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Reference Points for Retirement Behavior: Evidence From German Pension Discontinuities

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Abstract

This paper studies the large concentration of retirement behavior around statutory retirement ages, a puzzling stylized fact. To investigate this fact, I estimate bunching responses to 644 pension benefit discontinuities, using administrative data on the universe of German retirees. Financial incentives alone cannot explain retirement patterns, but there is a large direct effect of statutory retirement ages. I argue that the framing of statutory ages as reference points for retirement provides a plausible explanation. Simulations based on a model with reference dependence highlight that shifting statutory ages via pension reforms is an effective policy to influence retirement behavior.

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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 18% of total public expenditure on pensions, and the old-age dependency ratio is predicted to almost double by 2050 (OECD 2019). Extending individuals' working lives is an important margin of adjustment to these demographic trends. In standard economic models, retirement behavior can be influenced by appropriate financial incentives. In this paper, I present evidence that how retirement incentive schedules are perceived by workers matters, and this can have larger effects on retirement behavior than the incentives themselves.

In particular, I analyze the role of saliently featured age thresholds that I term *statutory retirement ages*. These are used by pension systems to frame retirement rules and they usually include an Early Retirement Age and a Full or Normal Retirement Age. Panel A of Figure 1 shows that job exits of German workers are strongly concentrated around statutory retirement ages. There are sharp spikes in the distribution at ages 60, 63 and 65, the main locations of statutory ages.[1] In total, 29% of job exits at age 55 and above occur precisely in the month when the worker reaches a statutory age. These retirement spikes 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 Panel B of Figure 1. 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.

I investigate this stylized fact and make three main contributions. First, I provide new, large-scale reduced-form evidence, building on Mastrobuoni (2009) and especially Behaghel and Blau (2012) who document bunching at the Full Retirement Age in smaller samples using U.S. survey data. I estimate bunching responses to more than 600 benefit discontinuities in the German public pension system, using administrative data on the universe of German retirees. I find that financial incentives alone cannot explain retirement patterns: on average, responses to statutory retirement ages are seven times larger than to pure financial incentives. These results suggest a first-order impact of non-standard behavior on the retirement age distribution. Second, based on additional evidence, I argue that a parsimonious model with reference dependence fits the empirical patterns well. Third, counterfactual simulations suggest that shifting statutory ages is 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 several advantages. To begin with, there is rich variation in statutory retirement ages and financial incentives: There are six pathways into retirement entailing different statutory ages and benefit schedules, and a series of pension reforms provide additional cohort-based variation at the monthly 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

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

from sizeable incentives for retirement to disincentives. Moreover, 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" time to retire, and a "full" level of pension benefits. 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.

Another advantage of the 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. I establish two main results. 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. 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 some cases of specific discontinuities that lend themselves to natural comparison. For instance, 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 the second approach, I use the full set of discontinuities to generalize the results. Expressed in terms of observed elasticities of the retirement age w.r.t. the net-of-tax rate, the average response to statutory ages is seven times larger than to pure financial incentives. I also propose a reduced-form strategy to formalize the joint estimation of responses to statutory ages and financial incentives, combining the large number of bunching estimates in a regression. The identification assumption is that responses to different types of discontinuities are driven by the same underlying parameters. The estimated direct effect of statutory ages is large and significant, and the "true" net-of-tax elasticity of around 0.05 is modest. Results are robust to controlling for heterogeneity in age, income, education and other observable characteristics of workers facing different types of discontinuities.

The second part of the paper explores mechanisms behind the reduced-form effect of statutory ages. I begin by showing evidence from two reforms, suggesting that the effect is indeed due to the government setting statutory ages, and that the framing of statutory ages can affect retirement behavior. 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. 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 the Normal

Retirement Age around which explanations in letters are framed. Moreover, I discuss potential alternative mechanisms. On the one hand, firm responses do not seem to 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. On the other hand, liquidity constraints could explain at least part of the response to the Early Retirement Age, although this remains hard to verify directly in the absence of data on assets. Hence, the behavioral interpretation in the remainder of the paper focuses on Full or Normal Retirement Ages.

The third part of the paper turns to an interpretation of the empirical findings in a simple model of retirement with reference dependence. The reference point is given by a salient threshold in the form of a Full or Normal Retirement Age, for instance because workers perceive it as a normal time to retire. Reference dependence is modeled as a change in marginal disutility from continuing work at the reference point. Incorporating this standard formulation into a bunching framework yields predictions consistent with the empirical patterns, namely sharp bunching at statutory ages irrespectively of financial incentives.

Reference dependence may not be the only possible behavioral explanation for bunching at statutory ages, but I argue that it provides a parsimonious model which fits the data well. In particular, the shape of the empirical retirement age distribution around statutory ages is consistent with an asymmetric density shift as predicted by reference dependence with loss aversion. On the other hand, the empirical density does not exhibit missing mass in the neighborhood of statutory ages, as would be predicted by alternative models where individuals derive a fixed utility premium from retiring at this age. Such a discrete utility gain is one way to represent alternative behavioral mechanisms where individuals perceive retiring exactly at statutory ages as implicit advice by the government, or as a social norm. Moreover, if workers follow a suggestion by the government, one may expect that responses to statutory ages are concentrated among less financially sophisticated workers who find it difficult to make optimal retirement decisions. However, I do not find a negative relationship between bunching at statutory ages and proxies for financial literacy.

Based on the model, the magnitude of observed bunching can be directly related to parameters governing the strength of reference dependence, and these parameters can be straightforwardly recovered via structural bunching estimation. The estimation exploits the same variation in statutory ages and financial incentives across discontinuities used in the reduced-form analysis. Estimated local utility kinks at Full and Normal Retirement Ages are large and significant, with magnitudes equivalent to variation in the implicit tax rate of at least 51%.

Finally, counterfactual simulations highlight an important policy implication: Reforms shifting statutory ages are effective in influencing retirement behavior and can generate a positive fiscal impact, which would be more difficult to achieve via financial incentives. First, I simulate an increase in the Normal Retirement Age from 65 to 66. This leads to an increase in average actual retirement ages by 3 months. The second simulated reform provides stronger financial incentives for late retirement in the form of a “delayed retirement credit”. In order to match the effect on retirement behavior from the first scenario, financial rewards 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: A back-of-the-envelope calculation suggests that the Normal Retirement Age increase entails a long-term annual fiscal gain +€1.1bn, whereas the financial rewards leads to a net fiscal loss of −€1.2bn. The difference in fiscal effects arises because workers pay contributions for longer in both scenarios, but in contrast to the second scenario, shifting statutory ages can induce 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 mixture of the two.[2] Most closely related to this paper, Mastrobuoni (2009) documents sizeable responses to a change in the Full Retirement Age using U.S. survey data, and Behaghel and Blau (2012) argue that loss aversion is a potential explanation for benefit claiming spikes.[3] In this paper, I leverage a unique setting combining rich, independent variation in statutory ages and financial incentives and full-population administrative data over two decades. I obtain compelling and precise estimates of the large direct effect of statutory retirement ages on job exit behavior, and provide new evidence on behavioral mechanisms. To my knowledge, this paper is the first to jointly quantify reference point effects and standard elasticities, which allows me to simulate and explicitly compare the effects of statutory age reforms to pure financial incentives.

Second, I contribute to a growing literature on the role of reference points in field settings. In particular, Allen et al. (2017) and Rees-Jones (2018) investigate bunching at reference points among marathon runners and income tax filers, respectively. Building on these approaches, I take the use of bunching methods further and estimate underlying reference dependence parameters by exploiting variation in financial incentives and statutory retirement ages across multiple discontinuities.[4] The bunching approach is complementary to full structural approaches such as DellaVigna et al. (2017) and Thakral and Tô (2019). In addition, the results in this paper highlight the empirical relevance of salient thresholds as reference points,[5] and contribute to a broader literature on the importance of individuals' perception of incentives set by policy (e.g. Duflo et al. 2006).

[2]Similar recent studies estimating the total effects of pension reforms involving statutory ages and financial incentives include Lalive and Staubli (2015), Cribb et al. (2016), and Fetter and Lockwood (2018). Moreover, Brown (2013) and Manoli and Weber (2016) analyze retirement responses to pure financial incentives.

[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).

[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]This contributes to an ongoing debate about the relevance of salient/backward-looking reference points vs. forward-looking reference points (see O'Donoghue and Sprenger 2018).

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. (2020) emphasize the importance of contextual factors in determining responses, mostly focusing on optimization frictions. Estimating bunching at many discontinuities, this paper shows that reference point effects 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 discusses 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.[6] Hence, pensions are roughly proportional to lifetime income and there is relatively little redistribution. The average net replacement rate is just over 50% (OECD 2019). Public pensions are the main source of income for most recipients.[7] Moreover, there is an 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 (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.[8]

Discontinuous Benefit Rules. The key advantage of the empirical setting is that there are more than 600 pension discontinuities. Three types of discontinuous pension benefit rules are at their source. First, marginal pension adjustment changes at statutory retirement ages. A full monthly benefit 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

[6] Appendix B provides additional details on benefit calculation and other aspects of the institutional setting.

[7] In a 2003 survey, 11% of retirees reported to receive any income from employer pension schemes and only 1% had a private pension. Among retirees with any employer or private pension, the average income from that source corresponds to 34% and 23% of their public pension, respectively (Heien et al. 2005).

[8] The distinction between the Full and Normal Retirement Age is somewhat peculiar to the German pension system. Historically, FRAs were introduced in some pathways to allow certain workers to claim a full pension before the NRA. However, late claiming rewards are only available after the NRA for all workers.

benefit 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% per month after the NRA.[9]

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. The regular pathway requires just 5 years of contributions, but pensions can only be claimed from the NRA. At 15 and 35 years of contributions, workers become eligible for pathways with ERAs between 60 and 63, and FRAs between 60 and 65. Thus, they can receive a pension for more years and/or the benefit level is higher at any given age due to more favorable adjustment, which implies a discontinuous increase in pension wealth. Some pathways have additional requirements including gender, disability and periods of unemployment. Finally, the third type of discontinuous pension rule occurs in a pathway without statutory retirement ages where pensions can be claimed at any age. The disability pathway has a low contribution requirement of 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 or after 63.[10]

Framing of Statutory Retirement Ages. Statutory ages are one source of pension discontinuities, but the way they are presented to workers differs fundamentally from other, "pure" financial incentives. Figure 2 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. First, statutory ages are saliently featured as normal retirement dates. The title "Retirement at 67" refers to the post-reform NRA. In fact, this title is a commonly used name for the reform in the media and public discourse. Using a hypothetical worker ("Maria F."), readers are then told that if they want to retire "as early as possible" they can retire at the ERA, but if they wish a full pension, they should retire at the FRA. Furthermore, 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 such as a "normal" retirement age, statutory ages are presented as reference ages, and "early" and "late" retirement is defined relative to them. Moreover, pension adjustment is framed as a loss (penalty) or gain (reward) relative to a "full" reference level linked to a statutory age.[11] Such framing of retirement ages has been shown to affect reported retirement plans in experimental settings (e.g. Brown et al. 2013, Merkle et al. 2017).

[9] In contrast to the U.S., there is no discontinuity in the availability of public health insurance at statutory ages.

[10] 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.

[11] More generally, statutory ages play a crucial role in the way pensions and retirement are presented to workers. For instance, pension reforms tend to be presented as changes to statutory ages rather than changes to benefit levels they might effectively entail.

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:

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

The worker earns a gross wage w from starting age 0 to the period before retirement, which is subject to payroll tax $\tilde{\tau}$. 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, which is assumed to be known for simplicity. Finally, all payments are discounted at factor δ.

The slope of the budget constraint, that is the marginal gain in lifetime consumption possibilities C from delaying retirement by one period, defines the implicit net wage $w^{net} = dC/dR$. Expressing the consumption gain as a fraction of the gross wage, the *implicit net-of-tax rate* is $1-\tau = w^{net}/w$. Delaying retirement generally 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 dB/dR. In the German case 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.

Panel B of Figure 1 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 kinks at all statutory ages, but their sign and magnitudes differ. Kinks at the ERA and the FRA are convex, i.e. the marginal net-of-tax rate is reduced. Moreover, there is a non-convex kink, i.e. an increase in the marginal return to work, at the NRA.[12] 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.[13]

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 Panel B of Figure 1, for instance, the worker reaches

[12] An exception is the regular pathway where pensions can only be claimed from the NRA, in which case there is a convex kink at the NRA.

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

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 in all main pathways where eligibility requires 5, 15 or 35 years of contributions.[14] 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.[15] First, the six pathways described in Table 1 vary in statutory ages and contribution requirements. Second, a series of cohort-based pension reforms have been enacted since the early 1990s. Appendix Figure A2 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 gradually increased from 60 to 65 for cohorts 1940 to 1944, such that each monthly birth cohort faces a one-month change in the FRA. Similar gradual changes to the FRA or ERA were also implemented in the other pathways.

In total, this yields 386 budget constraint kinks linked to statutory ages. Contribution notches and disability kinks amount to 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 A3 provides some examples of lifetime budget constraints, where workers face different statutory ages and pure financial incentive discontinuities depending on their month of birth, gender, contribution history and disability status.

Panel A of Table 3 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 change in the net-of-tax rate is 0.32 at pure financial incentive kinks, and 0.44 at contribution notches. The figure at notches is obtained from the approximation as a kink for the marginal buncher following Kleven and Waseem (2013). 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 across statutory ages is 0.39. There is also some within-group variation in effective kink sizes due to different individual earnings histories, but the within-group standard deviations are relatively small. The average retirement age at which statutory ages are located is

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

[15] 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. More precisely, kinks are discontinuities in the marginal net-of-tax rate, whereas notches are discontinuities in the average net-of-tax rate.

62.5, while pure financial incentive discontinuities occur at an average age of 60.4.

2.4 Data

The analysis is based on a novel administrative data set covering the universe of retirees who claim a public pension between 1992 and 2014 provided by the German State Pension Fund. 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 pensions were calculated under a particular set of post-reunification rules. The analysis focuses on birth cohorts 1933 and 1949, for whom the relevant part of the retirement age distribution is fully observed. 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.[16] Lifetime earnings and average annual earnings are backed out using information on contribution periods and contribution points,[17] 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 year of birth and gender. In order to account for the fact that observed take-up of pathways may reflect workers' choices, pathways are assigned 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 occupations 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

[16] The imputation is mostly relevant for job exits before the ERA, and affects relatively few job exits at the different types of discontinuities. See Appendix C for further details of the data and key variables.

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

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, and control variables are added at the group level. Table 2 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,[18] provides a way of detecting such responses. The bunching mass B at an age threshold $\hat{R}$ is the observed local spike above a counterfactual retirement age density $h_0(\hat{R})$, which can be obtained by fitting a 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.

Assuming that the density would have been smooth in the absence of the threshold,[19] bunching can be interpreted in terms of a local retirement response. A standard approach focused on responses to financial incentives then computes an elasticity by relating the excess mass to the kink size $\Delta\tau/(1-\tau)$, 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 result that the excess mass is directly related to the labor supply response of the marginal bunching individual (Saez 2010), here $b \approx \Delta R$. 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 where workers only respond to financial incentives. In this case, bunching is only a function of the elasticity and a vector of observables 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

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

[19] The empirical implementation allows for round-number effects in addition. See Appendix D.1 for details of the bunching estimation in practice.

estimated from bunching at a single discontinuity as above. However, bunching responses can serve to identify additional parameters. 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 discontinuities, such that $n > k+1$ and parameters can be estimated across "bunching observations" B_i.

