiträge (z.B. für Fachschulausbildung) oder Beiträge vom Staat, von der Agentur für Arbeit, von der Krankenkasse oder anderen Stellen (z.B. für Wehr- oder Zivildienst, Kindererziehung, Arbeitslosigkeit und Krankheit) für Sie gezahlt wurden. Um die Höhe der Rente zu ermitteln, werden alle Entgeltpunkte zusammengezählt und mit dem so genannten aktuellen Rentenwert vervielfältigt. Der aktuelle Rentenwert beträgt zurzeit 28,61 EUR in den alten und 26,39 EUR in den neuen Bundesländern. Das heißt, ein Entgeltpunkt entspricht heute beispielsweise in den alten Bundesländern einer monatlichen Rente von 28,61 EUR. Beginnt die Altersrente vor oder nach dem 01.07.2026, kann dies zu Abschlägen bzw. Zuschlägen bei der Rente führen.

Rentenbeiträge und Entgeltpunkte
Bisher haben wir für Ihr Rentenkonto folgende Beiträge erhalten:

Von Ihnen	**57.866,03 EUR**
Von Ihrem/n Arbeitgeber/n	**57.866,03 EUR**
Von öffentlichen Kassen (z.B. Krankenkasse, Agentur für Arbeit)	**267,41 EUR**
Für Ihre Kindererziehungszeiten wurden vom Bund pauschale Beiträge gezahlt.	
Aus den erhaltenen Beiträgen und Ihren sonstigen Versicherungszeiten haben Sie bisher insgesamt Entgeltpunkte in folgender Höhe erworben:	**23,7382**

Rente wegen voller Erwerbsminderung
Bei einer Rente wegen Erwerbsminderung schreiben wir Ihnen, sofern Sie das 62. Lebensjahr noch nicht vollendet haben, zusätzliche Entgeltpunkte gut, ohne dass hierfür Beiträge gezahlt worden sind. Eine Erwerbsminderungsrente wird auf Antrag grundsätzlich nur gezahlt, wenn in den letzten fünf Jahren vor Eintritt der Erwerbsminderung mindestens drei Jahre Pflichtbeitragszeiten vorliegen.

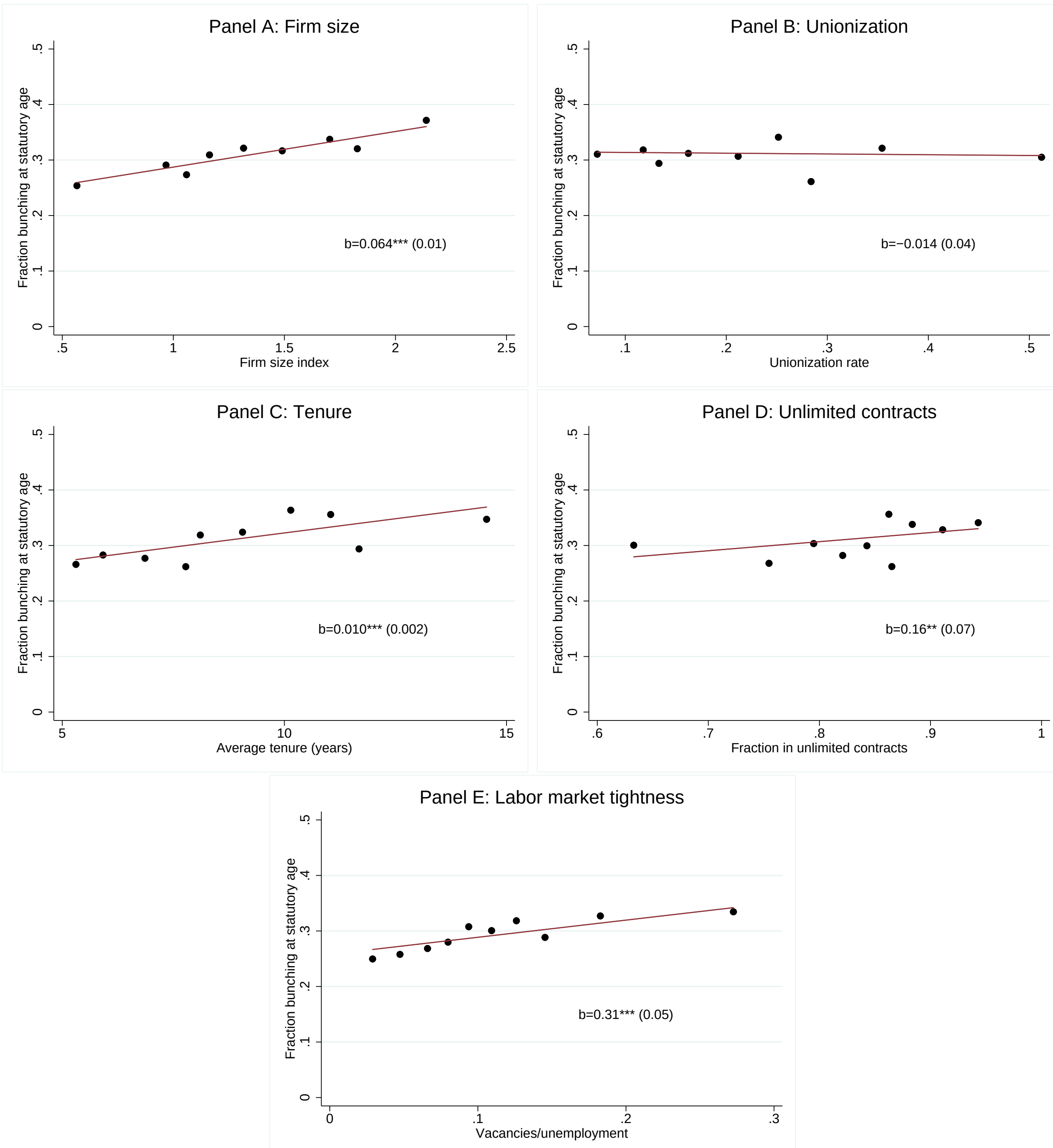
Höhe Ihrer künftigen Regelaltersrente
Zur Berechnung Ihrer künftigen Rente ermitteln wir die durchschnittlichen Entgeltpunkte für die letzten fünf Kalenderjahre. Dabei können wir für das jeweils letzte Kalenderjahr vor der Renteninformation nur einen vorläufigen Durchschnittsverdienst aller Versicherten verwenden. Der endgültige Durchschnittsverdienst weicht regelmäßig von dem vorläufigen Wert ab. Daher kann sich die ermittelte Rente im Vergleich zu Ihrer vorherigen Renteninformation auch bei gleichbleibender Beitragszahlung erhöht oder vermindert haben.

Rentenanpassung
Die Dynamisierung (Erhöhung) der Rente erfolgt durch die Rentenanpassung. Sie richtet sich grundsätzlich nach der Lohnentwicklung, die für die Rentenanpassung - insbesondere aufgrund der demografischen Entwicklung - nur vermindert berücksichtigt wird. Die Höhe der zukünftigen Rentenanpassungen kann nicht verlässlich vorhergesehen werden. Wir haben Ihre Rente daher unter Berücksichtigung der Annahmen der Bundesregierung zur Lohnentwicklung dynamisiert. Die ermittelten Beträge sind - wie alle weiteren späteren Einkünfte (z.B. aus einer Lebensversicherung) - wegen des Anstiegs der Lebenshaltungskosten und der damit verbundenen Geldentwertung (Inflation) in ihrer Kaufkraft aber nicht mit einem heutigen Einkommen in dieser Höhe vergleichbar (**Kaufkraftverlust**). So werden bei einer Inflationsrate von beispielsweise 1,5 Prozent pro Jahr bei Beginn Ihrer Regelaltersrente 100 EUR voraussichtlich nur noch eine Kaufkraft nach heutigen Werten von etwa 84 EUR besitzen.

Unser Service
Haben Sie Fragen, benötigen Sie einen Versicherungsverlauf oder unseren Rat? Rufen Sie uns einfach an. Sie erreichen uns unter der kostenfreien Nummer unseres Servicetelefons **0800 100048070** von Montag bis Donnerstag von 7:30 Uhr bis 19:30 Uhr und am Freitag von 7:30 Uhr bis 15:30 Uhr. Sie können sich auch in unseren Auskunfts- und Beratungsstellen oder im Internet informieren. Auch Fragen zur staatlich geförderten zusätzlichen Altersvorsorge oder zur Grundsicherung im Alter und bei Erwerbsminderung beantworten wir gern.