Specifically, I aim at 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 a direct effect of statutory ages. 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. In fact, equations (2) and (3) imply differences in observed elasticities across 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.[20] 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 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. I return to discussing the empirical validity of assumptions A and B in sections 4.2 and 4.3.

[20] 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. 2020). In a situation with optimization frictions, the observed elasticity underestimates the true elasticity.

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) and extensive-margin responses more generally (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 discontinuities in the same way, the relative magnitude of the effects of interest can still be identified.[21]

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 that lend themselves to two natural comparisons between statutory retirement ages and pure financial incentives.

Statutory Retirement Age vs. Contribution Notch Within Group. First, Panels A1 and A2 of Figure 3 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 12.2 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. The jump in the average tax rate is 0.7pp, and this notch corresponds to an approximate kink size of 0.28. The average job exit age around the notch is 60.4. There is sharp bunching at 15 years and some missing mass to the left. However, the excess mass of 1.36 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.

Statutory Retirement Age vs. Pure Financial Incentive Kink. For the second comparison, Panels B1 and B2 show bunching at two similar kinks, with and without a statutory retirement age. Panel B1 shows bunching around the FRA at 63 for cohorts 1944 to 1946 in the invalidity pathway. The kink size is 0.33 and the excess mass is estimated at 10.4, 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 0.29 at age 63.

[21] 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).

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. In contrast to the large excess mass at the FRA, bunching is hardly visible and the excess mass is only 0.04 at the disability kink. Consequently, the observed elasticity of 0.001 is far below the estimate at the FRA.

4.1.2 Bunching Across All 644 Discontinuities

Panel B of Table 3 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 this is driven by large responses to all three types of statutory ages, with the largest excess mass at NRAs. Attributing all bunching to the change 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.[22] Next, columns (5) to (7) report bunching responses to the 258 pure financial incentive discontinuities. The average excess mass is 3.81, and the average observed elasticity is 0.07. Among pure financial incentives, the elasticity is 0.08 at notches and 0.01 at kinks.[23]

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 raw 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 from pure financial incentives of around 0.01 to 0.04 (Brown 2013; Manoli and Weber 2016). Moreover, a first indication that bunching at statutory ages seems to occur independently of financial incentives is given by the large excess mass at non-convex NRA kinks, where there is a disincentive to bunch.

To further investigate the extent to which differences in bunching are driven by differences in financial incentives, Figure 4 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 across all kink sizes, even when there is a zero or negative incentive to retire. The second insight is that whether a discontinuity is presented as a statutory age matters 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 the largest pure financial incentives induce less bunching than statutory ages. Note that this does not imply that there are no responses to financial incentives. Both Panels A

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

[23]The larger observed elasticities at notches could be driven by several factors. First, kinks occur in 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.

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 statutory retirement ages. In order to quantify the importance of this "statutory age effect", I employ the following regression specification:

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

where an observation 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.[24] Finally, Z_i is a vector of control variables, and ν_i is an error term.

Equation (5) may be a natural reduced-form specification, 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 group-level characteristics and fixed effects in a flexible way. Second, rather than finding an exact solution, the equation can be estimated via OLS, combining the information from 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.

The key identification assumption for this specification is assumption A. 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. Direct empirical support for assumption A is lent by the results from Figure 4. The estimated slopes in Panels A and B suggest that within type of discontinuity, the elasticity with respect to financial incentives is similar at statutory ages and pure financial incentive discontinuities.

Table 4 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 characteristics including income, education, gender, marital status and retirement age at the discontinuity as controls, as well as pathway and year-of-birth fixed effects. Column (4) adds the largest set of group fixed effects, controlling for pathway times year-of-birth

[24] In this section, I estimate the reduced-form effects of all types of statutory ages. Later, the structural estimation focuses on FRAs and NRAs, as these are arguably the more clear-cut cases to put forward a behavioral explanation.

fixed effects. Finally, column (5) controls for occupation-level characteristics including firm size and unionization rates. With a coefficient of 0.16 to 0.22, 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. In spite of the varying set of controls and fixed effects, the point estimates remain stable across specifications, although the ERA effect becomes insignificant due to larger standard errors in columns (4) and (5). Estimates of the elasticity range between 0.03 and 0.05, but they are only significant in columns (1) and (2).

4.3 Heterogeneity

A potential concern with comparing responses between statutory ages and pure financial incentives is that workers facing different discontinuities might differ in some relevant characteristics. For instance, pure financial incentive discontinuities tend to occur at somewhat younger retirement ages, and many apply to the disability pathway. This may in turn be correlated with elasticities, violating identification assumption A. The main estimation is robust to controlling for a range of observables and fixed effects, but in this section I present additional evidence that the effect of statutory ages is not confounded by such differences.

Can Heterogeneity Explain Differences in Bunching Responses? Figure 5 shows average observed bunching elasticities at statutory ages and pure financial incentive discontinuities by a range of observables. First, Panels A and B sort bunching observations by birth cohort and the retirement age at the discontinuity, respectively. The remaining panels of the figure sort bunching observations by quintiles of individual characteristics, including lifetime earnings (Panel C), years of education (Panel D), and health status proxied by the negative of sick leave periods (Panel E), as well as occupation-level characteristics including firm size (Panel F), unionization (Panel G) and tenure in the firm (Panel H). In order to obtain partial correlations, each characteristics is first residualized via a regression on a set of basic variables including the other characteristics in the figure. Bunching observations are then sorted into quintiles by the residual from this regression.[25] There are large and significant differences in observed elasticities at statutory ages vs. financial incentives among all birth cohorts, across the available range of retirement ages, and in each quintile of each characteristic. Hence, the strongly differential responses across types of discontinuities do not seem to be driven by differences across workers along the lines of age or other characteristics. Appendix Figure A5 shows that this conclusion is robust to using different sets of controls in the residualization regression or using raw characteristics, although the slope of bunching responses within each type of discontinuity can be sensitive to these choices.[26]

[25] Rees-Jones (2018) uses a similar method in order to capture heterogeneity in bunching by tax reductions conditional on individual characteristics.

[26] In addition, Appendix Table A1 reports results from a Oaxaca-Blinder decomposition, suggesting that the joint explanatory power of observable characteristics is limited. The decomposition attributes differences in excess mass between pure financial incentive discontinuities and statutory retirement ages to a component explained by differences in observables and an unexplained component. 84% of the additional bunching at statutory ages cannot be explained by differences in observable characteristics. Financial incentives account for around 4% of observed differences, while

Estimation with Heterogeneous Parameters. As discussed above, a concern for identification arises if parameters are heterogeneous across workers facing different types of discontinuities. A second approach to address this is to allow directly for heterogeneous parameters in the following 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. An arguably natural definition of groups is to allow for heterogeneity at the level where benefit schedules and 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, allowing for a lower elasticity in the disability pathway, for instance.

Columns (6) to (8) of Table 4 report 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. First, column (6) estimates a specification with pathway-specific coefficients, and column (7) repeats the exercise with groups defined by birth cohorts. Column (8) reports estimates with groups defined by pathway and birth cohort. In the spirit of the comparison presented in Figure 3, this specification estimates elasticities and statutory age effects within narrowly defined groups such as women born in 1945. Overall, results remain very similar to the baseline estimation. In all specifications, statutory age effects are highly significant and increase slightly to between 0.06 and 0.24 compared to columns (1) to (5). The estimated elasticity is between 0.05 and 0.09. In particular, the fact that estimated statutory age effects change little suggests that differences in elasticities across pathways do not seem to introduce much bias in the baseline results.

5 Mechanisms

In this section, I discuss potential mechanisms behind the reduced-form effect of statutory retirement ages.

5.1 Can the Government Effectively Change Statutory Retirement Ages?

First, I show that workers' retirement decisions react directly to a change in statutory ages, suggesting that the government can effectively set and change statutory ages. To this avail, I exploit variation due to cohort-based reforms (see Appendix Figure A2). 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. As it is implemented gradually, the reform creates fine-grained variation where each monthly birth cohort faces faces an additional one-month increase in the FRA.

worker and firm variables including those discussed here explain 15% and -3%, respectively.

Figure 6 shows the effect of the FRA increase 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 while the FRA is gradually increased. For the post-reform cohorts, the average job exit age is just below 63 and again remains stable. A before-after estimate indicates an effect of the reform on job exit ages of 1.70 years, corresponding to a 4.1 months increase in actual retirement ages per one-year increase in the FRA.[27]

Panel B shows job exit age distributions of the last pre-reform birth cohort 1939, the first post-reform cohort 1945, as well as selected monthly cohorts during the transition period. The graphs suggest that the increase in the average job exit age is driven by a shift in the distribution from the pre-reform FRA to the post-reform FRA. Before the reform, there is a large job exit age spike at age 60 and a relatively small spike at 65. After the reform, a large spike at 65 emerges. Since the women's ERA remains at age 60 after the reform, there is still a smaller spike at this age. In addition, job exit age distributions among selected transition cohorts are shown, namely June 1940, February 1941, April 1942, and July 1943, whose FRA is 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 A6 shows the complete set of distributions for the 60 monthly birth cohorts during the transition period. Across all cohorts, the spike in retirement moves in lockstep with the monthly FRA change.

5.2 The Effect of Framing

Does the framing of statutory ages affect retirement behavior? This is difficult to test directly, as the framing is ubiquitous and to my knowledge the way statutory ages are presented per se has not changed over the last decades. To obtain suggestive evidence, I exploit a reform affecting the intensity of framing instead, where the German State Pension Fund increased the frequency of information letters sent to workers. 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 (see Dolls et al. 2018). The stated goal of the reform was to better inform workers about benefit and retirement rules. Appendix Figure A7 shows an example of a letter. 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 retirement ages are also shown. However, letters emphasize statutory ages as reference dates, in particular the NRA. For instance, the first paragraph shows the exact date when the individual will reach the NRA. Moreover, two out of three benefit scenarios in the letter use the NRA as the hypothetical retirement date.

[27] 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.

Panel A of Appendix Figure A8 shows the fraction of workers bunching at different types of discontinuities by calendar quarter around the reform. First, there is no visible change in the response to pure financial incentives, in spite of the goal of providing better information. On the contrary, the probability of bunching at statutory ages increases, and this is driven by a significant increase in the probability of bunching at the NRA. The before-after coefficient shown in the figure indicates a 3pp increase at the NRA. In addition, the reform creates variation in the number of letters across birth cohorts (see Appendix B.4 for details). In Panel B of the figure, there is a gradual increase in the probability of retiring at the NRA for cohorts 1941 onwards as the number of letters received in the years before the NRA increases. However, there is no clear effect for earlier cohorts who receive just one letter before the NRA. This lack of immediate effect may be related to receiving the letter only in one year just before the NRA, leaving relatively little time to change retirement plans. Overall, the probability of bunching at the NRA increases by 2pp among the post-reform cohorts.

These findings are consistent with an effect of direct communication by the pension administration that emphasizes statutory ages, but they remain somewhat suggestive. Mastrobuoni (2011) uses a similar strategy exploiting the introduction of the U.S. social security statement. In line with my results, the study finds no effect on the responsiveness to financial incentives. However, he also finds no substantial effect on the probability of bunching at statutory retirement ages.[28] Finally, it is worth noting that the estimated effect is small and bunching is already remarkably large before the reform when workers receive only one letter in their lifetime. This may point at the importance of the broader framing discussed in section 2.1.

5.3 Alternative Mechanisms

5.3.1 The Role of Firms

Laying off workers at statutory ages is sometimes cited as a way for firms to avoid costs of firing older workers. In the German labor market, mandatory retirement is possible at the NRA, but not at the ERA or FRA. Recent evidence by Rabaté (2019) suggests that similar mandatory retirement rules can only explain 12% of bunching at the NRA in France. Similarly, firm responses do not seem to be the main driver of statutory age retirements in the German setting. In particular, I investigate bunching at statutory ages among two subgroups where firm incentives play no role or a smaller role. First, although limited, there are a number of self-employed individuals enrolled in the public pension system.[29] Second, small firms with less than 10 employees are exempt from employment protection rules, so there should be little need for employers to lay off older workers

[28] This difference could be driven by two factors. First, the content of the U.S. statements differs somewhat from the German letters. In fact, Mastrobuoni (2011) interprets them as an information treatment rather than a framing treatment. While still centered around the NRA, the U.S. statements show expected social security benefits at a range of possible retirement ages between 62 and 70. The German letters, on the other hand, only show expected benefits from retiring at the NRA, or immediately. Second, the small positive estimates from this paper might be within the confidence intervals of Mastrobuoni (2011), which are not shown.

[29] Self-employed individuals can be enrolled in the public pension system for two reasons. First, a small set of self-employed occupations are mandated to participate. Second, self-employed workers can enrol voluntarily.

specifically at statutory ages. Appendix Figure A9 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 (Panel C). There are sharp spikes among the self-employed at the main statutory ages and the fraction bunching of 28% is only 3pp less than in Panel A. Hence, most bunching at statutory ages seems to persist in the absence of firm responses. Moreover, although most contracts are not subject to employment protection rules, there are also sharp spikes at statutory ages in Panel C and the fraction bunching is 30%.

More generally, variables related to firms' incentives do not seem to explain much of the bunching at statutory ages. Firing frictions may be more severe for larger firms, in more unionized sectors, and for workers with longer tenure and unlimited contracts, for instance. Moreover, in a tighter labor market it may be more valuable to keep older workers beyond statutory ages. In Figure 5, there is large additional bunching at statutory ages compared to pure financial incentives in all quintiles of firm size, unionization and tenure, which are observed at the occupation level. In addition, Appendix Table A5 shows results from individual-level regressions of the probability of bunching at statutory ages on these characteristics, as well as the fraction of workers in unlimited contracts and a measure of labor market tightness at the state-year level. The probability of bunching increases with firm size, but somewhat surprisingly decreases in unionization, tenure and unlimited contracts and increases in labor market tightness, while the coefficients are modest in magnitude.

5.3.2 Statutory Retirement Ages as Implicit Advice?

The results so far suggest a behavioral explanation for bunching at statutory ages, but reference dependence is not the only possible mechanism. A leading alternative behavioral mechanism may be that individuals interpret statutory ages as an implicit suggestion or advice by the government and those who find it difficult to make optimal retirement decisions follow this suggestion. A natural implication of this mechanism would be that responses to statutory ages are concentrated among less financially sophisticated workers. In the data, there is no clear negative relationship between bunching at statutory ages and available proxies for financial literacy. In Figure 5, workers at all education and income levels respond strongly to statutory ages. If anything, higher education and income seem to be associated with slightly larger responses to statutory ages, while there is also an increase in the response to pure financial incentives in the highest education quintile. These correlations are somewhat sensitive to the choice of control variables, however (see Appendix Figure A5). Appendix Table A5 performs a similar correlation test at the individual level. In column (1), workers retiring at statutory ages have higher education and are more likely to be in an economically trained occupation. They also have higher lifetime income and higher last earnings before retirement, providing no indication that higher financial literacy diminishes bunching at statutory ages. Column (2) shows that the results are robust to limiting the sample to retirements no more than one year away from statutory ages. These correlations are similar to results by Behaghel and Blau (2012) who find that benefit claiming at the FRA is positively related to some survey measures of cognitive ability and wealth.[30]

5.3.3 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. Liquidity-constrained workers may not be able to smooth lifetime consumption throughout the gap between job exit and ERA to the desired extent. 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, Appendix Table A5 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. However, the importance of this mechanism remains hard to check directly in the absence of data on assets and I cannot fully exclude that liquidity constraints explain part of the response to the ERA, besides serving as a potential reference point among earlier retirees. Hence, the conceptual interpretation and structural estimation in the remainder of the paper focuses on the FRA and NRA.