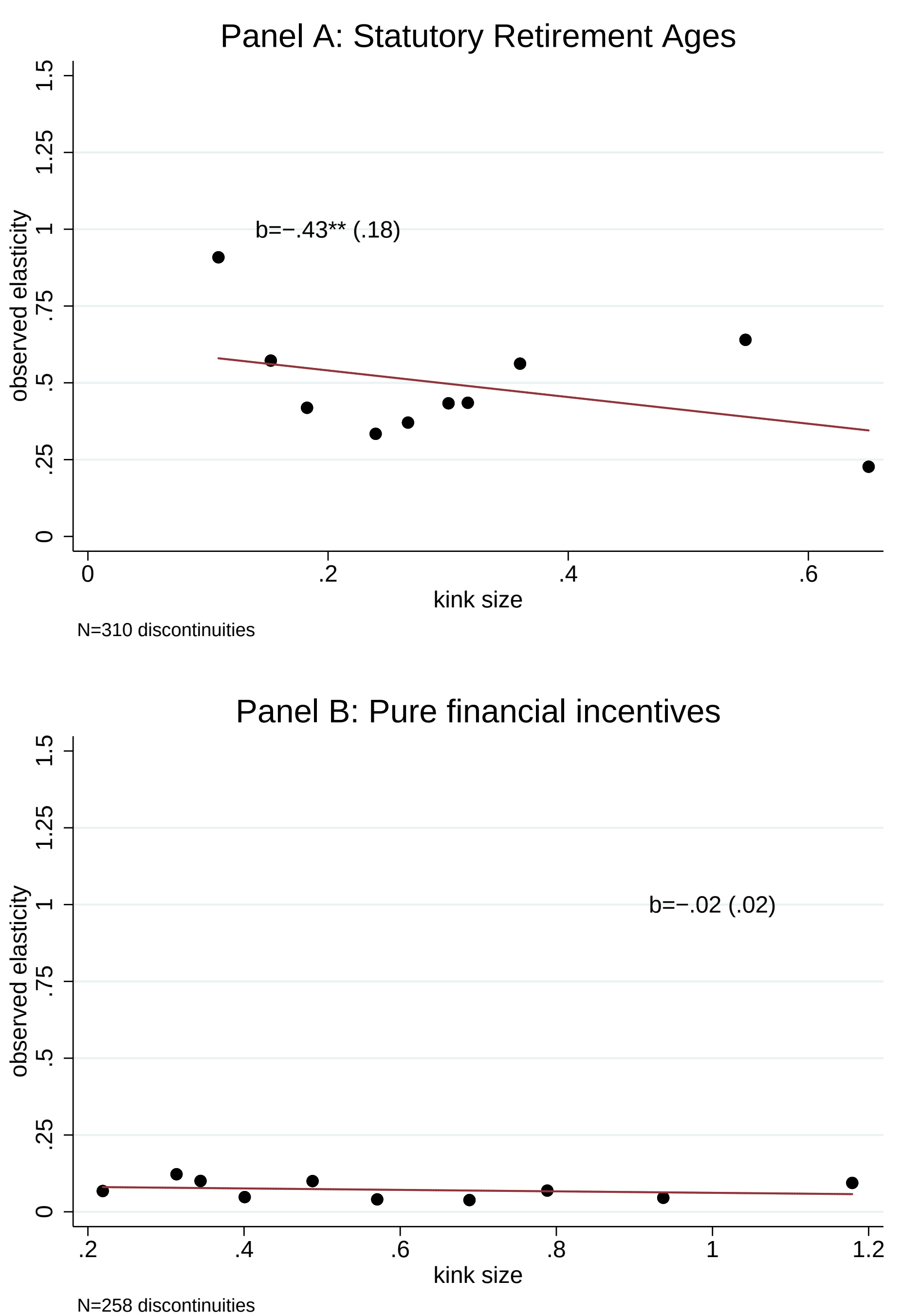
Note: The figure shows an example of an information letter (*Renteninformation*) sent to workers by the state pension fund. The number of letters of this kind was increased throughout the reform described in section 5.2. Red boxes on the right provide a summary and explanation of the content of the letter.

Figure A6: Bunching and Firm Incentives



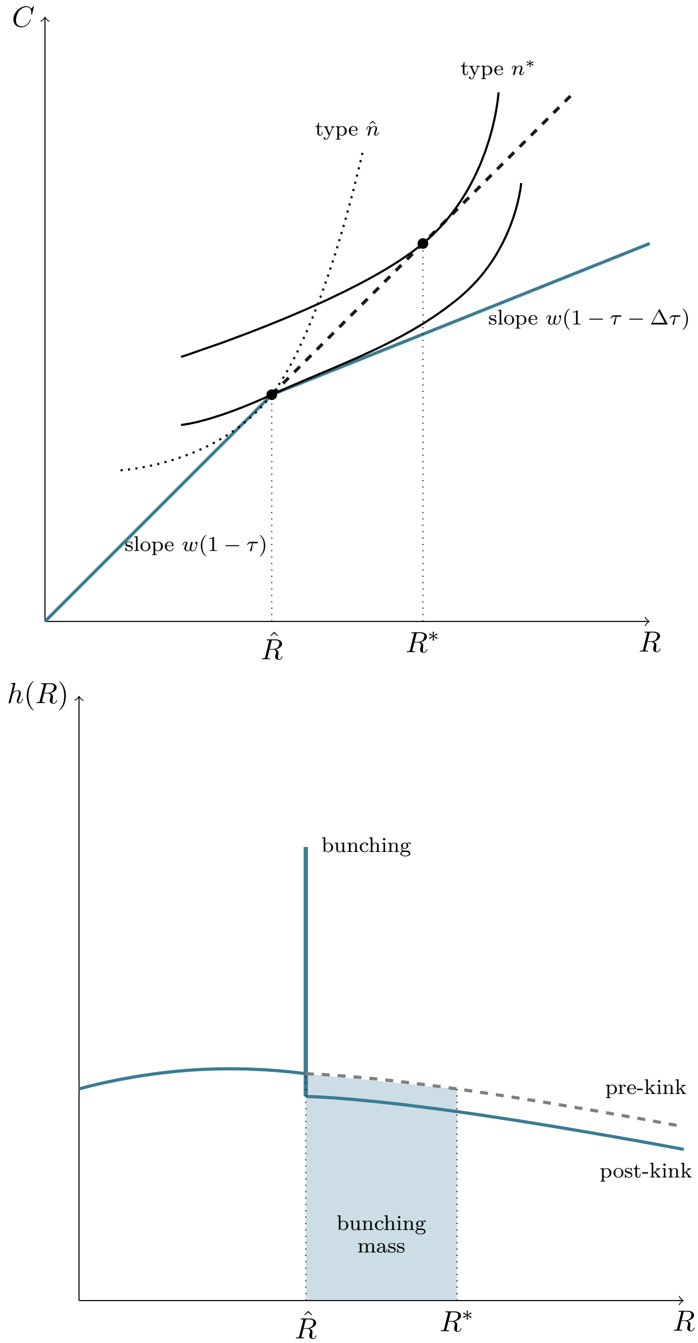
Note: The figure plots the fraction of workers bunching at statutory retirement ages against a number of variables related to firm incentives. Black dots show average values by decile of the respective explanatory variable. Firm size, unionization, tenure and unlimited contracts are at the occupation level. Firm size index is based on four size categories, 0=below 20 employees, 1=20 to 200, 2=200 to 2000, 3=above 2000. Unionization rate is fraction with union membership. Average tenure is years working in the same firm. Fraction in unlimited contracts is fraction with term limit in their employment contract. Labor market tightness is calculated as the vacancies-unemployment ratio at the state-year level. In panels A to D, the red line is fitted by a univariate occupation-level regression whose slope coefficient is also shown with robust standard errors in parantheses. The occupation-level data is weighted by group size. In panel E, the red line is fitted by a univariate individual-level regression whose slope coefficient is shown with standard error clustered at the pathway × month level in parantheses.

Figure A7: Observed Elasticities and Kink Size



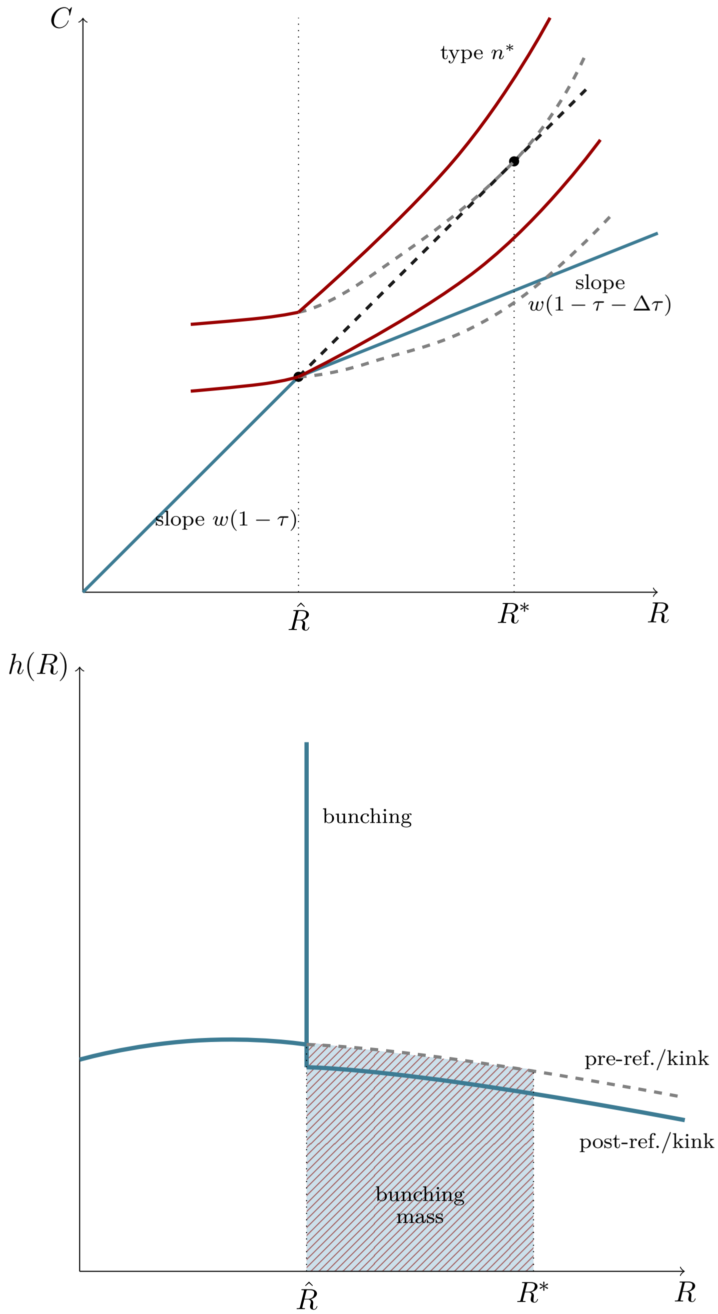
Note: The figure shows binned scatterplots of the observed elasticity vs. the kink size at a discontinuity, separately for statutory retirement ages (panel A) and pure financial incentive discontinuities (panel B). In panel A, the type of statutory ages (Early, Full or Normal Retirement Age) is controlled for. Each panel also includes the coefficient from a discontinuity-level regression of normalized excess mass $b/\hat{R}$ on kink size, with bootstrapped standard error in parantheses.

Figure A8: Retirement Bunching at a Budget Constraint Kink



Note: The figure shows bunching responses to a budget set kink in an indifference curve diagram (upper panel) and a density diagram (lower panel). In the upper panel, the blue line is the post-kink budget set, whereas the dashed gray line is the pre-kink budget set. The dotted curve is an indifference curve of an individual with ability $\hat{n}$ who retires at $\hat{R}$ before and after the change. The solid curves are indifference curves of the marginal buncher with ability n^* who is tangent to the old budget set at R^* and tangent to the upper part of the new budget set at $\hat{R}$. In the lower panel, the solid blue line denotes the post-kink density, whereas the dotted line denotes the pre-kink density. The blue shaded area is the initial location of the mass of workers bunching in response to the kink.

Figure A9: Bunching at a Joint Budget Constraint Kink and Reference Point



Note: The figure shows bunching responses to a retirement age threshold combining a budget set kink and a reference point in an indifference curve diagram (upper panel) and a density diagram (lower panel). In the upper panel, the blue line is the kinked budget set, and the dashed black line is the initial budget set. The dashed gray curves to the right of $\hat{R}$ are the indifference curves of the marginal buncher with ability n^* in the absence of the reference point, whereas the solid red curves are her indifference curves with the reference point (post-ref.). The marginal buncher's initial indifference curve is tangent to the pre-kink budget set at R^*, and her post-ref. indifference curve is tangent to the kinked budget set at $\hat{R}$. In the lower panel, the solid blue line denotes the density with the reference point and the kinked budget set (post-ref./kink), whereas the dotted line denotes the pre-ref./kink density. The blue and red shaded area is the initial location of the mass of workers bunching in response to the budget set kink and the retirement age reference point.

Table A1: Oaxaca-Blinder Bunching Decomposition

	(1)	(2)	(3)
Reference category:	Statutory Retirement Ages	pure financial incentives	average
Excess mass difference	-16.0	-16.0	-16.0
Explained by			
financial incentives	2.75	-0.44	1.16
%	-17.2%	2.72%	-7.22%
worker variables	-1.76	0.07	-0.84
%	11.0%	-0.46%	5.27%
firm variables	0.40	-0.88	-0.24
%	-2.52%	5.48%	1.48%
Unexplained	-17.4	-14.8	-16.1
%	108.7%	92.3%	100.5%
Obs. (discontinuities)	629	629	629

Note: The table shows results from a Oaxaca-Blinder decomposition, where differences in excess mass between statutory retirement ages and pure financial incentive discontinuities are attributed to differences in explanatory variables and an unexplained component. The bunching sample is used. "Financial incentives" include kink size and an indicator for non-convex kinks. "Worker variables" include dummies for female, married and East Germany, last earnings before retirement, lifetime income, career length, sick leave years and education years. "Firm variables" include the following occupation-level variables: firm size index, unionization rate, active union member rate, tenure in the firm, fraction in unlimited contracts, fraction receiving severance pay, fraction of involuntary job exits. Columns differ according to which group is chosen as a reference group, i.e. the coefficients of which group are used to calculate explained shares. In column (1), the reference group are statutory ages, in column (2) the reference group are pure financial incentive discontinuities, and column (3) is based on average coefficients across the two reference groups.

Table A2: Reduced-Form Estimation: Heterogeneous Coefficients

Panel A: By Pathway

	(1) Long-term Insured	(2) Women	(3) Unemp./ part-time	(4) Invalidity	(5) Disability
kink size $\frac{\Delta\tau}{1-\tau}$	0.16***	0.03***	0.07***	0.06***	0.002*
	(0.02)	(0.004)	(0.02)	(0.003)	(0.001)
Statutory age at kink:					
Early Retirement Age	0.03***	0.07***	0.03***	0.11***	
	(0.01)	(0.01)	(0.01)	(0.005)	
Full Retirement Age	0.02	0.15***	0.03***	0.03***	
	(0.02)	(0.01)	(0.01)	(0.004)	
Normal Retirement Age	0.31***	0.26***	0.08***	0.26***	
	(0.02)	(0.03)	(0.02)	(0.01)	
Discontinuities	98	127	159	165	78

Panel B: By Year of Birth (Selected)

	(1) 1933	(2) 1936	(3) 1939	(4) 1942	(5) 1945	(6) 1948
kink size $\frac{\Delta\tau}{1-\tau}$	0.03	0.02	0.04***	0.06***	0.07***	0.06***
	(0.11)	(0.16)	(0.01)	(0.02)	(0.02)	(0.02)
Statutory age at kink:						
Early Retirement Age	0.15	0.18	0.04	0.07***	0.07***	0.08***
	(0.10)	(0.12)	(0.06)	(0.02)	(0.02)	(0.01)
Full Retirement Age			0.04***	0.16***	0.03	0.06***
			(0.01)	(0.03)	(0.09)	(0.01)
Normal Retirement Age	0.23***	0.23**	0.14**	0.49***	0.28**	0.20***
	(0.09)	(0.10)	(0.07)	(0.18)	(0.11)	(0.05)
Discontinuities	15	15	46	58	23	37

Note: The table shows heterogeneous coefficients from discontinuity-level regressions of normalized excess mass $b/\hat{R}$ on kink size as well as dummies for the presence of statutory age types $s \in \{ERA, FRA, NRA\}$ based on equation (6), using the bunching sample. Weighted averages are presented in table 6. Panel A presents heterogeneous coefficients by pathway, where the regular pathway is excluded, since there is no variation in the presence of statutory ages and group-specific coefficients cannot be estimated in this case. Panel B shows heterogeneous coefficients by year of birth for selected cohorts. Groups with no variation in D^s are excluded from the estimation. Interactions between statutory age dummies are also included in all specifications. Regressions weighted by group size. Bootstrapped standard errors in parantheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A3: The Effect of Increasing the Full Retirement Age

	(1)	(2)
Dependent variable: Job exit age (years)		
post-reform	1.75***	1.78***
	(0.01)	(0.01)
Pre-reform mean dep. var.	61.0	61.0
Observations	905,475	905,475
R-squared	0.17	0.24
Controls & Pathway FE	no	yes

Note: The table shows results from an individual-level regression of a worker's job exit age on a dummy for the post-reform period where the Full Retirement in the Women's Pathway is increased from 60 to 65. The post-reform indicator is for cohorts born from January 1945 onwards, when the reform is fully implemented. The sample consists of workers in the women's pathway born between 1935 and 1947, excluding the reform transition cohorts 1940 to 1944. Column (2) includes control variables and pathway fixed effects. Controls include gender, education, marital status, net lifetime income, last earnings before retirement, economic training, a dummy for East Germany, career length, sick leave years. Standard errors clustered at the pathway × month of birth level. *** p<0.01, ** p<0.05, * p<0.1.