6 Retirement Bunching and Reference Points in a Simple Model

In this section, I incorporate reference dependence into a simple model of retirement decisions. 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. Moreover, I show in section 6.3 that the retirement density around statutory ages is consistent with the reference-dependent model, but more difficult to reconcile with alternative behavioral models. As discussed above, the remaining analysis focuses on the FRA and NRA, as they are not confounded by liquidity constraints.

6.1 Basic Setup and Bunching at a Budget Constraint Kink

Consider a simple static model of retirement decisions where workers maximize lifetime utility $U = u(C) - v(R, n)$.[31] 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

[30]Moreover, the ratio of pension wealth to annual earnings, a proxy for the relative importance of public pensions for the worker, is positively related to the probability of bunching at statutory ages in Appendix Table A5. Thus, higher stakes do not seem to diminish responses, which speaks against inattention explaining retirements at statutory ages.

[31]The static model corresponds to the "lifetime budget constraint" model of retirement suggested by Burtless (1986). Similar static models are used in recent applications such as Brown (2013) and Manoli and Weber (2018) in order to quantify bunching at local discontinuities. Appendix E provides an outlook on the relationship with dynamic models and discusses how a number of extensions, including parameter heterogeneity and income effects, can be incorporated into the analysis.

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 divided by the gross wage again 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

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

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 $\hat{R}$. Analogously to standard bunching models, the framework predicts bunching at the kink. Appendix Figure A10 illustrates the effect of the kink following Saez (2010) and Kleven (2016), and the full derivation is shown in Appendix F.1. The amount of bunching can be linked to the retirement response of a marginal bunching individual whose indifference curve is tangent to the initial budget set at R^* and to the upper part of the new budget set at $\hat{R}$. Bunching is charaterized by

$$\frac{R^*}{\hat{R}} = \left(\frac{1-\tau}{1-\tau-\Delta\tau}\right)^{\varepsilon} \tag{7}$$

or, if $\Delta\tau$ is small,

$$\frac{b}{\hat{R}} \approx \varepsilon\frac{\Delta\tau}{1-\tau} \tag{8}$$

where $b = B/h_0(\hat{R})$ is the excess mass. This corresponds to the Saez (2010) bunching formula and implies equation (2), which is used to calculate observed elasticities in the reduced-form estimation.

6.2 Bunching at a Reference Point

Next, reference dependence can be incorporated into this standard bunching framework. Reference dependence captures the notion that workers evaluate their retirement age relative to a threshold $\hat{R}$. In particular, I consider a fixed, exogenous reference point set by policy in the form of a Full or Normal Retirement Age. Preferences of a reference-dependent agent are

$$U = u(C) - v(R,n) - \mathbb{1}(R \geq \hat{R}) \cdot \widetilde{\lambda}(R - \hat{R}) \tag{9}$$

The last term in equation (9) introduces a discontinuity in individual marginal disutility from continuing work at $\hat{R}$. 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 kink in the utility function. This is consistent with an interpretation where workers perceive postponing retirement as a loss relative to a normal time to retire. Similar formulations of reference dependence with loss aversion are commonly used in the literature (e.g. DellaVigna et al. 2017 and Rees-Jones 2018). Note that the model represents a reduced-form way of incorporating loss aversion in two dimensions. First, gain utility is abstracted from for simplicity. Second, the parameter λ captures reference dependence directly in terms of the retirement age, rather than also considering reference dependence in consumption.[32] As I show below, this entails the advantage that bunching responses are analogous to those at a budget constraint kink, and underlying parameters can be identified straightforwardly via structural bunching estimation.

Figure 7 illustrates bunching responses to the reference point in a budget set diagram and a density diagram. 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 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 budget constraint kink, 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. The bunching mass B is given by

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

where $h_0(R)$ is the counterfactual density and the approximate equality holds if $h_0(R)$ is constant on $[\hat{R}, R^*]$. The two tangency conditions for the marginal buncher imply $R^* = n^*[w(1-\tau)]^\varepsilon$ and $\hat{R} = n^*[w(1-\tau) - \tilde{\lambda})]^\varepsilon$. Hence

$$\frac{R^*}{\hat{R}} = \left(\frac{1-\tau}{1-\tau-\lambda}\right)^\varepsilon \tag{10}$$

where $\lambda = \widetilde{\lambda}/w$ expresses the reference dependence parameter relative to the gross wage w. Equation (10) 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 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 can be estimated based on bunching observed at a reference point, but one

[32] A previous version of this paper considered reference dependence in terms of both the retirement age and consumption. Reference dependence in consumption could be motivated by the gain-loss framing of benefit levels around the FRA, for instance. While both models predict bunching at a reference point, the present formulation is better suited in terms of transparent identification of the key parameters and is well in line with the retirement distribution around statutory ages (see section 6.3).

also needs to know or estimate the elasticity ε for this purpose. Intuitively, ε plays a role for the amount of bunching for 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. Thus, in order to compute total bunching, an initial situation without any discontinuity needs to be compared to a situation with the budget set kink and reference point. Appendix Figure A11 illustrates bunching responses to such a combined threshold. 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 $\hat{R}$. Again, all individuals initially located between $\hat{R}$ and R^* bunch at the threshold and 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, the excess mass $b = B/h_0(\hat{R})$ is

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

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 Further Predictions and Alternative Behavioral Models

Consistent with the empirical patterns, the model predicts sharp bunching at statutory retirement ages. However, reference dependence with loss aversion also makes further, distinctive predictions about the shape of the retirement age distribution. In particular, the framework implies a shift of the distribution on one side of the reference point: In Figure 7, the rotation of indifference curves causes a leftward shift of all retirement ages above $\hat{R}$. Workers initially located between $\hat{R}$ and R^* bunch, while workers initially above R^* retire earlier but remain above $\hat{R}$. Hence, there is no hole or missing mass, but an asymmetry of the distribution around $\hat{R}$, where the density is shifted to the left (downwards) over the range above the reference point.

These additional predictions can help assess the plausibility of the reference-dependent model against alternative behavioral models. Appendix F.2 sets out a model with a fixed utility premium that individuals derive from retiring at a statutory age. This can be interpreted as a reduced-form representation of alternative mechanisms where individuals view retiring exactly at statutory ages as implicit advice by the government (see section 5.3.2), or as a social norm. The model also predicts sharp bunching, but a different shape of the density around statutory ages. As there is a fixed utility cost of deviating from the statutory age in either direction, individuals whose counterfactual retirement age would be sufficiently close to the threshold bunch, but there are no retirement responses further away from the threshold. Hence, the alternative model predicts missing mass on both sides and no further shift in the density.

Figure 8 shows the empirical density pooled around all FRAs and NRAs (Panel A), as well as stylized graphs of the density predicted by the reference-dependent model (Panel B1), and the alternative model with a fixed utility gain (Panel B2). The empirical distribution exhibits the usual sharp bunching and the density to the right of the threshold is visibly lower than on the left. This is consistent with a leftward shift of the density above statutory ages. The red curve in the graph shows a counterfactual density fitted via a polynomial with an additional correction on the right such that the bunching mass equals the density shift. The counterfactual fits well, illustrating that a leftward shift as predicted in Panel B1 is a plausible source of observed bunching. On the contrary, the empirical density is not well in line with the alternative model, as there is no visual indication of missing mass in the neighborhood of the threshold. If anything, the density seems to locally increase towards the threshold on both sides.[33] Finally, Appendix Figure A12 shows that the empirical density exhibits similar patterns when considering FRAs and NRAs separately.

7 Structural Bunching Estimation and Counterfactuals

7.1 Structural Bunching Estimation

The previous section establishes a straightforward link between bunching at a reference point and the parameters governing the strength of reference dependence. Equations (7) and (11) imply that bunching observed at different discontinuities provides sufficient statistics to estimate these parameters. In particular, the variation 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 part, 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.[34]

Bunching at discontinuity i can be written as

$$\frac{b_i}{\hat{R}_i} = \left(\frac{1 - \tau_i}{1 - \tau_i - \Delta\tau_i - \Lambda(D_i)} \right)^{\varepsilon} - 1 + \xi_i \tag{12}$$

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 specified as a

[33] Similarly, the empirical density is not well in line with alternative functional forms of reference dependence, including a utility notch (a discontinuity in the level of utility) and diminishing sensitivity (a discontinuity in the second derivative of utility). Both of these formulations would induce sharp bunching at the reference point together with missing mass on one side (see the simulations in Allen et al. 2017 and Rees-Jones 2018).

[34] 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.

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 degree of reference dependence is allowed to vary with the type of statutory age as in the reduced-form estimation.

Appendix Table A6 reports results from a corresponding non-linear least squares estimation at the discontinuity level. The estimation focuses on the FRA and NRA, and all discontinuities linked to an ERA are excluded. 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 they can coincide. The estimated λ^s parameters are positive and highly significant, with magnitudes of 0.23 at the FRA and 0.38 at the NRA. The estimates imply that marginal disutility from working an additional period changes by 23% to 38% of a worker's gross wage at the respective statutory age. In addition, the parameters can be scaled in terms of budget constraint kink equivalents. The estimated magnitude of reference dependence corresponds to a 51% kink at the FRA and 120% at the NRA. The very large estimate at the NRA is due to large observed bunching in spite of non-convex kinks. Finally, the elasticity of 0.05 is precisely estimated and similar to the reduced-form results. Appendix Table A7 shows that the parameter estimates are robust to a range of alternative specifications of reference point effects, including direct estimation of kink size equivalents, estimation without interaction effects, and separate estimation by type s.

7.2 Counterfactual Simulations

Finally, I simulate the effects of counterfactual policy scenarios. I focus on two policies often considered as options for pension reform. The first reform increases the NRA, as a number of countries including the U.S. and Germany are doing or planning to do. In the simulation, the NRA is raised from 65 to 66, without providing additional financial incentives to postpone retirement. In order to focus on reference point effects, the simulated reform does not entail a benefit cut across the board below the NRA.[35] The second reform increases financial rewards for late retirement similar to the U.S. "Delayed Retirement Credit", while the NRA remains at 65. Simulating and comparing the effects of both scenarios is possible as the structural bunching estimation yields joint estimates of the parameters governing the responses to reference points and to financial incentives.

Table 5 summarizes the effects of both scenarios simulated for birth cohort 1946.[36] As a result of the one-year NRA increase, actual job exit ages increase by 3 months on average, and the increase

[35]Reforms that increase the NRA in practice often feature such a benefit cut across the board, which entails a sizeable positive mechanical fiscal effect. In the reform simulated here, only a relatively small mechanical effect arises due to late retirement rewards being paid from the new NRA onwards. See Appendix G for further details of the policy simulations.

[36]I focus on workers born in 1946 as this is the last birth cohort not subject to a planned gradual increase in the NRA by 2031, such that the actual NRA is still 65 for these workers.

among individuals who retire at 65 and above is 10 months. Appendix Figure A13 shows the simulated effect on the job exit age distribution. There is un-bunching of the spike at age 65, and the density above 65 increases. A new, large job exit spike emerges at the post-reform NRA of 66. A key implicit assumption behind the simulation is that the NRA shifted to the new location is perceived by workers as a reference point similarly to the previous NRA. While this may not be true for arbitrarily large changes to the NRA, support that the assumption holds over some range of ages is provided by the evidence from section 5.1, where bunching moves in lockstep with the reform. It is also 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 late 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 would have to be more than doubled from currently 6% p.a. to 12.6%. 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 +€1038m in net present value terms for birth cohort 1946. This is due to the additional contributions paid by workers postponing 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 −€572m. 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. Under some additional assumptions, a back-of-the-envelope calculation yields similar figures for the annual fiscal impact on the pension system (see Appendix G.2). Assuming that a series of identical cohorts retire until reforms are fully phased in, the two scenarios generate a long-term annual fiscal impact of around +€1.1bn and −€1.2bn, respectively.

These results further highlight that statutory retirement ages are an effective policy tool for governments to influence retirement decisions. Such reforms can improve the fiscal balance of the pension system, as they can lead to an increase in actual retirement ages without requiring high financial rewards for postponing retirement.[37] On the other hand, the simulations show that positive fiscal effects are more difficult or impossible to achieve using pure financial incentives such as a delayed retirement credit.

8 Conclusion

In this paper, I provide new, comprehensive evidence that the way retirement incentives are presented to workers has large effects. The results highlight the direct role of statutory ages, at which

[37] It is important to note that the magnitude of fiscal gains from increasing the NRA depends on the characteristics of the pension system. For instance, providing steep marginal pension increases for late retirement at the same time would dampen the fiscal effect. At the extreme, if the reform featured full actuarially fair benefit adjustment between the old and the new NRA, there would be no behavioral fiscal effects of increasing retirement ages per se but only mechanical fiscal effects.

almost one third of job exits occur. Reference dependence provides a behavioral explanation for this phenomenon. In comparison, responses to pure financial incentives emphasized by standard models of retirement are modest.

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

Two limitations of the analysis are 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. In addition, statutory age reforms likey have some distributional implications. Second, I do not study the formation of individual reference points around government policies. In particular, an open question may be how far governments can push statutory retirement ages beyond their established, historical range such that individuals still perceive them as "credible" reference points. Similarly, some caution might be warranted when completely decoupling statutory ages from financial incentives to which they were historically linked. Exploring these questions could be promising avenues for future research.

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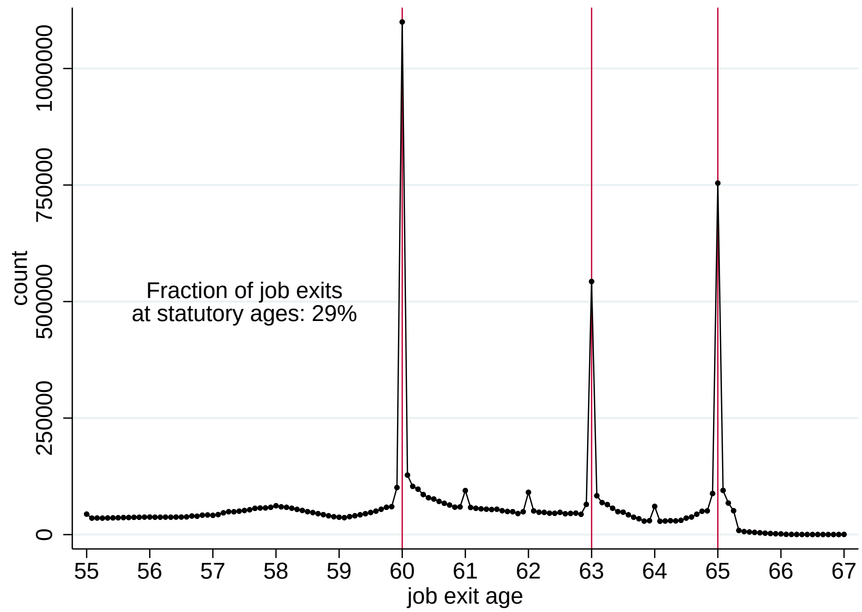
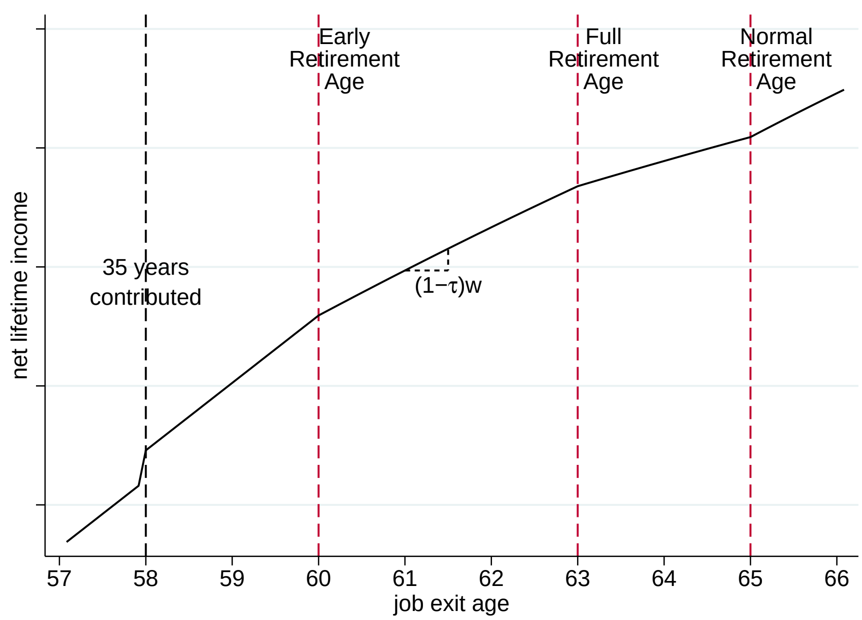
Figure 1: Job Exit Age Distribution and Lifetime Budget Constraint

Panel A: Job Exit Age Distribution (Full Sample)



Panel B: Stylized Lifetime Budget Constraint



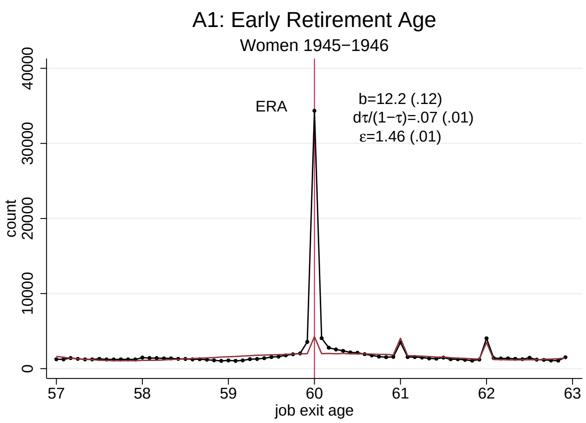
Notes: Panel A of the figure shows the pooled distribution of retirement (job exit) ages for the full individual sample, i.e. for all workers born between 1933 and 1949. The connected dots show the count of job exits within monthly bins. Vertical red lines indicate the main locations of statutory retirement 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 exactly in the month when the worker reaches a statutory retirement age. Panel B 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 $(1-\tau)w$ (see section 2.2). The stylized shape of the budget 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.
Data source of all figures and tables: *FDZ-RV - Themenfile SUFRTZN1992-2014XVSBB_Seibold*

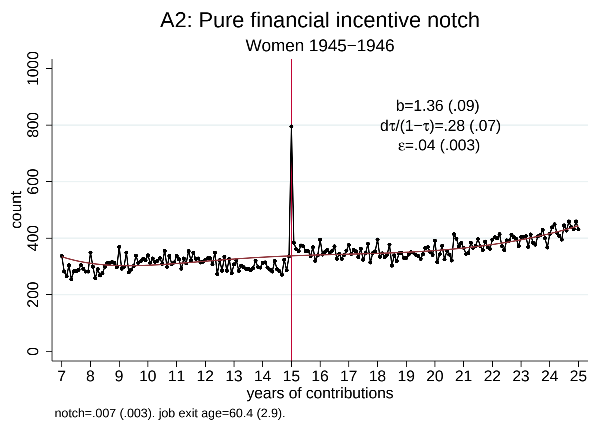
Figure 2: Framing

Notes: The figure shows excerpts from an information leaflet about a future pension reform. Explanation of the main points is provided in the red boxes on the right. The example in the right panel refers to Early and Full Retirement Ages in the long-term insured pathway. See Appendix Figure A1 for full brochure, including similar examples from the other pathways. Note that some of the pension rules in the leaflet can differ from those described in section 2, as the leaflet describes a planned reform.
Source: Deutsche Rentenversicherung (2017)

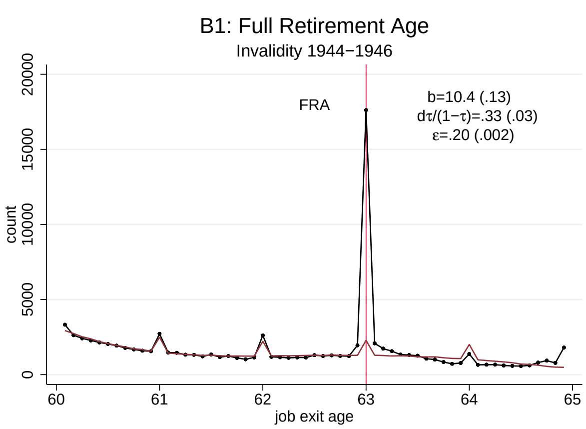
Figure 3: Bunching at Specific Discontinuities

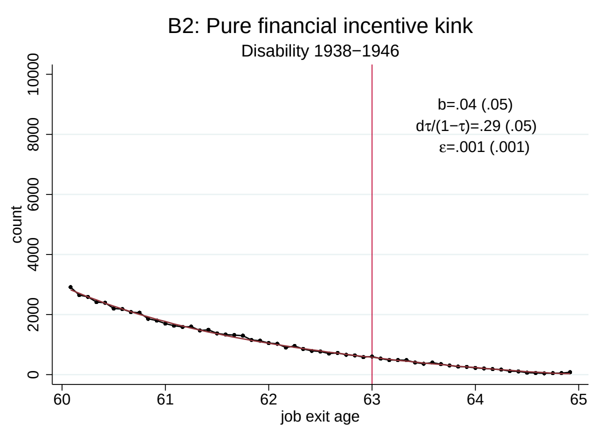
Panel A: Statutory Age vs. Pure Financial Incentive Notch





Panel B: Statutory Age vs. Pure Financial Incentive Kink

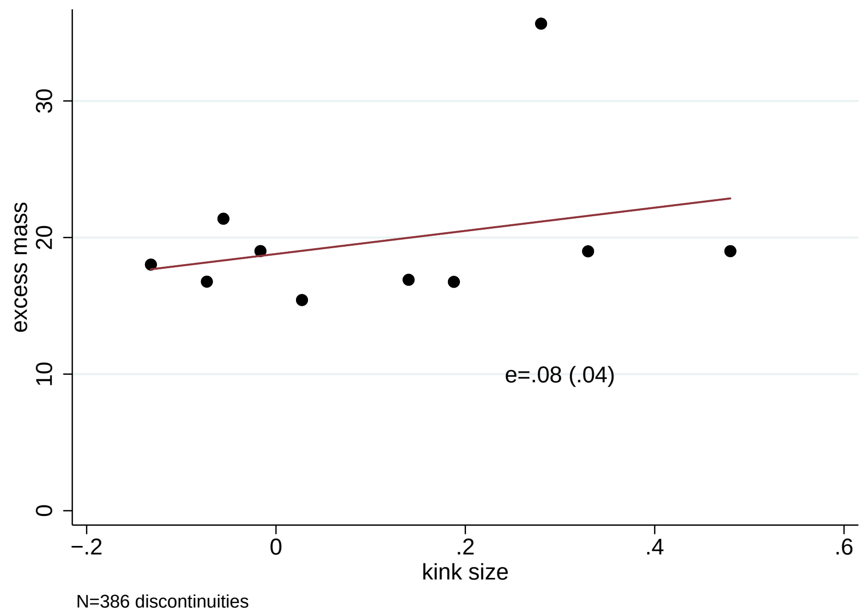




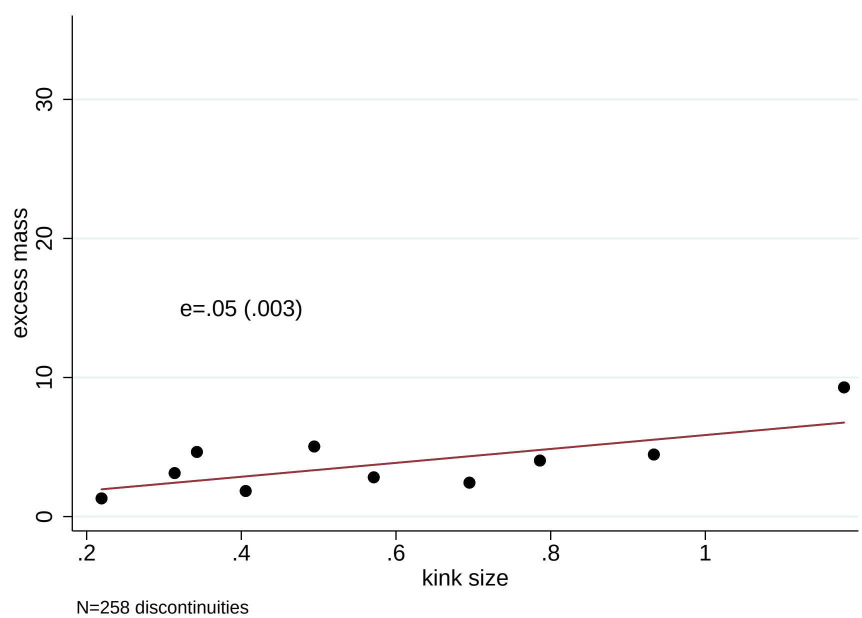
Notes: The figure shows bunching at selected discontinuities. Panel titles indicate the type of discontinuity and panel subtitles indicate pathways and birth cohorts used. In Panels A1, B1 and B2, the connected black dots show counts of job exit ages in monthly bins among the respective group of workers. 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 jump in the average tax rate, 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 4: Bunching by Size of Financial Incentive

Panel A: Statutory Retirement Age plus Financial Incentives

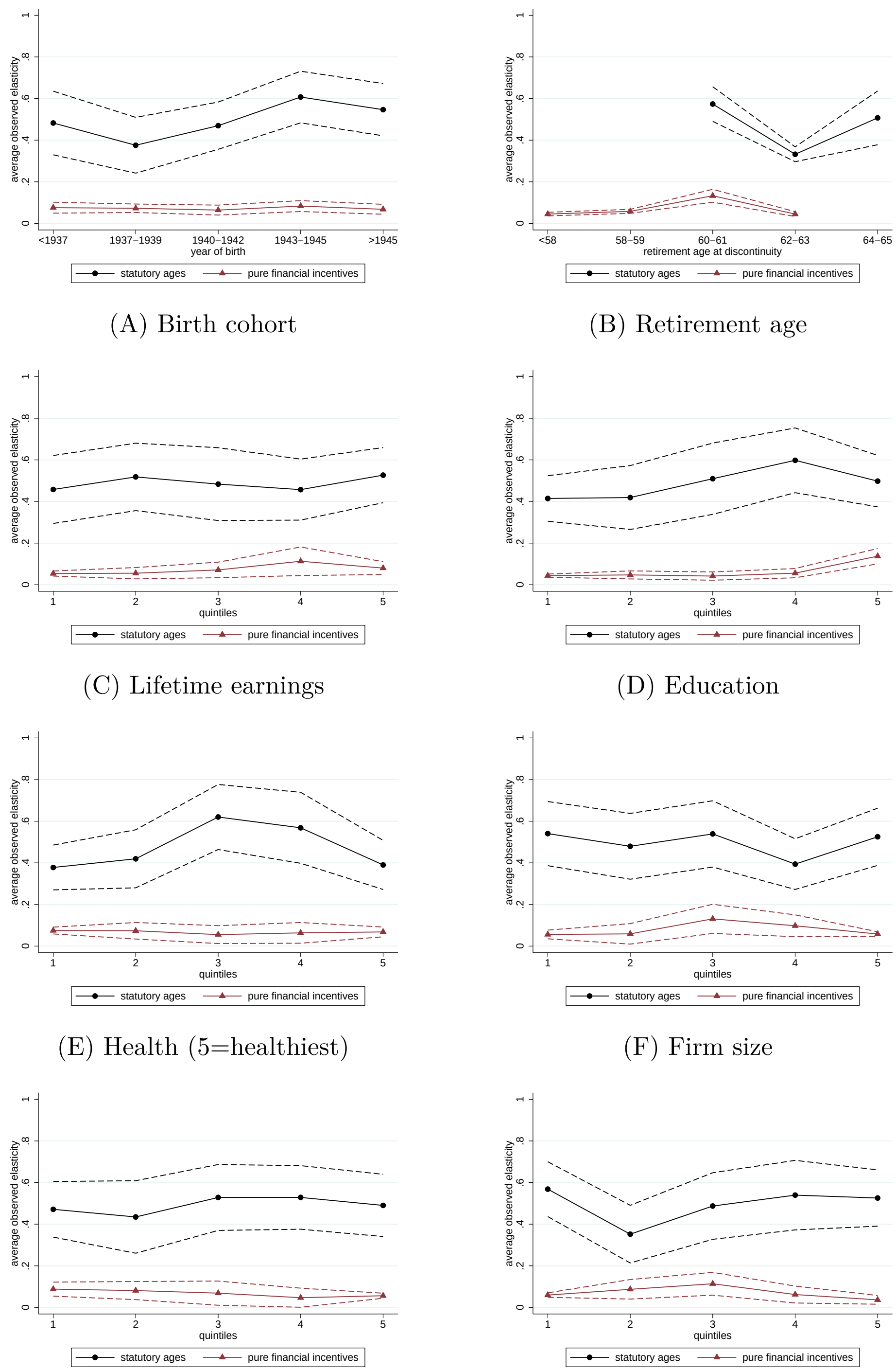


Panel B: Pure Financial Incentives



Notes: 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 A4 shows additional plots separately by statutory age types.