Table A4: The Effect of Information Letters

Panel A: By Calendar Year

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: Indicator for bunching at...					
	any statutory retirement age		Normal Retirement Age		pure financial incentive	
annual information letters	0.03*	0.02	0.03***	0.03***	-0.002***	-0.002***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.000)	(0.000)
Pre-reform mean dep. var.	0.25	0.25	0.06	0.06	0.01	0.01
Observations	1,579,402	1,579,402	1,579,402	1,579,402	1,579,402	1,579,402
R-squared	0.001	0.08	0.003	0.08	0.000	0.01
Controls & Pathway FE	no	yes	no	yes	no	yes

Panel B: By Birth Cohort

	(1)	(2)
Dependent variable: Indicator for bunching at...		
	Normal Retirement Age (NRA)	
at least one letter before NRA	0.02*	0.02***
	(0.01)	(0.004)
Pre-reform mean dep. var.	0.05	0.05
Observations	3,004,353	3,004,353
R-squared	0.000	0.07
Controls & Pathway FE	no	yes

Note: The table shows results from an individual-level regression of dummies for job exits at different types of discontinuities on a dummy for the post-reform period where workers receive annual information letters. In panel A, the post-reform indicator is for calendar months from 2004 onwards when annual information letters are sent. In panel B, the post-reform indicator is for birth cohorts who receive at least one information letter in the years before the Normal Retirement Age, i.e. cohorts 1938 onwards. Columns (2), (4), (6) of panel A, and column (2) of panel B include control variables and pathway fixed effects. Controls include gender, education, marital status, net lifetime income, last earnings before retirement, economic training, a dummy for East Germany, career length, sick leave years. Workers in the long-term insured and unemployed/part-time pathways are excluded from the regressions as these pathways are subject to statutory age reforms during the period. Standard errors clustered at the pathway × month of birth level. *** p<0.01, ** p<0.05, * p<0.1.

Table A5: Reduced-Form Estimation: Robustness

	(1) Larger response at larger kinks?	(2) Excluding mandatory retirement	(3) Testing salience effects	(4)
Dependent variables:	Obs. elasticity $\hat{\varepsilon}$	(2) to (4): Excess mass $b/\hat{R}$		
kink size $\frac{\Delta\tau}{1-\tau}$	0.007	0.04***	0.05***	0.05***
	(0.01)	(0.003)	(0.003)	(0.004)
Statutory age at kink:				
Early Retirement Age	0.51***	0.06***	0.12***	0.10***
	(0.05)	(0.005)	(0.02)	(0.01)
Full Retirement Age	0.25***	0.09***	0.23***	0.18
	(0.02)	(0.01)	(0.05)	(0.12)
Normal Retirement Age	0.16		-0.05	-0.09
	(0.12)		(0.07)	(0.09)
Interactions:				
kink size × any statutory age			-0.44***	
			(0.12)	
kink size × Early Retirement Age				-0.27**
				(0.09)
kink size × Full Retirement Age				-0.26
				(0.29)
kink size × Normal Retirement Age				-0.56***
				(0.16)
Observations (discontinuities)	568	551	644	644
R-squared	0.72	0.74	0.73	0.78

Note: The table shows results from discontinuity-level regressions similar to those in table 5 in order to perform additional checks. In column (1), the dependent variable is the observed elasticity. The sample size differs from the main specification because non-convex kinks, where the observed elasticity is not calculated, are excluded. In columns (2) to (4), the dependent variable is normalized excess mass $b/\hat{R}$, as in the main specifications in table 5. Column (2) excludes all discontinuities where mandatory retirement is possible, i.e. discontinuities linked to a Normal Retirement Age. Column (3) is the standard specification with an additional interaction between kink size and a dummy for any statutory retirement age. Column (4) allows for interactions of kink size with dummies for each type of statutory age. Interactions between statutory age dummies are also included in all specifications. Regressions weighted by group size. Bootstrapped standard errors in parantheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A6: Correlates of Bunching: Firm Incentives

	(1)	(2)
	Dependent variable:	Indicator for bunching at...
	Statutory Retirement Age	pure financial incentive discontinuity
firm size index	0.03***	-0.001**
	(0.001)	(0.0002)
union	-0.03***	0.002***
	(0.005)	(0.001)
tenure	-0.001***	0.0000
	(0.0002)	(0.0000)
unlimited	-0.04***	0.001**
contracts	(0.005)	(0.001)
labor market	0.36***	0.04***
tightness	(0.04)	(0.005)
Mean dependent variable	0.31	0.004
Observations	3,932,038	3,932,038
R-squared	0.15	0.02
Worker controls	yes	yes
Occupation-level controls	yes	yes
Year of birth & pathway FE	yes	yes

Note: The table shows results from individual-level regressions of dummies for job exits at different types of discontinuities on variables related to firm incentives. Firm size index, unionization, tenure and fraction in unlimited contracts are at the occupation level. Labor market tightness is at the state-year level. Worker controls include gender, education, marital status, net lifetime income, last earnings before retirement, economic training, a dummy for East Germany, career length, sick leave years. Additional occupation-level controls include active union member rate, fraction receiving severance pay and fraction of involuntary job exits. Standard errors clustered at the pathway × month of birth level. *** p<0.01, ** p<0.05, * p<0.1.

Table A7: Structural Bunching Estimation: Interaction Effects

	(1)	(2)	(3)
	Statutory Retirement Ages:		
	Early×Full	Full×Normal	Early×Normal
Reference dependence λ^s	-0.29***	-0.15***	-0.46***
	(0.02)	(0.02)	(0.04)
Kink size equivalent	-0.45***	-0.38***	-0.67***
	(0.04)	(0.04)	(0.05)

Note: The table shows estimates of λ^s parameters corresponding to interaction effects between statutory retirement age types from the baseline estimation. Table 8 shows main effects from the baseline estimation. All parameter estimates are obtained from non-linear least squares estimations based on equation (13), using the bunching sample. Kink size equivalents obtained by dividing λ^s by the implicit net-of-tax rate $1-\tau$ at each statutory age discontinuity. Bootstrapped standard errors in parantheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A8: Structural Bunching Estimation: Alternative Specifications

	(1)	(2)	(3)	(4)
	Statutory Retirement Ages:			
	Early	Full	Normal	any
Estimating kink equivalent directly				
Kink size equivalent	0.59***	0.54***	1.32***	
	(0.03)	(0.02)	(0.11)	
Estimation without interaction effects				
Reference dependence λ^s	0.15***	0.07***	0.38***	
	(0.004)	(0.03)	(0.03)	
Kink size equivalent	0.24***	0.15***	1.13***	
	(0.01)	(0.06)	(0.10)	
Separate estimation for each stat. age type				
Reference dependence λ^s	0.28***	0.24***	0.38***	
	(0.01)	(0.003)	(0.01)	
Kink size equivalent	0.47***	0.48***	1.13***	
	(0.01)	(0.01)	(0.05)	
Single reference dependence parameter				
Reference dependence λ				0.24***
				(0.003)
Kink size equivalent				0.51***
				(0.02)

Note: The table shows results from a range of alternative specifications in addition to the main parameter estimates shown in 8. All estimates result from non-linear least squares estimations based on equation (13) using the bunching sample. The first alternative specification estimates parameters scaled as kink equivalents $\frac{\lambda^s}{1-\tau}$ directly, rather than estimating λ^s and then scaling by $1-\tau$. The second specification estimates λ^s without including interaction effects between different types of statutory ages. The third specification estimates λ^s via separate estimations for each type of statutory age, rather than in one estimation. The final specification estimates a single reference dependence parameter λ for all types of statutory ages. Bootstrapped standard errors in parantheses. *** p<0.01, ** p<0.05, * p<0.1.

B Institutional Details

B.1 Pathways and Statutory Retirement Ages

Pensions in the German public pension system (*gesetzliche Rentenversicherung*) are legally defined in German Social Law, vol. 6 (*Sozialgesetzbuch (SGB) VI*), where a section is devoted to each of the six pathways. First, the *regular pathway* is defined in SGB VI §235. Workers are eligible for this pathway with at least 5 years of contributions (*Wartezeit*, lit. waiting time). A regular pension can only be claimed from the NRA. Hence, the implicit ERA and FRA of the regular pathway coincide with the NRA. The NRA is 65 for workers born until 1946, but for cohorts 1947 to 1964 it will increase gradually by one month for each year of birth from 65 to 67 (§235(2)).

Second, the *long-term insured pathway* is defined in §236. Workers are eligible with at least 35 years of contributions. The ERA is 63 throughout the sample period. The FRA is 63 until 1936, is raised gradually by 1 month for each month of birth from 63 to 65 during birth cohorts 1937 and 1938 (SGB VI appendix 21) where it remains until cohort 1948. The FRA increases to 65 and 3 months for cohort 1949 and will further increase gradually by one month for each year of birth from 65/3 to 67 for cohorts 1950 to 1964 (§236(2)).

Third, the *women's pathway* is defined in §237a. Women with at least 15 years of contributions are eligible. At least 10 years have to be full contributions, i.e. excluding voluntary contributions, made after their 40th birthday. The ERA is 60 throughout the sample period. The FRA is 60 until 1939, is raised to 65 during cohorts 1940 to 1944 (SGB VI appendix 20) and remains 65 for women born until the end of the sample period. For cohorts born 1952 and later, the pathway will be abolished.