Figure 5: Heterogeneity in Bunching Responses



(A) Birth cohort

(B) Retirement age

(C) Lifetime earnings

(D) Education

(E) Health (5=healthiest)

(F) Firm size

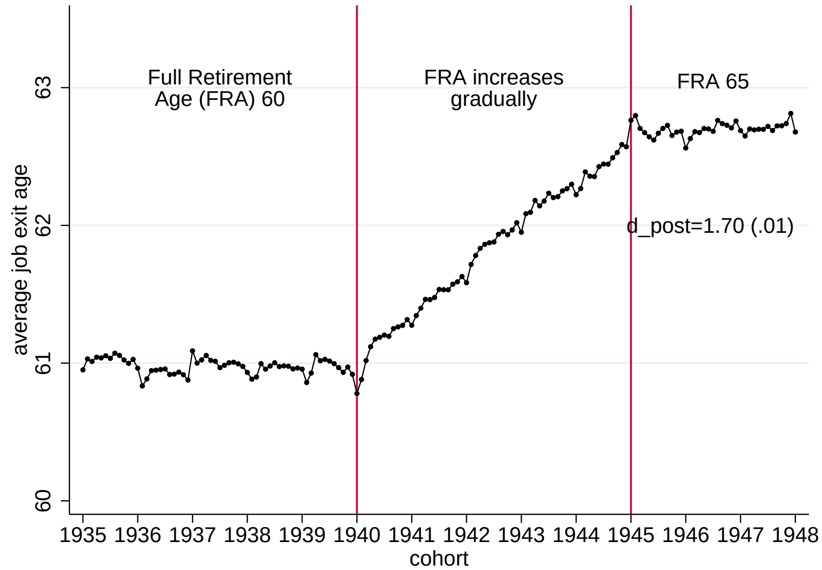
(G) Unionization

(H) Tenure

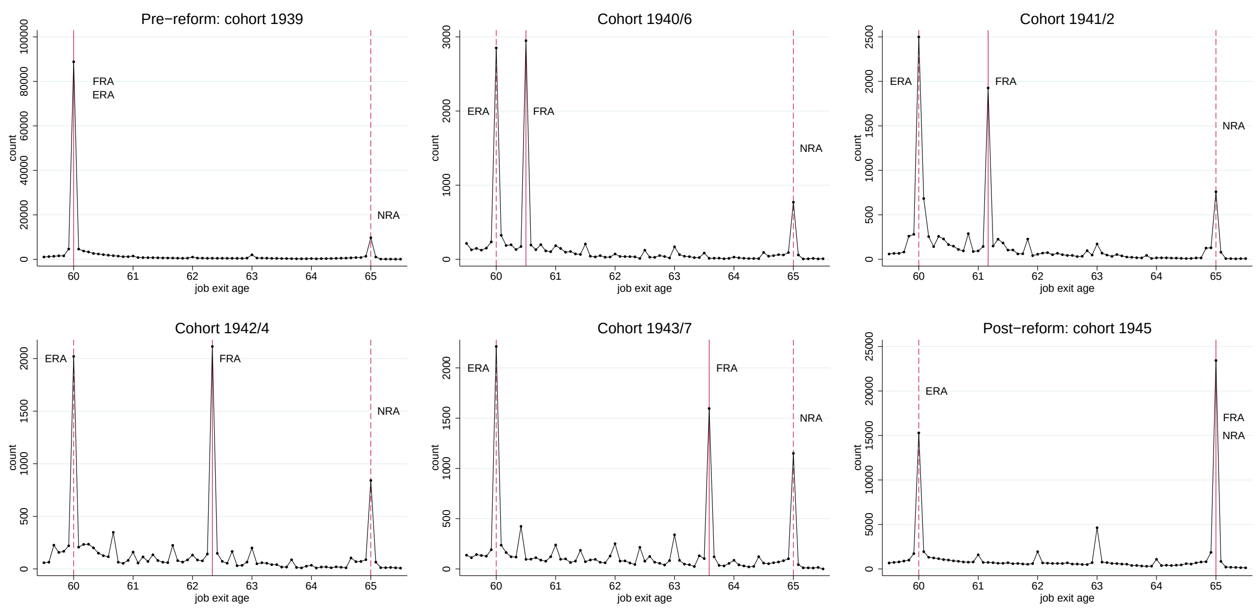
Notes: The figure shows average observed bunching elasticities by birth cohort, the retirement age at the discontinuity, and worker and firm-related characteristics, namely lifetime earnings, years of education, health status (5=healthiest), a firm size index computed from discrete size categories, unionization rate and tenure. In order to obtain the partial effect of each characteristic in Panels C to H, it is first regressed on a set of other basic variables including lifetime earnings, education, health, gender, marital status, parental leave, firm size, unionization, tenure and year-of-birth FE. Bunching observations are then sorted by quintiles of the residual from this regression. See Appendix Figure A5 for analogous graphs using raw characteristics and alternative controls in the residualization regressions. In all panels, black dots indicate bunching at statutory ages, and red triangles indicate bunching at pure financial incentive discontinuities. The dashed lines around the point estimates mark 95% confidence intervals based on bootstrapped standard errors.

Figure 6: The Effect of Increasing the Full Retirement Age

Panel A: Average Job Exit Age

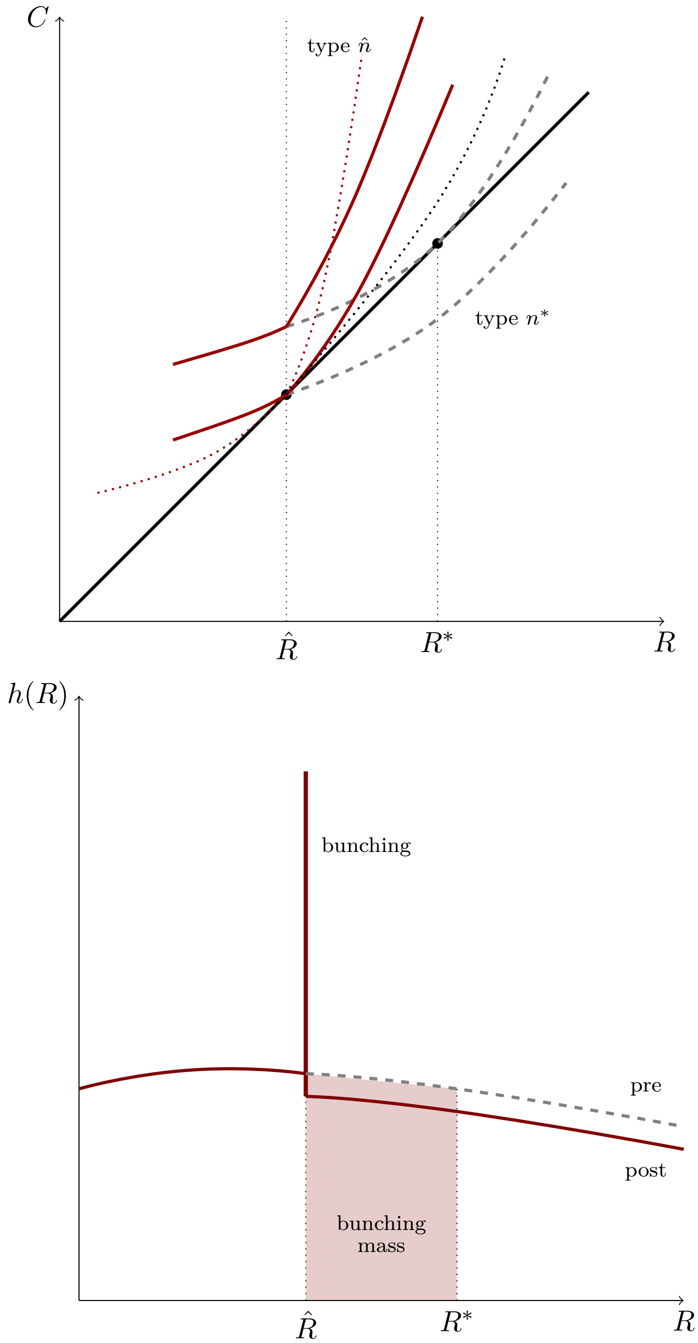


Panel B: Job Exit Age Distributions among Selected Cohorts



Notes: 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 A6 shows the full set of monthly job exit age distributions during the transition period.

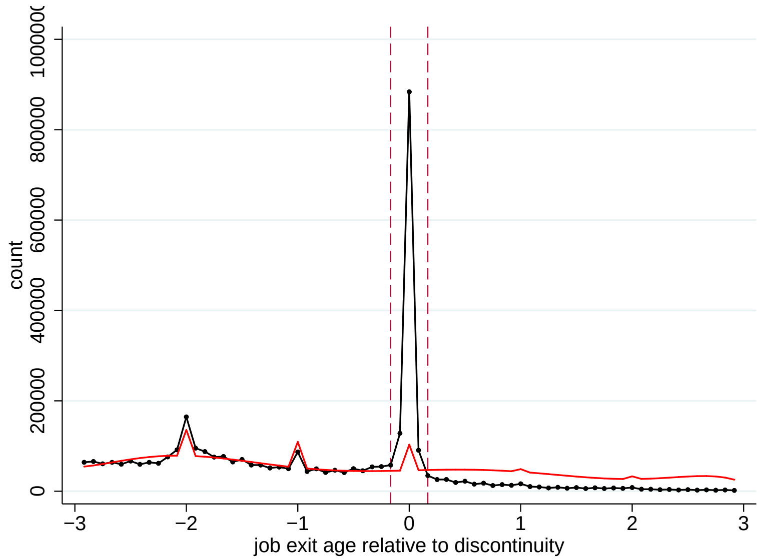
Figure 7: Retirement Bunching at a Reference Point



Notes: The figure shows predicted 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") indifference curves of the marginal buncher with ability n^*, whereas the solid red curves are her indifference curves after introducing the reference point ("post"). The dotted curves are indifference curves pre- (gray) and post-reference point (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-reference point density, whereas the dashed gray line denotes the initial density. The red shaded area is the initial location of the mass of workers bunching in response to the reference point.

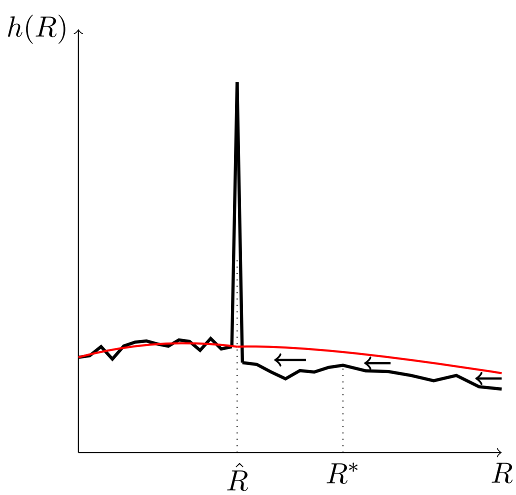
Figure 8: Empirical Density vs. Model Predictions

Panel A: Pooled Empirical Density

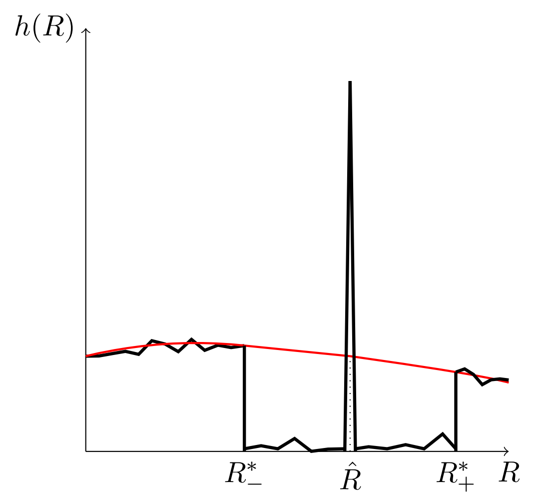


Panel B: Theoretical Predictions

(B1) Reference Dependence with Loss Aversion



(B2) Alternative Model: Fixed Utility Gain



Notes: Panel A of the figure shows the pooled empirical density around all Full and Normal Retirement Ages, with the age at the discontinuity normalized to zero. The black connected dots show the count of job exits within monthly bins. The red line shows a counterfactual distribution estimated as a 7-th order poynomial including round-age dummies. Vertical dashed lines indicate the bunching region excluded from the counterfactual estimation. To the right of the bunching region, the counterfactual is corrected for a leftward density shift as predicted by the reference dependence model. Panel B shows stylized density graphs, illustrating the predicted shape of the density around statutory ages under the reference dependence model (Panel B1) and an alternative behavioral model with a fixed utility gain from retiring at statutory ages as described in Appendix F.2 (Panel B2). Panels B1 and B2 correspond to the lower panels in Figure 7 and Appendix Figure F1, respectively, adapted to the shape of the empirical density. The black line shows a stylized observed distribution under each model emerging from a counterfactual given by the red line.

Table 1: Pathways into Retirement

Pathway	Required contributions	Other requirements	Statutory Retirement Ages (Cohort 1941)			Share of Sample
			Early	Full	Normal	
Regular	5 years	-	65	65	65	5%
Long-term insured	35 years	-	63	65	65	19%
Women	15 years 10 years full	female	60	61	65	32%
Unemployed/part-time	15 years 8 years full	unemployed or in part-time work before retirement	60	64	65	20%
Invalidity	35 years	disability status	60	60	65	12%
Disability	5 years 3 years full	stricter disability status	-			11%

Notes: The table presents an overview of pathways into retirement. 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 Appendix Figure A2. 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 exclude periods where contributions are paid voluntarily. The last column shows the share of workers in each pathway in the full individual sample.

Table 2: Summary Statistics

	(1) individual sample	(2) occupation-matched sample	(3) bunching sample
job exit age	60.88	61.89	61.11
	(2.80)	(2.67)	(1.54)
benefit claiming age	62.05	62.80	62.39
	(2.33)	(2.12)	(1.41)
career length	43.60	44.19	43.70
	(6.53)	(6.93)	(2.67)
contribution points	37.03	39.02	37.07
	(17.24)	(18.07)	(11.37)
net lifetime income	1,689,142	1,745,749	1,678,875
	(655,797)	(677,296)	(432,089)
female	0.46	0.45	0.45
	(0.50)	(0.50)	(0.43)
married	0.76	0.76	0.77
	(0.42)	(0.43)	(0.06)
education (years)	10.61	10.74	10.68
	(1.59)	(1.79)	(0.30)
sick leave (years)	0.07	0.06	0.07
	(0.25)	(0.21)	(0.04)
East Germany	0.18	0.20	0.18
	(0.38)	(0.40)	(0.09)
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)	8,557,797	3,954,968	
Obs. (discontinuities)			644

Notes: 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 defined as in equation (1) and calculated in terms of net present value at age 65. "East Germany" 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.

Table 3: Bunching Responses across 644 Discontinuities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Statutory Retirement Age plus Financial Incentives				Pure Financial Incentives		
	all	Early	Full	Normal	all	kinks	notches
	Panel A: Summarizing Discontinuities						
Kink size $\Delta\tau/(1-\tau)$:							
Mean	0.04	0.22	0.25	-0.50	0.42	0.32	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
Mean retirement age	62.5	61.1	62.7	65.0	60.4	60.5	60.4
	Panel B: Bunching Responses						
Excess mass b	19.8	14.1	21.6	32.7	3.81	0.10	4.31
	(0.79)	(0.98)	(0.86)	(1.77)	(0.28)	(0.04)	(0.34)
Observed	0.49	0.56	0.44	1.01	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

Notes: Panel A of the table summarizes discontinuities in the bunching sample by type. 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. "Mean retirement age" is the average retirement age at which a type of discontinuity is located. Panel B shows bunching responses by type of discontinuity. Excess mass and observed elasticities are computed as described in section 3. 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. Observed elasticities are only calculated only at convex kinks, that is excluding non-convex NRA kinks. All statistics are weighted by group size. In Panel B, standard errors are in parantheses.