Fourth, the *unemployed/part-time pathway* is defined in §237. Eligibility requires at least 15 years of contributions, and at least 8 out of the 10 years before retirement have to be full contributions. Moreover, the workers must be either unemployed for at least 1 year after age 58 years and 6 months, or in old-age part-time work. Old-age part-time work is a program where workers aged 55 and older reduce their hours to part-time while the decrease in earnings is partly compensated by a government subsidy to the worker. Note that the program has been terminated in 2009. The ERA of this pathway is 60 for workers born until 1945, rises gradually by 1 month for each month of birth from 60 to 63 during birth cohorts 1946 to 1948 (SGB VI appendix 19), and remains 63 until the end of the sample period. The FRA is 60 until 1936, increases gradually by 1 month for each month of birth from 60 to 65 during birth cohorts 1937 to 1940 (SGB VI appendix 19) and remains 65 until the end of the sample period. For cohorts born 1952 and later, the pathway will be abolished.

Fifth, the *invalidity pathway* is defined in §236a. Workers with at least 35 years of contributions and with an officially recognized disability of at least degree 50% are eligible. The degree of disability is an index factoring in all types of permanent physical and mental conditions. The ERA is 60 throughout the sample period. The FRA is 60 for workers born until 1940, is raised gradually by 1 month for each month of birth from 60 to 63 during birth cohorts 1941 to 1943 (SGB VI appendix 22), and remains 63 until the end of the sample period.

All these pathways are introduced in conjunction with the relevant statutory ages. The NRA (*Regelaltersgrenze*) is defined in §235 as the age from which a regular pension can be claimed. For the remaining pathways, the FRA (*Altersgrenze*) and the ERA (*Mindestaltersgrenze*[37]) are specified along with the pathways themselves. The FRA is further defined as the "age from which an insured person is eligible", while the ERA is the"age from which early claiming is possible".

The sixth pathway, the *disability pathway* is defined in §43. Workers are required to have at least

[37]sometimes referred to as *Alter der frühestmöglichen Inanspruchnahme* in legal texts

5 years of contributions, and at least 3 out the 5 years before retirement must be full contributions. Moreover, workers must have been officially recognized as “low earnings potential”, which entails permanently not being able to work more than 3 hours per day in any job. A partial disability pension may be available if the worker is deemed to be able to work more than 3 but less than 6 hours per day. Disability pensions can be claimed at any age and there is no ERA or FRA in this pathway. Contribution points are “filled up” (*Zurechnungszeit*) as if the worker had kept on earning their average pre-retirement income until age 60. Hence, disability pensions feature an additional insurance element compared to other pathways since benefits are less dependent on lifetime contributions.

B.2 Pension Adjustment

Explicit pension adjustment for a worker’s retirement age was introduced into the pension formula in 1997 along with the ERA and FRA reforms described above. The adjustment factor (*Zugangsfaktor*) is defined in §77 SGB and is 100% if a worker claims their pension at the FRA of their pathway. Pension adjustment induces permanent changes to workers pension benefits, which are are framed as penalties (losses) or rewards (gains) relative to the *full pension*. The percentage of pension adjustment depends on a worker’s retirement age relative to statutory ages. For each month of claiming before the FRA, the adjustment factor is reduced by 0.3%, with the maximum negative adjustment implied by the distance between the ERA (the earliest claiming age) and FRA. The adjustment factor remains 100% between the FRA and the NRA. Only after the NRA, there are rewards for late retirement: the adjustment factor increases by 0.5% for each month of claiming after the NRA.

Since 2001, disability pensions are also subject to an adjustment factor defined in §77(2)3. Until the end of the sample period, disability pensions are decreased by 0.3% for each month of claiming before age 63. There is a maximum negative adjustment of 10.8% that applies to claims below age 60. Moreover, there was a transition period between 2001 and 2003 according to SGB VI appendix 23, where the maximum negative adjustment was gradually increased from 0 to 10.8%. This was done to avoid a notch in the budget constraint of disability workers that would have created a strong incentive to retire before 2001. The end of the filling period of contribution points was gradually extended from 55 to 60 at the same time.

B.3 Benefit Calculation

Upon submitting her pension claim, a worker’s benefits B_i are computed according to the following “pension formula” (*Rentenformel*):

$$B_i(R_i) = V \cdot \alpha(\max(R_i, ERA)) \cdot \sum_{t=0}^{R_i-1} \frac{w_{it}}{\bar{w}_t} \tag{14}$$

The formula has three components. The first component is the *sum of contribution points*. In the Bismarckian system, the points a worker earns in a year are equal to her earnings w_{it} relative to the average income among the insured population $\bar{w}_t$. Points are then summed across all years in which contributions were paid. Hence, additional contributions always increase the worker’s benefits and pensions become roughly proportional to gross lifetime income. Second, the worker is assigned an *adjustment factor* α as a function of her benefit claiming age. The benefit claiming age $\max(R_i, ERA)$ is the job exit age if the job exit occurs no earlier than the the ERA, or the ERA otherwise. Adjustment is framed around the FRA as a reference point, where a worker can claim her full pension, i.e. $\alpha(FRA) = 100\%$. The adjustment function α follows a kinked schedule, with a penalty of 0.3% for each month of retirement before the FRA, a reward of 0.5% for each month of retirement after the NRA, and no adjustment between the FRA and the NRA. The third component is the *pension value* V which translates adjusted earned points into monthly benefits. V is indexed to annual nominal wage growth (€26.39 in 2014).

B.4 Information Letters

The German state pension fund provides information about pensions and retirement two workers via information letters, whose content is defined in §109. Before June 2002, a detailed information letter (*Rentenauskunft*) was sent to each enrolled worker in the month they turned 55 years old. The frequency of information letters was drastically increased between June 2002 and December 2003. During this transition period, the pension fund conducted surveys of workers and the design of letters was optimized in order to provide information in a more concise and easily comprehensible way. Under the new information provision regime from January 2004, workers are sent a new, somewhat shorter letter (*Renteninformation*) annually from age 27 and in addition, a detailed letter is sent every three years from age 55.

Appendix figure A5 shows an example of a basic letter. The letter contains information on contributions paid and points earned so far by the individual worker, and a more general explanation of how benefits are calculated, in particular how contributions translate into benefit eligibility, and the tax treatment of pension benefits. Moreover, workers are informed about potential losses of purchasing power under different inflation scenarios, and the potential need to supplement public pensions with private savings. The letter particularly emphasizes the NRA as a reference point. For instance, the second sentence shows the worker the precise date when she will reach the NRA. Out of three hypothetical scenarios for which pension benefits are calculated, two assume that the worker will retire in the month of the NRA. The detailed letter provides similar information, plus a more extensive account of the worker's contribution payments so far, and informs about a range of possible retirement dates before and after the NRA with corresponding pension adjustment.

During the reform, the number of information letters a worker receives before the NRA depends on their year of birth (see Dolls et al. 2018[38]). In the second half of 2002, cohorts 1938 and older receive letters. These workers are aged 64 or older at the time, and the NRA is at age 65. Similarly, cohort 1939 receives a letter in 2003, when they are aged 64. From 2004 onwards, annual letters are sent to all workers. Hence, cohorts 1938, 1939 and 1940 receive exactly one letter in the year before they reach the NRA. Workers born in the second half of 1937 may receive a letter (it depends on whether they turn 65 before the exact calendar month in which the pension fund sends the letter, which is not known). Younger cohorts receive an increasing number of letters in the years before the NRA. Cohort 1941 receives two letters before they turn 65, cohort 1942 receives three letters, etc.

C Data

C.1 Administrative Data Set

The administrative data covers the universe of retirees who claimed a public pension between the years 1992 and 2014. The main data set is constructed from 23 cross-sections, each of which covers all new public pension claimants in one calendar year (Data citation: *Versichertenrentenzugang*

[38]Dolls et al. (2018) exploit this reform to show that younger workers increase their retirement savings in response to information letters.

1992-2014, source: FDZ-RV). In total, there are 23.2 million individual pension claims, which includes all claimants of all types of pensions (incl. non-old age pensions). The following restrictions are applied: The sample is limited to workers in the six main old-age pension pathways described in section 2 who claim a pension for the first time between ages 55 and 67, have earned at least 5 contribution points and do not continue working after retirement. Individuals part of whose earnings careers have been abroad and members of a special scheme for miners are also excluded. East Germans retiring in 1995 and earlier are excluded since their pension was calculated under a particular set of post-reunification rules. The analysis focuses on workers born between 1933 and 1949 because for these cohorts sufficient parts of the retirement age distribution can be observed, given the available calendar years. After all these restrictions are applied, the main data (individual sample) contains 8.6 million observations.