Table 4: Reduced-Form Estimation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: Excess mass $b/\hat{R}$							
kink size $\Delta\tau/(1-\tau)$	0.036	0.035	0.025	0.034	0.050	0.077	0.050	0.086
	(0.004)	(0.004)	(0.018)	(0.034)	(0.042)	(0.008)	(0.011)	(0.012)
Statutory age at kink:								
Early Retirement Age	0.066	0.046	0.039	0.049	0.051	0.060	0.072	0.082
	(0.007)	(0.006)	(0.018)	(0.032)	(0.041)	(0.004)	(0.010)	(0.010)
Full Retirement Age	0.071	0.059	0.071	0.079	0.072	0.069	0.075	0.099
	(0.010)	(0.009)	(0.017)	(0.034)	(0.039)	(0.008)	(0.009)	(0.015)
Normal Retirement Age	0.162	0.190	0.201	0.215	0.218	0.244	0.235	0.242
	(0.017)	(0.018)	(0.034)	(0.068)	(0.080)	(0.014)	(0.022)	(0.016)
Observations (discontinuities)	644	644	644	644	583	627	627	627
R-squared	0.67	0.71	0.86	0.87	0.84	0.91	0.82	0.94
Statutory age interactions	no	yes	yes	yes	yes	yes	yes	yes
Worker controls	no	no	yes	yes	yes	no	no	no
Pathway FE, year-of-birth FE	no	no	yes	yes	yes	no	no	no
Pathway × year-of-birth FE	no	no	no	yes	yes	no	no	no
Occupation-level controls	no	no	no	no	yes	no	no	no
Heterogeneous coefficients:								
by pathway	no	no	no	no	no	yes	no	yes
by year of birth	no	no	no	no	no	no	yes	yes
by pathway × year of birth	no	no	no	no	no	no	no	yes

Notes: 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 retirement ages, using the bunching sample. Columns (1) to (5) report results from the baseline estimation according to equation (5). Statutory age interactions are interactions between dummies for each statutory age type. Worker controls include dummies for female, married and East Germany, education years, lifetime earnings, last income before retirement, career length, sick leave years, parental leave years and retirement age at the discontinuity. Occupation-level controls include firm size index, unionization rate, tenure in the firm, fraction in unlimited contracts, active union member rate, fraction receiving severance pay and 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. Columns (6) to (8) report weighted averages of heterogeneous coefficients estimated according to equation (6), where column (6) defines groups by pathway, (7) defines groups by year of birth, and (8) by pathway × year of birth. Groups with insufficient variation have to be dropped in columns (6) to (8), such that the number of observations is slightly smaller than in columns (1) to (4). All regressions are weighted by group size and bootstrapped standard errors in parantheses.

Table 5: 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)		+10.0	+10.0
Average job exit age (60 and above)	62.8	63.1	63.1
change (months)		+3.1	+3.2
Excess mass at NRA	29.9	26.6	12.0
change		−3.3	−17.9
Net fiscal effect (NPV for one cohort)		+€1038m	−€572m
contributions collected		+€421m	+€421m
benefits paid out		−€617m	+€993m

Notes: The table shows results from a simulation of two counterfactual policies: an increase in the NRA (column 2) and an increase in financial rewards for late retirement (column 3). The effects of both policies are simulated for birth cohort 1946. Fiscal effects are calculated in terms of net present value at age 65 for this birth cohort. Excess mass figures are weighted by group size. See Appendix Figure A13 for graphs of the simulated retirement age distribution under both scenarios.

Online Appendix

A Appendix Figures and Tables

Figure A1: Framing

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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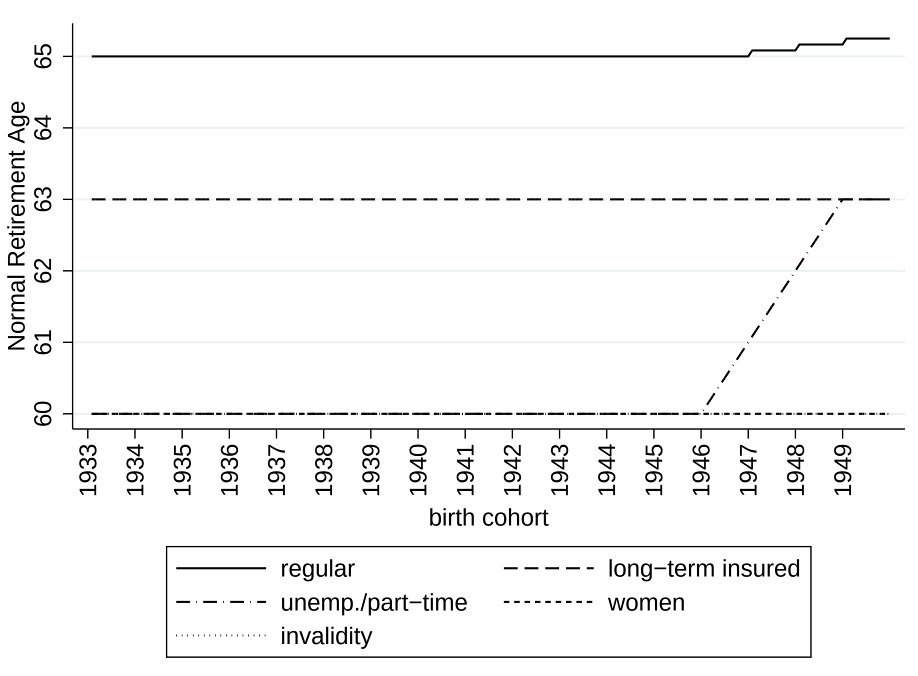
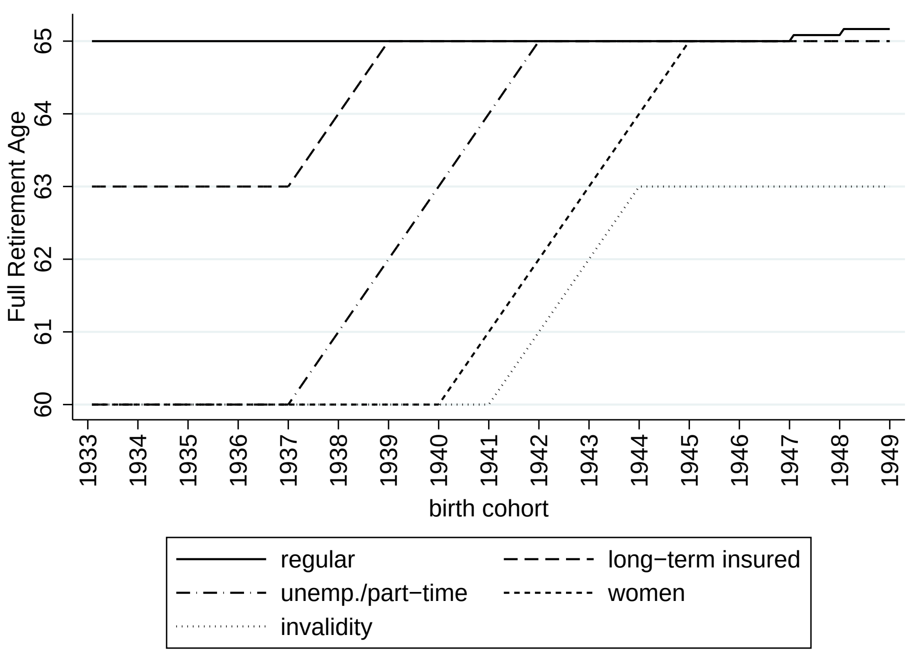
Notes: The figure shows excerpts of an information leaflet that informs workers about a future pension reform where the Normal Retirement Age will be increased to 67. Explanation of the main points is provided in the red boxes on the right. The bottom right panel on this page is taken from an information 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: Deutsche Rentenversicherung (2017), Deutsche Rentenversicherung (2015)

Figure A2: Statutory Retirement Ages across Pathways and Birth Cohorts

Panel A: Early Retirement Ages



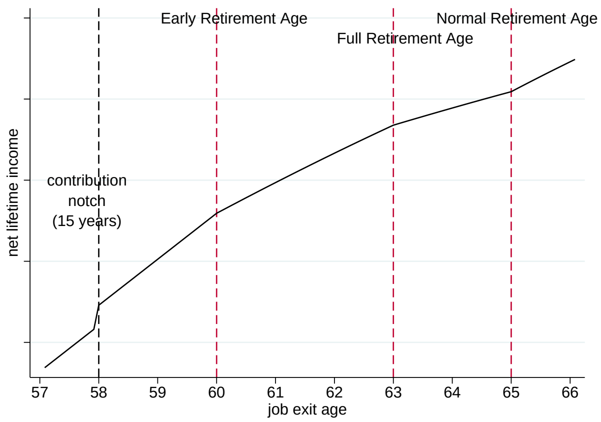
Panel B: Full Retirement Ages



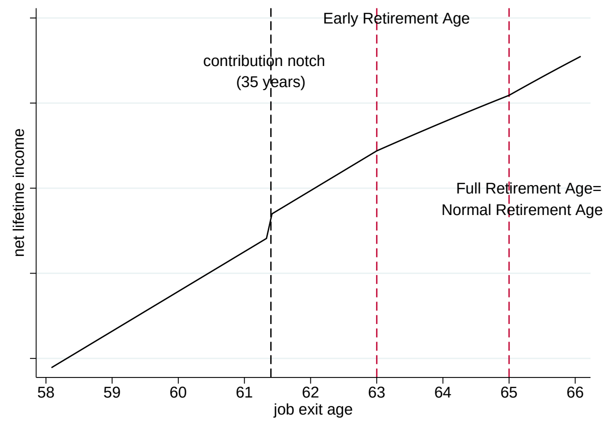
Notes: The figure shows the evolution of Early Retirement Ages (ERA) and Full Retirement Ages (FRA) of different pathways across monthly birth cohorts. In Panel A, the regular ERA is increased from 65 to 65/3 between 1947 and 1949 and the unemployed/part-time ERA is gradually increased from 60 to 63 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 A3: Lifetime Budget Constraints: Some Examples

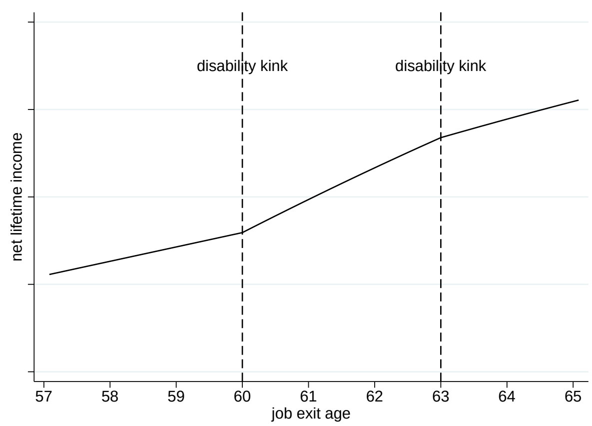
Panel A: Female, born December 1942



Panel B: Male, born March 1939

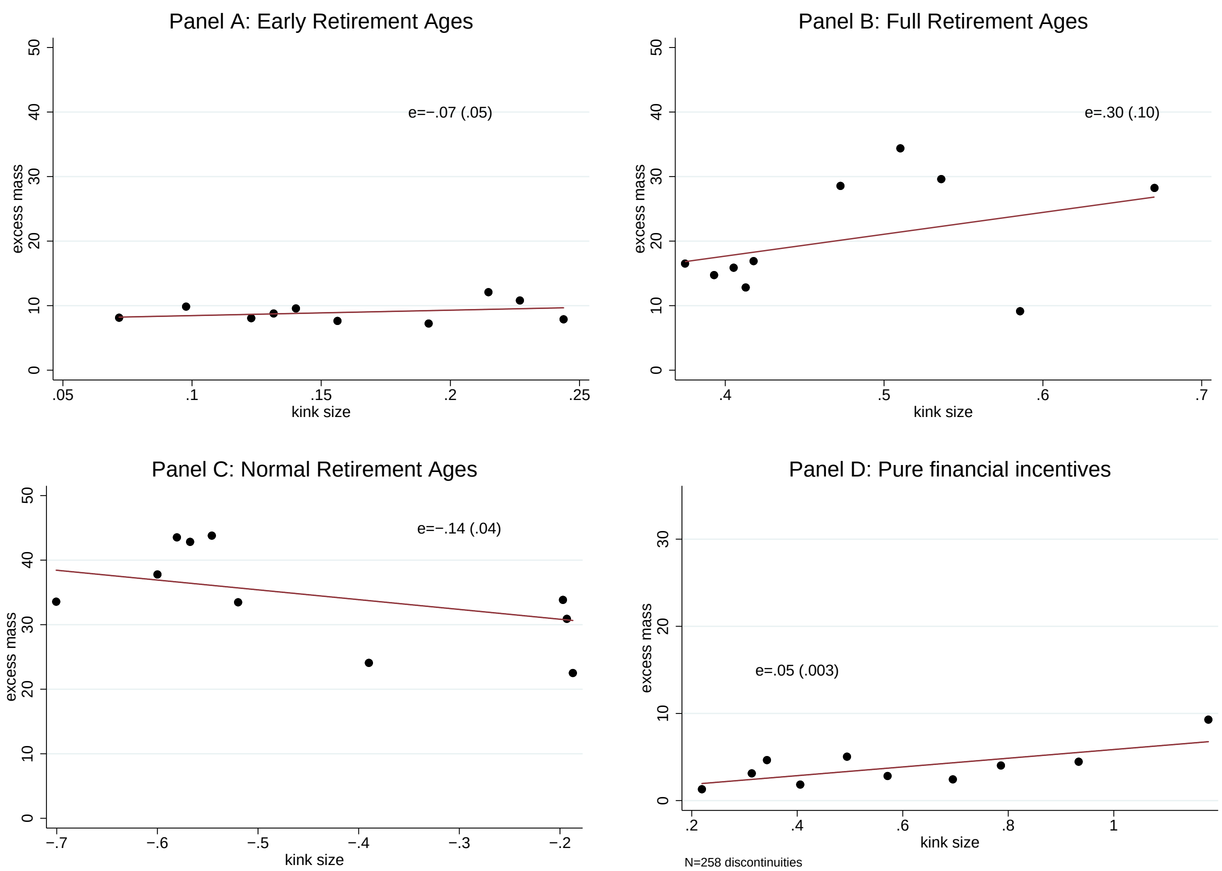


Panel C: Male, born January 1946, satisfies disability requirement



Notes: 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 a non-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.