C.2 Variable Definitions

Job exit ages. A worker's age at benefit claiming and the age of the last contribution can be observed in the data as the distance between the month of birth and the month of claiming or the last contribution. Job exit ages cannot be directly observed, but correspond to the age at the last contribution for most workers. However, for some workers their last month of work does not entail any contributions, or their last month of contributions stems from a status other than employment. For instance, workers in so-called mini jobs with earnings less than €450 are exempt from contributions, and contributions have to be paid during periods of receiving certain types of unemployment benefits. To account for this, additional information on the insurance status in the last three years before a worker's benefit claim is used. This status is coded into four categories, 1=work/contributions, 2=no work/no contributions, 3=work/no contributions, 4=no work/contributions. If a worker's last known status is 1 or 2, the last contribution coincides with the job exit. This is the case for 87% of workers in the sample. Categories 3 and 4 pose the problem that the job exit cannot be inferred from the last contribution. However, the timing of job exits can be bounded by the information on workers' status in the three years before retirement. For instance, if a worker is known to be in category 1 20 months before benefit claiming and category 4 8 months before retirement, her job exit is age must have been between 20 months and 8 months before the benefit claiming age. Hence, job exit ages of the remaining workers are imputed via a uniform distribution between the closest known bounds. This imputation is mostly relevant for job exits before the ERA since gaps between job exits and benefit claiming occur in these cases. At the ERA or later, most workers claim benefits right after their job exit so last contributions are not typically confounded by a status other than work.

Years of Contributions. Pathway eligibility is partly determined by a worker's years of contributions (*Wartezeit*). Besides contribution periods (*Beitragszeiten*) from employment and voluntary contributions of self-employed individuals, "substitute periods" (*Ersatzzeiten*, e.g. due to political imprisonment in the former GDR) count towards the 15-year threshold. In addition, some periods of education, childcare, sick leave, receipt of some types of unemployment benefits and the disability filling period (*Berücksichtigungs- und Anrechnungszeiten*) count towards the 35-year threshold. The contribution periods actually used for pension calculation cannot be observed directly in the data, but they can be reconstructed from a number of variables related to workers' earnings histories. Around the 15-year threshold, contributions are calculated as the sum of contribution (both full and partial) and substitute periods. For the 35-year threshold, other relevant periods listed above are added.

Lifetime budget constraints. Lifetime budget constraints are simulated based on the formulas presented in section 2.2. First, a pension benefit calculator is constructed according to equation

(14) using a sample period average pension value V, a worker's observed sum of earned points $\sum_{t=0}^{R_i-1} \frac{w_{it}}{\bar{w}_t}$ and the adjustment factor function $\alpha(R_i, ERA)$ that applies to their specific pathway and birth cohort. Individual net lifetime income at the worker's actual job exit age is then computed according to equation (1) with a discount factor of 3%. For the time horizon, remaining life expectancies at age 55 taken from mortality tables by the German Federal Statistics Office taking into account heterogeneity by gender and year of birth. Lifetime gross wage earnings are approximated as the sum of earned points multiplied by an average of mean annual incomes across the sample period. Net earnings are calculated from gross earnings using a tax simulator taking into account personal income tax and social insurance contributions, and income splitting is applied to married individuals. Since the budget constraint abstracts from periods of inactivity, the starting age is set to 25 years, a value that would generate roughly the observed average contribution points if all workers had uninterrupted earnings careers.

In order to simulate net lifetime income across a range of job exit ages, an approximation of annual earnings w_{it} is needed. A lifetime average of gross annual earnings is computed as lifetime wage earnings divided by the hypothetical uninterrupted career length from age 25 until the observed job exit age. Net annual earnings are calculated using the income tax simulator. A worker's net lifetime income can then be simulated across a range of job exit ages by extrapolating additional income from work based on annual earnings and simulating pensions across claiming ages, the latter taking into account additional contributions and changing adjustment. Monthly implicit net wages are calculated as the increment in net lifetime income, and the implicit net-of-tax rate is the implicit net wage divided by gross income.

C.3 Group Assignment

Pathway eligibility. As explained in section 2.4, workers choose the pathway from which to claim a pension. Observed pathway choice may be endogenous to retirement ages, and reforms in particular may induce some switching across pathways. For instance, when the FRA is increased to 65 in a certain pathway, an increase in the number of workers eligible for that pathway claiming regular pensions can usually be observed. This occurs because there is no difference in benefits across pathways at the NRA and beyond, and workers may perceive claiming a regular pension as easier or more natural than claiming a special, non-regular pension. To account for this, pathway assignment is based on eligibility throughout the analysis.

Pathway eligibility is based on observable characteristics where possible, with some imputation to account for unobservables. Workers with at least 35 years of contributions are eligible for the long-term insured pathway. For the women's pathway, women with at least 15 years of contributions are deemed eligible. The additional requirement of full contributions in 8 out of the last 10 years is not used since the exact timing of contributions is not always sufficiently observable. Workers are defined as eligible for the the unemployed/part-time pathway if they have at least 15 years of contributions, and they are observed to be unemployed or in part-time work within the last 3 years before benefit claiming. Disability cannot be observed directly in the data, but a subset of workers satisfying the contribution requirements of the invalidity and disability pathways of 35 and 5 years, respectively, can be identified.

If a worker is eligible for only one pathway, assignment is unambiguous. Moreover, workers who are observed to claim from one of the non-regular pathways are assumed to have chosen their "best" pathway and are assigned accordingly. Among the remaining workers who are found eligible for more than one pathway, assignment is based on a notion of which of those pathways is most advantageous. For instance, if a woman is eligible for the women's pathway, she must also be eligible for the regular pathway, but the set of available retirement age/consumption combinations in the women's pathway dominates that of the regular pathway because both ERA and FRA are lower. Besides, she may be eligible for the unemployed/part-time and/or long-term insured pathways, but those are also dominated by the women's pathway. Hence, women claiming a regular pension who are eligible for the women's pathway (and possibly unemployed or long-term insured) are assigned to the women's pathway rather than regular. Unemployed/part-time is assigned analogously.

Both long-term insured and invalidity pathways require at least 35 years of contributions, but among the workers satisfying this, only those with an officially recognized disability can choose the invalidity pathway. Since counterfactual disability status cannot be observed, the share of workers satisfying the requirement has to be imputed. In particular, it is assumed that the relative shares of disabled individuals among those potentially eligible for both pathways is the same as the shares among those actually claiming in the pathways at a given age. Hence, the ratio of invalidity/long-term insured claimants is computed for each integer retirement age in each year of birth, and ambiguous cases are assigned based on the corresponding ratio. Similarly, disability and regular pensions both require only 5 years of contributions, and the ratio of actual claimants by year of birth and integer retirement age is used to impute eligibility in ambiguous cases.

In the data, the most important difference between the number of actual claimants and eligible workers arises in the regular pathway where eligibility is largely overestimated by claiming. Hence, many regular claimants would have been eligible for more advantageous pathways, particularly long-term insured and women's pathways. The vast majority of these switchers are workers retiring at the NRA and beyond, where they receive the same benefits from the regular pathway as they would from other pathways.

Groups and Discontinuities. Workers are grouped into cells by year of birth and pathway. This split accounts for most of the variation in statutory ages and lifetime budget constraints faced by workers, while still preserving sufficiently large group sizes for the purpose of bunching estimation. During the cohorts where reforms change statutory ages at the month-of-birth level, workers around the statutory age in the affected pathway are grouped by pathway and month of birth instead. This yields a total number of 420 groups of whom 108 are at the year-of-birth and 312 at the month-of-birth level. At the level of these groups, there are 386 statutory age kinks and 78 pure financial incentive kinks.

In addition, there are seven types of notches created by pathway contribution thresholds. At 5 years of contributions, workers switch from no pension at all to either regular or disability. At 15 years of contributions, women switch from the regular pathway to the women's pathway. Moreover, workers who are unemployed or in old-age part-time work before retirement switch from regular to that pathway at 15 years of contributions. At 35 years of contributions, regular workers switch to the long-term insured or invalidity pathway. Finally, workers previously eligible for the women's or unemployed pathway may switch to the invalidity pathway at 35 years. For each year of birth, workers around a notch are identified based on pathway eligibility as described above. Restrictions in terms of years of contributions are relaxed in order to observe workers to the left of the notch who are close to the threshold but, by definition of the threshold, cannot yet be observed to claim the corresponding pathway. In order to account for variation in the notch size depending on retirement ages, each year of birth and type of notch is further divided into two ranges of retirement ages, 55 to 60 and 60 to 65. This yields a total of 180 groups each of whom faces one notch. Collecting all kinks and notches, the bunching sample contains 644 discontinuities.

C.4 Survey Data

Survey Sample and Variables. The German Socioeconomic Panel (SOEP) is a panel household survey, of which the waves 1984 to 2013 are used (data citation: *Socio-Economic Panel*

(SOEP), data for years 1984-2013, version 30i, SOEP, 2015). In total, there are 175,224 working individuals whose occupation is reported. To maximize power, all age groups are used to compute occupation-level averages. There are an average of 475 workers in each 3-digit occupation cell. The following variables of interest can be directly observed in the survey: union membership, active union membership, currently in unlimited contract, severance paid upon job exit, involuntary job exit. A firm size index is computed based on the size categories <20 employees, 20 to 200, 200 to 2000, and >2000 employees. Tenure on the job can be computed as the time from the month of job start to the month of interview.

Matching at Occupation Level. In the administrative data, occupations are reported at the 3-digit level according to the *KldB 1988* classification. The survey data reports occupations according to the slightly updated *KldB 1992* classification. A mapping between the two classifications is created manually. Among the 337 3-digit KldB 1988 occupations, 90% have a unique match in KldB 1992. 10% have two or more matches, and 4% have three or more matches. To get occupation-level values, the occupation-level average from the survey data is taken if the occupation has a unique match. If there is more than one match, an average weighted by the size of each occupation cell among the matches is taken. In the administrative data, occupations are observed from the year 2000 onwards. Matching those observations with the survey data yields the occupation-matched sample with just under four million individuals.

D Empirical Methodology

D.1 Bunching Estimation

The bunching estimation is based on Chetty et al. (2011) where a counterfactual density is fitted to the observed distribution of job exit ages around each discontinuity, excluding the data in the bunching region around the discontinuity. The counterfactual C_j is estimated as a regression of the form

$$C_j = \sum_{i=0}^{p} \beta_i (R_j)^i + \sum_{r \in \Gamma} \delta_r \mathbb{1}(R_j = r) + \sum_{k=R^-}^{R^+} \gamma_k \mathbb{1}(R_j = k) + \varepsilon_j$$

where C_j is the number of individuals in monthly job exit age bin j, Γ is a set of round retirement age types, and $[R^-, R^+]$ is the excluded range of job exit ages around the discontinuity. Hence, the regression fits a p-th order polynomial to the distribution of job exit ages, while allowing for additional round-number bunching through the coefficients δ_r. The counterfactual density at the discontinuity is then predicted as

$$\hat{C}_j = \sum_{i=0}^{p} \hat{\beta}_i (R_j)^i + \sum_{r \in \Gamma} \hat{\delta}_r \mathbb{1}(R_j = r)$$

thus omitting the contribution of the dummies in the excluded range. The bunching mass $\hat{B} = \sum_{k=R^-}^{R^+} C_j - \hat{C}_j$ is the difference between the observed and the counterfactual distribution in the bunching region. Finally, the excess mass is defined as bunching relative to the counterfactual density:

$$\hat{b} = \frac{\hat{B}}{\sum_{k=R^-}^{R^+} \hat{C}_j / (R^+ - R^- + 1)}$$

In practice, the order of the polynomial is chosen as $p = 7$ and the excluded range $[R^-, R^+]$ as well as the set of round ages Γ to control for are determined separately for each type of discontinuity. Around statutory ages, the bunching region is generally defined as the discontinuity and one additional month on either side. Round-age dummies are included for each full-year age above 55, where additional dummies for full-year ages above 60 and 64 allow for heterogeneity in round-number bunching by age. Other statutory ages that may fall in the estimation range are also netted out of the counterfactual by dummies. Between 24 and 36 bins are included on both sides of the discontinuity for the estimation of the polynomial, with the exception of ERAs where only 12 bins are included to the left. In the regular pathway, invalidity and some cohorts of unemployed/part-time, round-number dummies are not included because there is no visible round-number bunching. In the disability pathway, bunching is restricted to the month of the discontinuity itself as there is no visible diffuse bunching mass. For groups at the month-of-birth level, dummies for job exit ages that fall in the calendar month of December are additionally included in Γ. December effects are also allowed to be heterogeneous across 5-year age ranges. The estimation around the contribution notches includes 120 bins on each side of the notch in order to increase statistical power, and has no round-number dummies. The month of the notch itself and 12 months to the left are excluded to account for missing mass. Bunching is estimated sharply at the month of the notch. The missing mass is extended to 24 months in the long-term insured pathway to line up with the relatively larger bunching mass.

Observed elasticities are calculated at each discontinuity according to equation (2). Kink sizes are computed based on the marginal implicit net-of-tax rate just before the kink and the rate just after (at) the kink. Notches are approximated as kinks faced by the marginal buncher as in Kleven and Waseem (2013): The average net-of-tax rate between the location of the marginal buncher and the notch is used as the rate before the kink, and the actual marginal net-of-tax rate is used after the kink. Standard errors for individual bunching mass estimates are bootstrapped by re-sampling the individual data within the respective group. Standard errors for regressions based on bunching estimates are obtained by re-sampling at the discontinuity level.

D.2 Discontinuities Used for Bunching

The following table lists all discontinuities in the bunching sample.

Pathway	Cohorts	Age Group	Frequency	Source of Discontinuity	Type	Number
Regular	1933-1949	55-67	annual	ERA=FRA=NRA	kink	17
Long-term insured	1933-1936	55-67	annual	ERA=FRA	kink	4
Long-term insured	1937-1949	55-67	annual	ERA	kink	13
Long-term insured	1939-1946	55-67	annual	FRA=NRA	kink	8
Long-term insured	1947-1948	55-67	annual	FRA	kink	2
Long-term insured	1933-1938 1947-1949	55-67	annual	NRA	kink	9
Long-term insured	1937-1938 1949	55-67	monthly	moving FRA	kink	36
Women	1933-1939	55-67	annual	ERA=FRA	kink	7
Women	1940-1949	55-67	annual	ERA	kink	10
Women	1945-1946	55-67	annual	FRA=NRA	kink	2
Women	1947-1949	55-67	annual	FRA	kink	3
Women	1933-1944 1947-1949	55-67	annual	NRA	kink	15
Women	1940-1944	55-67	monthly	moving FRA	kink	60
Unemp./part-time	1933-1936	55-67	annual	ERA=FRA	kink	4
Unemp./part-time	1937-1945 1949	55-67	annual	ERA	kink	9
Unemp./part-time	1942-1946	55-67	annual	FRA=NRA	kink	5

Unemp./part-time	1947-1949	55-67	annual	FRA	kink	3
Unemp./part-time	1933-1941 1947-1949	55-67	annual	NRA	kink	12
Unemp./part-time	1937-1941	55-67	monthly	moving FRA	kink	60
Unemp./part-time	1946-1948	55-67	monthly	moving ERA	kink	36
Invalidity	1933-1940	55-67	annual	ERA=FRA	kink	8
Invalidity	1941-1949	55-67	annual	ERA	kink	9
Invalidity	1944-1949	55-67	annual	FRA	kink	6
Invalidity	1933-1949	55-67	annual	NRA	kink	17
Invalidity	1941-1943	55-67	monthly	moving FRA	kink	36
Disability	1938-1949	55-67	annual	pension adjustment around age 63	kink	12
Disability	1938-1943	55-67	monthly	adjustment introduction in 2001	kink	72
Long-term insured	1937-1949	55-63/0	annual	35 year contribution threshold (from regular)	notch	13
Long-term insured	1938-1943	63/1-65	annual	35 year contribution threshold (from regular)	notch	17
Women	1937-1949	55-60/0	annual	15 year contribution threshold (from regular)	notch	13
Women	1933-1949	60/1-65	annual	15 year contribution threshold (from regular)	notch	17
Unemp./part-time	1937-1949	55-60/0	annual	15 year contribution threshold (from regular)	notch	13
Unemp./part-time	1933-1949	60/1-65	annual	15 year contribution threshold (from regular)	notch	17
Invalidity	1937-1949	55-60/0	annual	35 year contribution threshold (from regular)	notch	13
Invalidity	1933-1949	60/1-65	annual	35 year contribution threshold (from regular)	notch	17
Invalidity	1937-1949	55-60/0	annual	35 year contribution threshold (from unemp.)	notch	13
Invalidity	1933-1949	60/1-65	annual	35 year contribution threshold (from unemp.)	notch	17
Invalidity	1937-1949	55-60/0	annual	35 year contribution threshold (from women)	notch	13
Invalidity	1933-1949	60/1-65	annual	35 year contribution threshold (from women)	notch	17
total						655

Note that 11 out of the 655 discontinuities listed above are excluded from the analysis because the local density is too low to estimate a stable counterfactual, i.e. there are too few workers around the discontinuity.