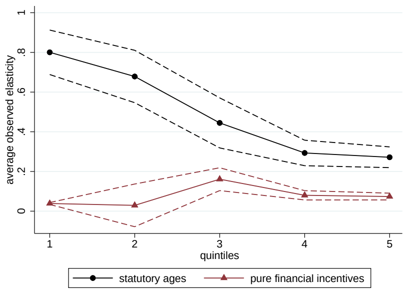
Figure A4: Bunching by Size of Financial Incentive



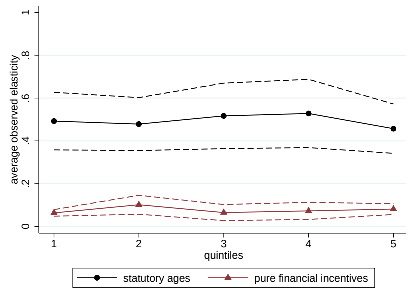
Notes: The figure shows binned scatterplots of the retirement response (excess mass) vs. the underlying financial incentive (kink size) at a discontinuity, separately for Early Retirement Ages (Panel A), Full Retirement Ages (Panel B), Normal Retirement Ages (Panel C), and pure financial incentive discontinuities (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 A5: Heterogeneity: Additional Graphs

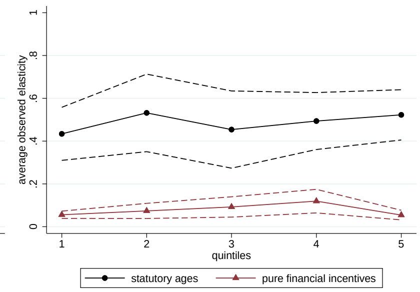
(A) Lifetime Earnings



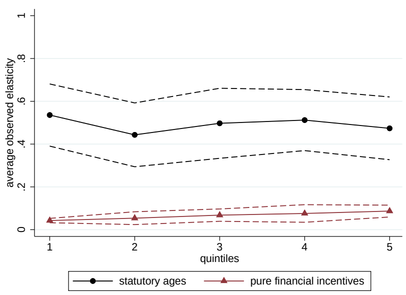
(i) No controls



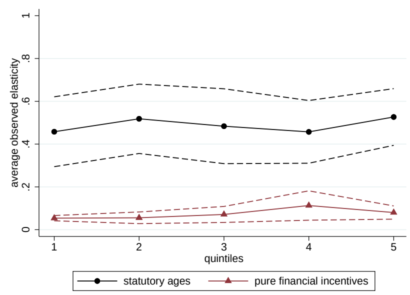
(ii) Limited characteristics



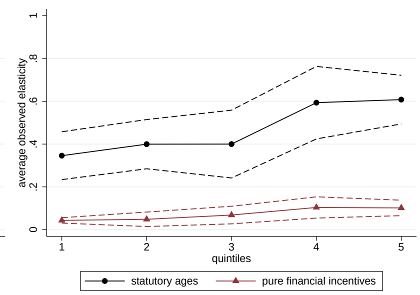
(iii) Baseline characteristics



(iv) Extended characteristics

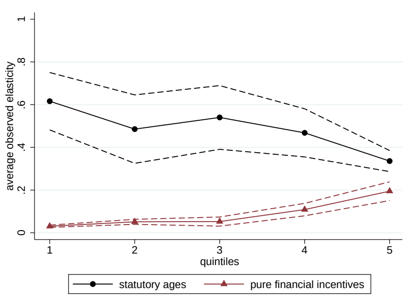


(v) Baseline+cohort FE

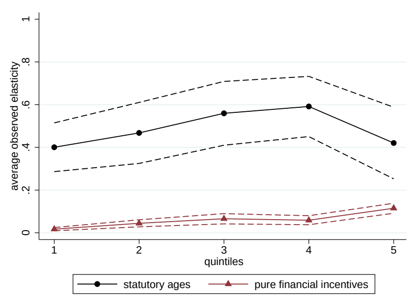


(vi) Baseline+cohort/pathway FE

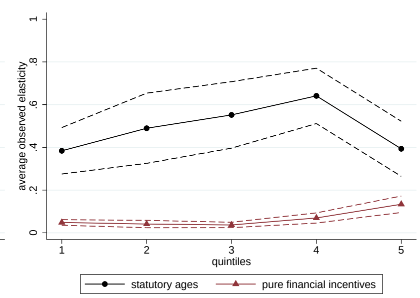
(B) Education



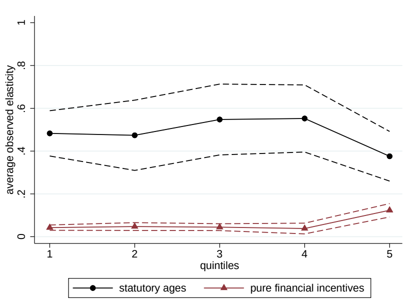
(i) No controls



(ii) Limited characteristics



(iii) Baseline characteristics



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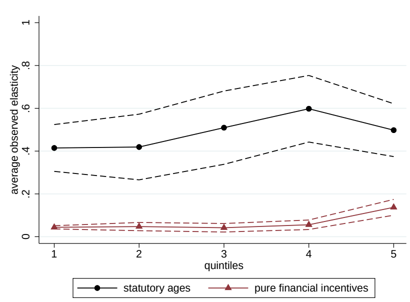
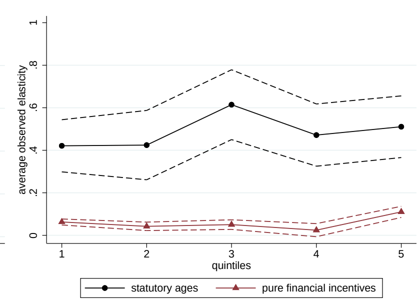


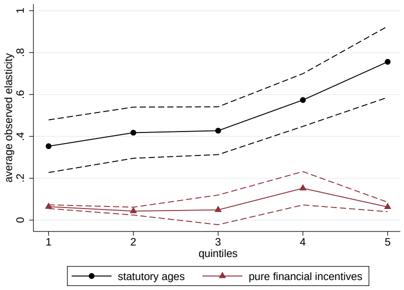
(v) Baseline+cohort FE



(vi) Baseline+cohort/pathway FE

Figure A5: Heterogeneity: Additional Graphs (continued)

(C) Health (5=healthiest)



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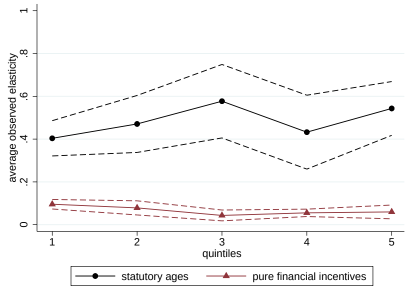

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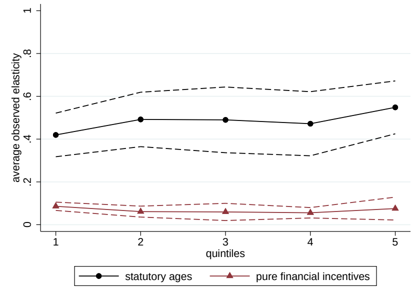
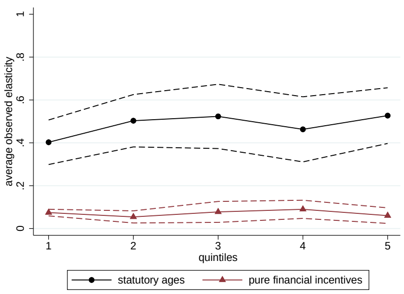
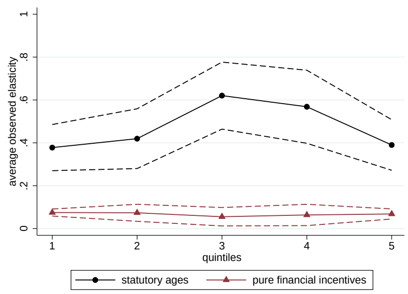


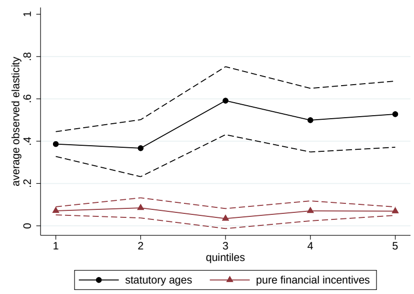
(iii) Baseline characteristics



(iv) Extended characteristics

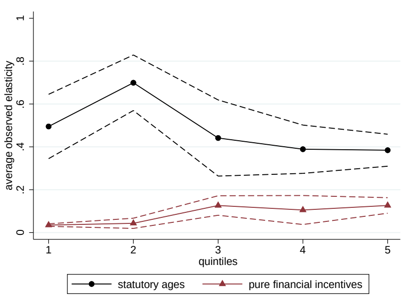


(v) Baseline+cohort FE



(vi) Baseline+cohort/pathway FE

(D) Firm Size



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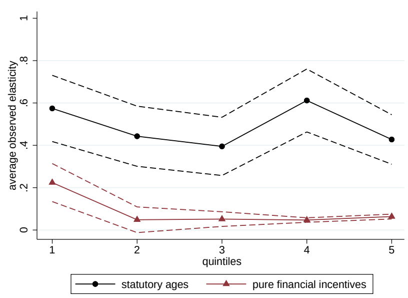

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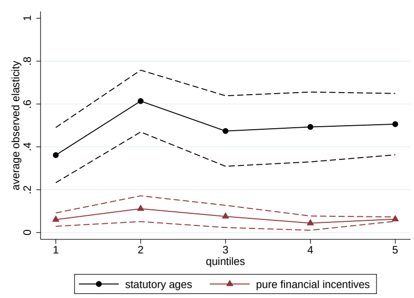
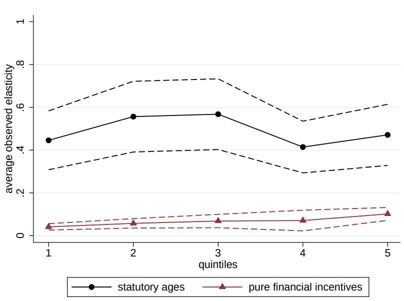
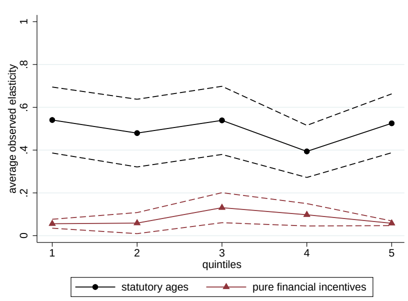


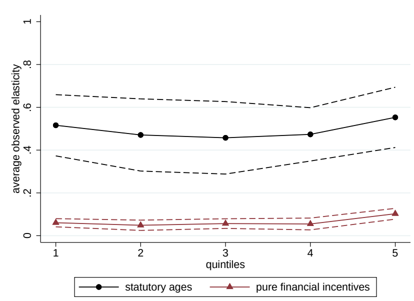
(iii) Baseline characteristics



(iv) Extended characteristics



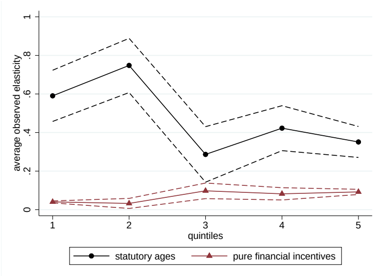
(v) Baseline+cohort FE



(vi) Baseline+cohort/pathway FE

Figure A5: Heterogeneity: Additional Graphs (continued)

(E) Unionization



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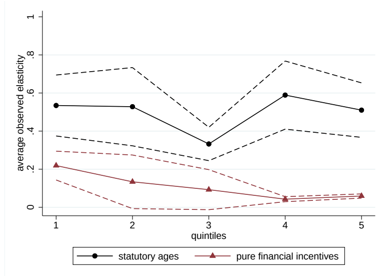

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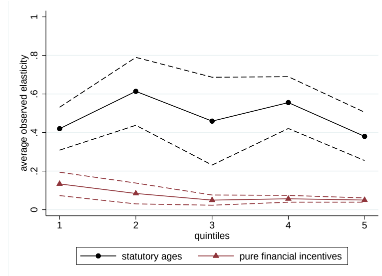
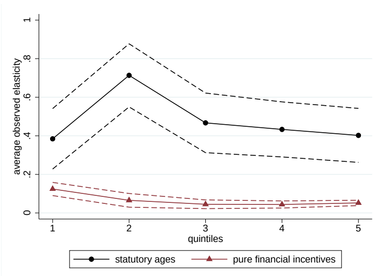
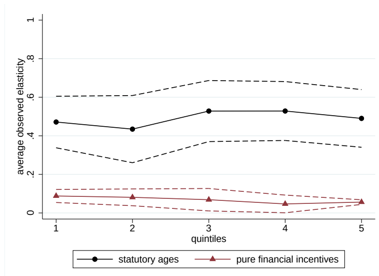


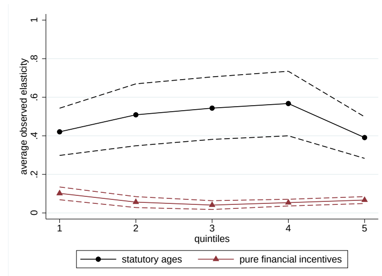
(iii) Baseline characteristics



(iv) Extended characteristics

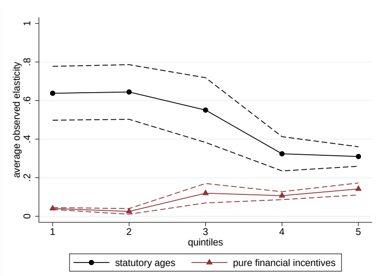


(v) Baseline+cohort FE

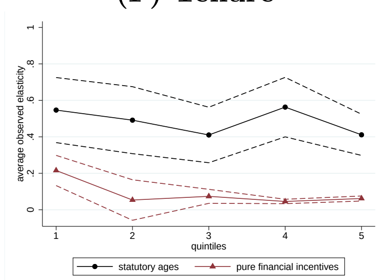


(vi) Baseline+cohort/pathway FE

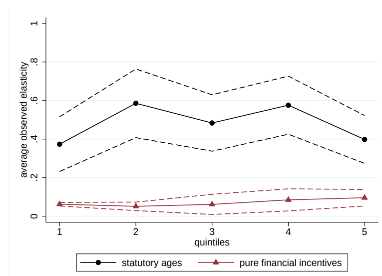
(F) Tenure



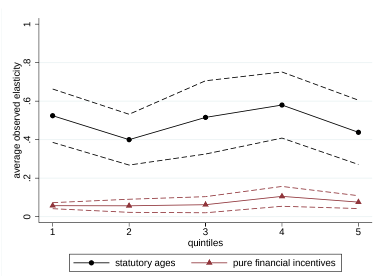
(i) No controls



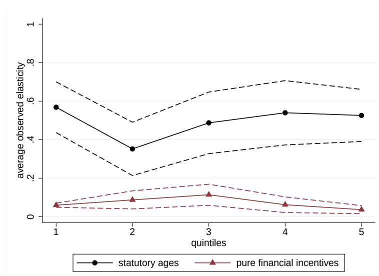
(ii) Limited characteristics



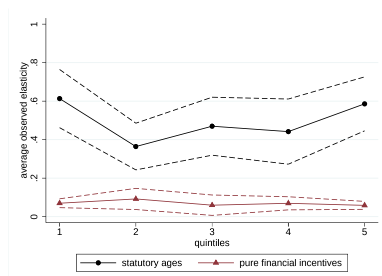
(iii) Baseline characteristics



(iv) Extended characteristics



(v) Baseline+cohort FE



(vi) Baseline+cohort/pathway FE

Notes: The figure shows average observed bunching elasticities by (A) lifetime earnings, (B) years of education, (C) health status (5=healthiest), (D) a firm size index computed from discrete size categories, (E) unionization rate and (F) tenure. For each variable, bunching observations are sorted by quintiles of (i) the raw variable, (ii) the variable residualized by a limited set of other characteristics, (iii) by the baseline set of characteristics, (iv) by an extended set of characteristics, (v) by baseline characteristics and cohort FE, and (vi) by baseline characteristics, cohort FE and pathway FE. In the residualization regressions, limited characteristics include lifetime earnings, education, health, gender, marital status and East Germany; baseline characteristics additionally include parental leave, firm size, unionization, tenure; extended characteristics additionally include last income before retirement, career length, economic training, active union membership, fraction receiving severance pay, fraction in unlimited contracts, fraction of involuntary job exits. Black dots indicate bunching at statutory ages, and red triangles indicate bunching at pure financial incentive discontinuities. The dashed lines around the point estimates mark 95% confidence intervals based on bootstrapped standard errors.