E Model Extensions

E.1 Heterogeneous Parameters

The analysis in section 6 considers homogenous preferences across workers. However, parameter heterogeneity can be incorporated into the bunching approach. Kleven (2016) shows that in the presence of heterogeneous elasticities bunching at a pure budget set kink can be related to a local average retirement elasticity. Consider a joint distribution $\hat{f}(n, \varepsilon)$ and a joint counterfactual density of retirement ages $\tilde{h}_0(R, \varepsilon)$, such that $h_0(R) = \int_\varepsilon \tilde{h}_0(R, \varepsilon) d\varepsilon$. Denoting by ΔR^*_ε the response of the marginal buncher at ε, total bunching can be written as

$$B = \int_\varepsilon \int_{\hat{R}}^{R^*_\varepsilon} \tilde{h}_0(R, \varepsilon)\, dR\, d\varepsilon \approx h_0(\hat{R}) E[\Delta R^*_\varepsilon]$$

where the approximate equality holds if $\tilde{h}_0(R, \varepsilon)$ is constant on $[\hat{R}, R^*_\varepsilon]$ for each ε. Hence, R^* can be replaced by $E[\Delta R^*_\varepsilon]$ in equation (8) to account for the local average response.
Similarly, a joint distribution of $(n, \varepsilon, \lambda)$ can be incorporated into the bunching quantities leading to equations (11) and (12).

$$B = \int_\lambda \int_\varepsilon \int_{\hat{R}}^{R^*_{\varepsilon,\lambda}} \tilde{h}_0(R, \varepsilon, \lambda)\, dR\, d\varepsilon\, d\lambda \approx h_0(\hat{R}) E[\Delta R^*_{\varepsilon,\lambda}]$$

where $\tilde{h}_0(R, \varepsilon, \lambda)$ is the counterfactual and $\Delta R^*_{\varepsilon,\lambda}$ is the response of the marginal buncher at (ε, λ). The approximate inequality holds if $\tilde{h}_0(R, \varepsilon, \lambda)$ is constant on $[\hat{R}, R^*_{\varepsilon,\lambda}]$ for each (ε, λ). Thus, equation (11) is identified off the average response $E[\Delta R^*_{\varepsilon,\lambda}]$.

E.2 Income/Wealth Effects

The standard bunching formula (9) applies to small kinks where income effects are small (Saez 2010). Equivalently, the formula can be derived from a quasi-linear utility function as above. For larger kinks, however, there may be income effects arising from the change in the implicit net wage. Kleven (2016) argues that in this case, bunching recovers a weighted average between a compensated and an uncompensated elasticity. In other words, if one views the bunching elasticity as an estimator of a compensated elasticity, it is downward biased towards the uncompensated elasticity (assuming leisure is a normal good). The intuition behind this result is that income effects attenuate responses to price changes, since they work in the direction opposite to the substitution effect.

A similar intuition applies to bunching in response to reference points: The presence of income or wealth effects attenuate the response of the marginal buncher. For instance, an individual responding to a reference point by decreasing their retirement age described by equation (11) is willing to adjust retirement by less if the marginal utility of additional consumption increases at lower retirement ages. In other words, with income effects, the bunching equations (8), (11) and (12) overstate the response at given parameter values. Therefore, estimated parameters can be interpreted as lower bounds on the "compensated" ε and λ in the presence of income effects.

E.3 Dynamic vs. Static Models of Retirement

Retirement decisions are dynamic problems and often modeled as such in the literature. This section sets out a dynamic life-cycle model of retirement, and shows how it linked to the static model considered in section 6. In particular, the static model can be viewed as a reduced form of the full dynamic model under two assumptions: First, all uncertainty in earnings capacity is realized at the "beginning" of old age when the retirement age is decided, and second, there are no liquidity constraints.

E.3.1 A Life-Cycle Model of Retirement

Consider a life-cycle model of consumption for an individual with a fixed life span T who makes an extensive-margin labor supply choice selecting a retirement age R. Assume that period utility is separable in consumption and leisure and that working at age t causes disutility α_t. Then lifetime utility at age zero[39] from retiring at R is

$$U_0(R) = \sum_{t=0}^{R-1} \beta^t \left(u(c_t) - \alpha_t\right) + \sum_{t=R}^{T} \beta^t u(c_t)$$

where β is the discount factor. The individual's lifetime budget constraint requires that lifetime consumption equals lifetime earnings, $C = Y(R)$ or

$$\sum_{t=0}^{T} \left(\frac{1}{1+r}\right)^t c_t = \sum_{t=0}^{R-1} \left(\frac{1}{1+r}\right)^t w_t + \sum_{t=R}^{T} \left(\frac{1}{1+r}\right)^t B(R)$$

[39]The starting age can be interpreted as the beginning of "old age" where retirement is considered.

where r is the interest rate, w_t is the wage at age t that reflects earnings capacity at that age and $B(R)$ is the pension benefit per period paid for retiring at age R.

E.3.2 Solution of the Dynamic Model

ASSUMPTION 1.1. Dynamic uncertainty in earnings capacity. *The worker is subject to a shock to earnings capacity w_t at every age t.*

This captures unexpected age-specific shocks such as to health or labor market opportunities and could for example be generated by a Markov process $w_{t+1} = \rho w_t + \epsilon_{t+1}$. Note that disutility from work is assumed to follow a deterministic process throughout, i.e. all α_t are known based on α_0.[40] Dynamic uncertainty forces the worker to re-evaluate the choice whether to retire at every age based on the new information arriving. Following Stock and Wise (1990) and Manoli and Weber (2016), this problem can be solved by comparing the values of working and retiring at every age. The relevant lifetime utility is now utility at age t from retiring at R

$$U_t(R) = \sum_{s=t}^{T} \beta^{s-t} u(c_t) - \sum_{s=t}^{R-1} \beta^{s-t} \alpha_t$$

Making the decision whether to retire at age t, the value of retirement is

$$V^R(t, B(t)) = u(c_t^R(t)) + \beta V^R(t+1, B(t))$$

and the value of employment is

$$V^W(\Omega_t) = u(c_t^W) - \alpha_t + \beta E_t \left[V(\Omega_{t+1})\right]$$

where $\Omega_t = \{t, B(t), w_t, \alpha_0\}$ is the set of state variables at age t and
$V(\Omega_{t+1}) = \max\{V^R(t+1, B(t+1)), V^W(\Omega_{t+1})\}$ is the value of next period's decision.

The worker's optimal choice follows a reservation value rule, retiring if her earnings capacity drops below a certain age-specific threshold $\bar{w}_t(\Omega_t)$, which is implicitly defined by

$$V^R(t, B(t)) = V^W(t, B(t), \bar{w}_t, \alpha_0)$$

or

$$u(c_t^W) - u(c_t^R(t)) + \beta OV_t = \alpha_t$$

where $OV_t = E_t \left[V(\Omega_{t+1})\right] - V^R(t+1, B(t))$ is the *option value* from working one more period. Hence, at the critical value $\bar{w}_t(\Omega_t)$ the benefits from working one more period, namely the gain in current consumption plus the option value equal the cost of postponing retirement in terms of disutility from work.

Notice that no assumption has been made so far about saving and borrowing behavior. At the one extreme, there can be full consumption smoothing so that there is no drop in consumption at retirement (other than an intended one due to the arrival of new information). At the other extreme, consumption could follow a hand-to-mouth pattern without saving or borrowing such that $c_t^W = w_t$ and $c_t^R(t) = B(R)$. Either case, including intermediate cases, can be accomodated by the dynamic model.

[40] The same retirement patterns could be generated by dynamic uncertainty in disutility from work and deterministc earnings capacity.

E.3.3 Derivation of the Static Model

ASSUMPTION 1.2. No dynamic uncertainty. *The time path of earnings capacity w_t is deterministic given the initial realization w_0.*

ASSUMPTION 2. Full consumption smoothing. *The worker is able to borrow and lend freely to maximize lifetime utility.*

Under assumption 1.2, the retirement decision can be made in period 0 as no additional information becomes available later on. Moreover, under assumption 2 consumption at each age t can be written as a function of lifetime income only. In particular, when $\beta = 1/(1+r)$, the individual wishes to consume the same amount at each age and

$$c_t = \frac{Y(R)}{\sum_{t=0}^{T}\left(\frac{1}{1+r}\right)^t} = \frac{C}{\sum_{t=0}^{T}\left(\frac{1}{1+r}\right)^t} \quad \forall t$$

Thus, the relevant lifetime utility at age 0 from retiring at R is

$$U_0(R) = u(c_t)\sum_{t=0}^{T}\beta^t - \sum_{t=0}^{R-1}\beta^t\alpha_t = U(C) - v(R)$$

where $U(C) := u(c_t)\sum_{t=0}^{T}\beta^t$ and $v(R) := \sum_{t=0}^{R-1}\beta^t\alpha_t$ are reduced-form utility from lifetime consumption and disutility from working until age R, respectively. $U(C)$ is increasing and concave in C if period utility $u(c_t)$ is increasing and concave in c_t. Increasing and convex disutility $v(R)$ can result from the α_t's increasing with t at an accelerating rate.

The nonstochastic lifetime budget constraint is

$$C = \sum_{t=0}^{R-1}\left(\frac{1}{1+r}\right)^t w_t + \sum_{t=R}^{T}\left(\frac{1}{1+r}\right)^t B(R)$$

For further simplification, suppose the interest rate r is zero and the worker earns a constant period wage w. Then the constraint becomes

$$C = wR + (T-R)B(R)$$

The model derived in this section corresponds to the so-called "lifetime budget constraint" model of retirement suggested by Burtless (1986). While being based on the two strong assumptions specified above, its significant advantage is that retirement decisions can be treated in a way analogous to hours of work decisions in a standard labor supply model. In particular, the optimal date of retirement is characterized by the first-order condition

$$\frac{v'(R)}{U'(C)} = \frac{dC}{dR}$$

where dC/dR is the marginal gain in lifetime consumption from postponing retirement given by the budget constraint.