Figure A6: The Effect of Increasing the Full Retirement Age

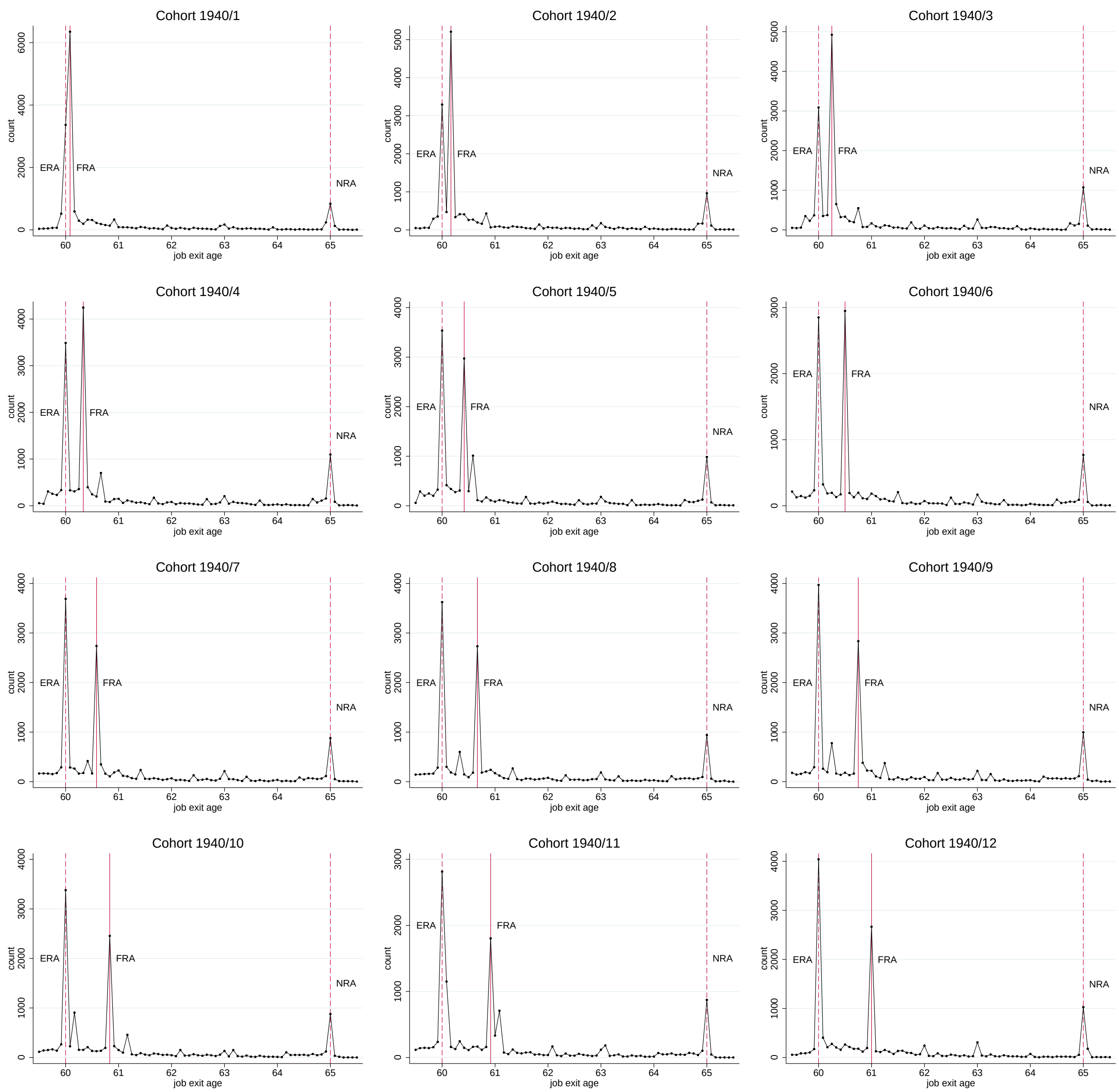


Figure A6: The Effect of Increasing the Full Retirement Age (continued)

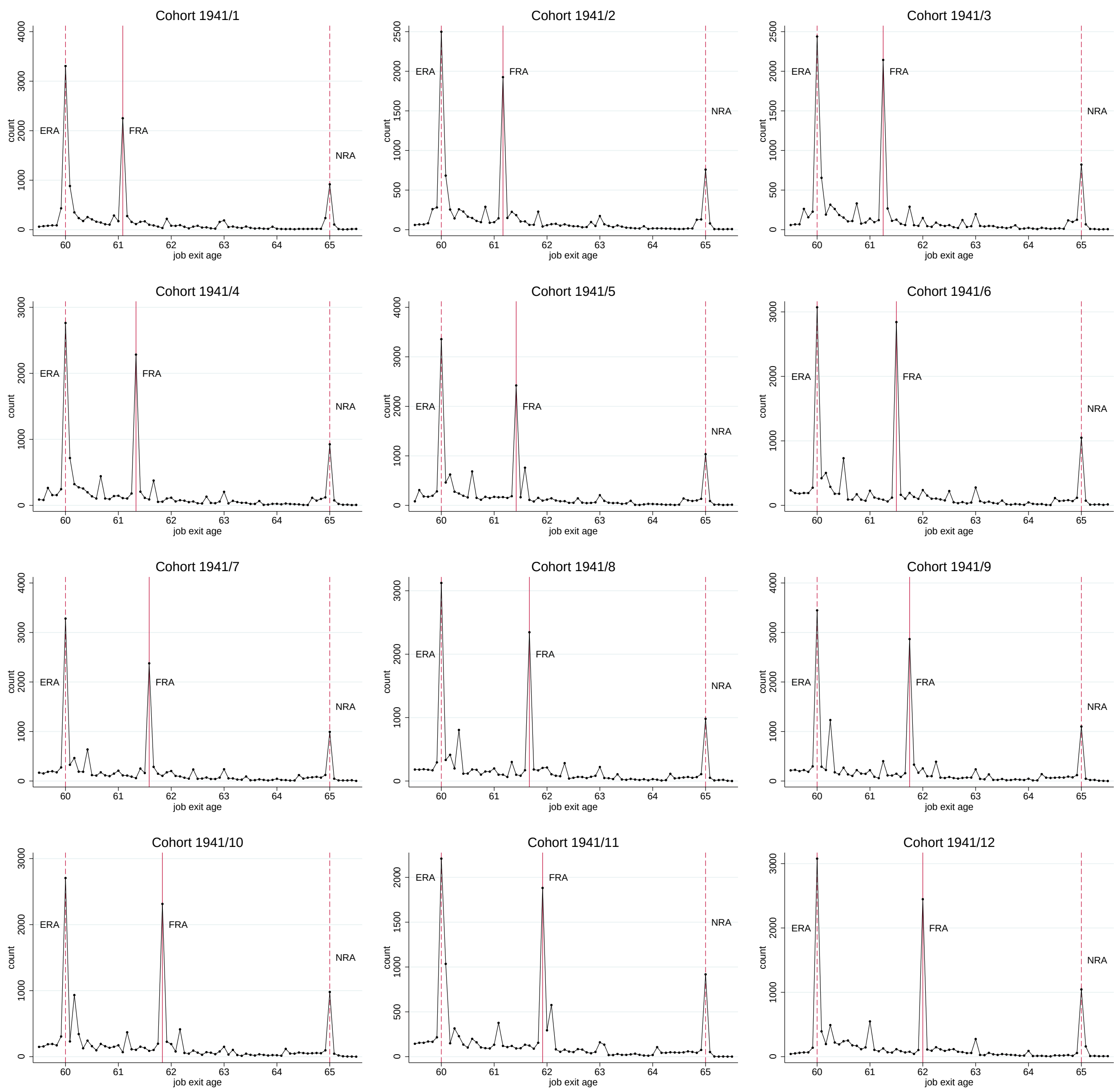


Figure A6: The Effect of Increasing the Full Retirement Age (continued)

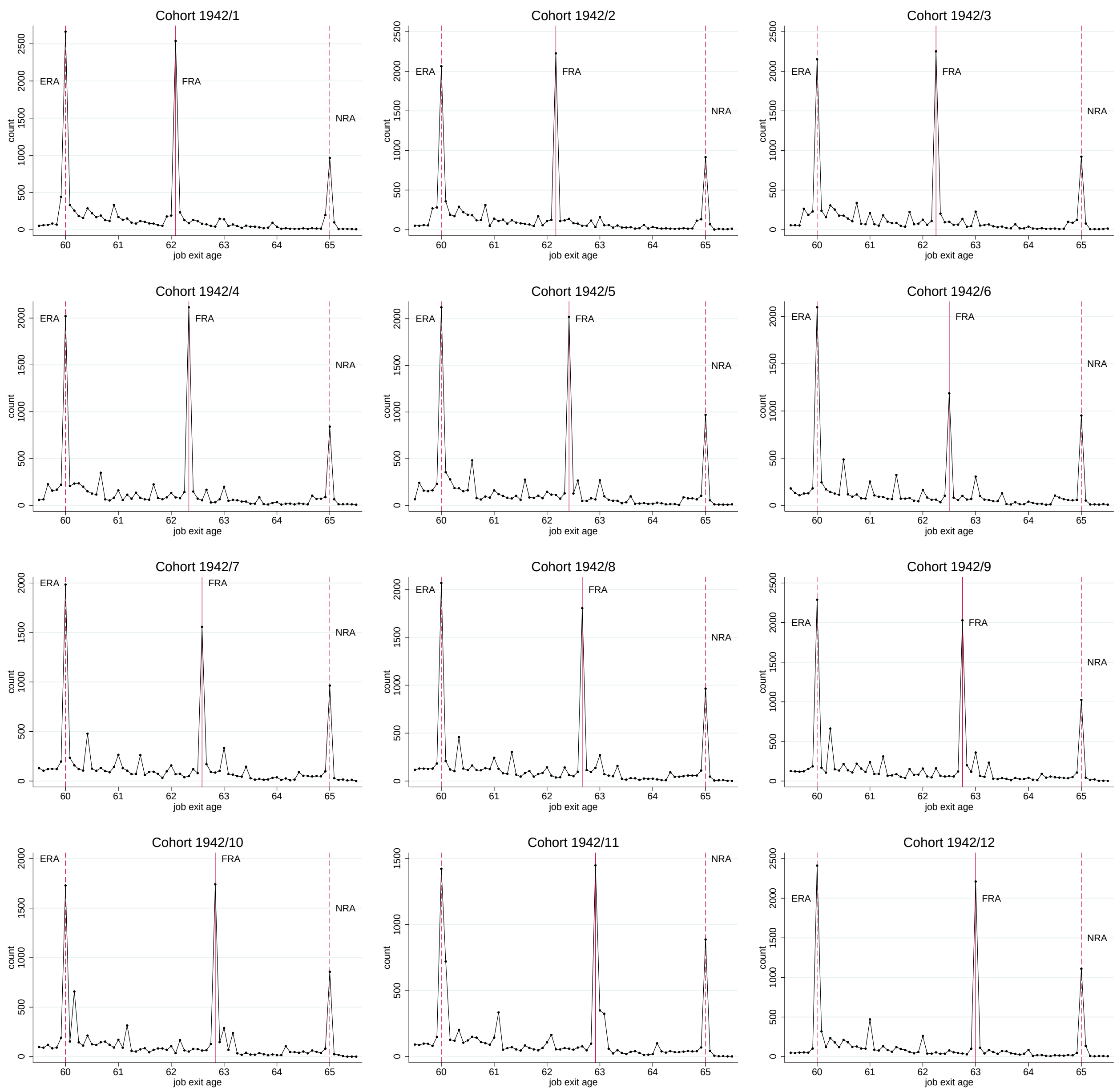


Figure A6: The Effect of Increasing the Full Retirement Age (continued)

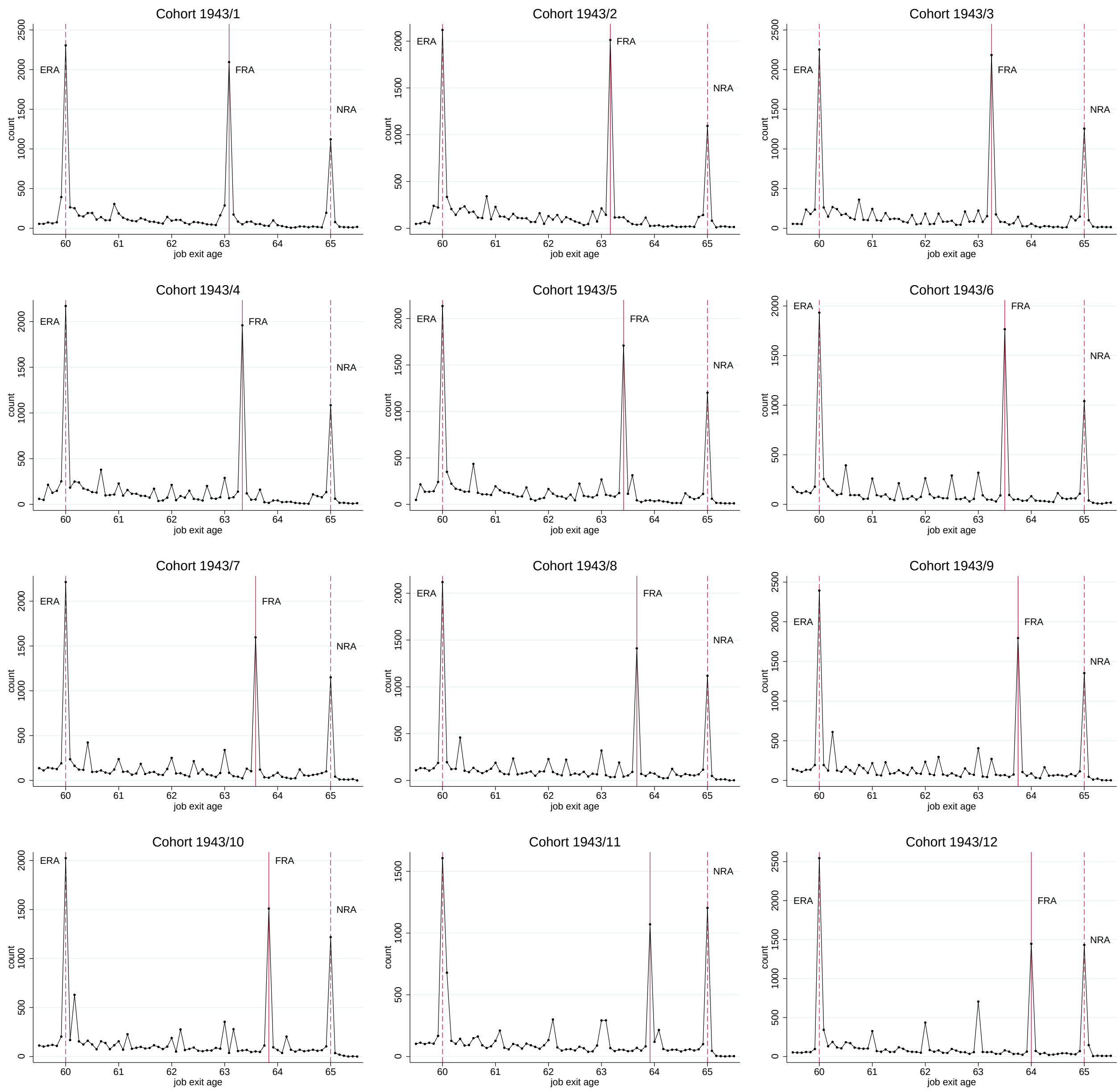
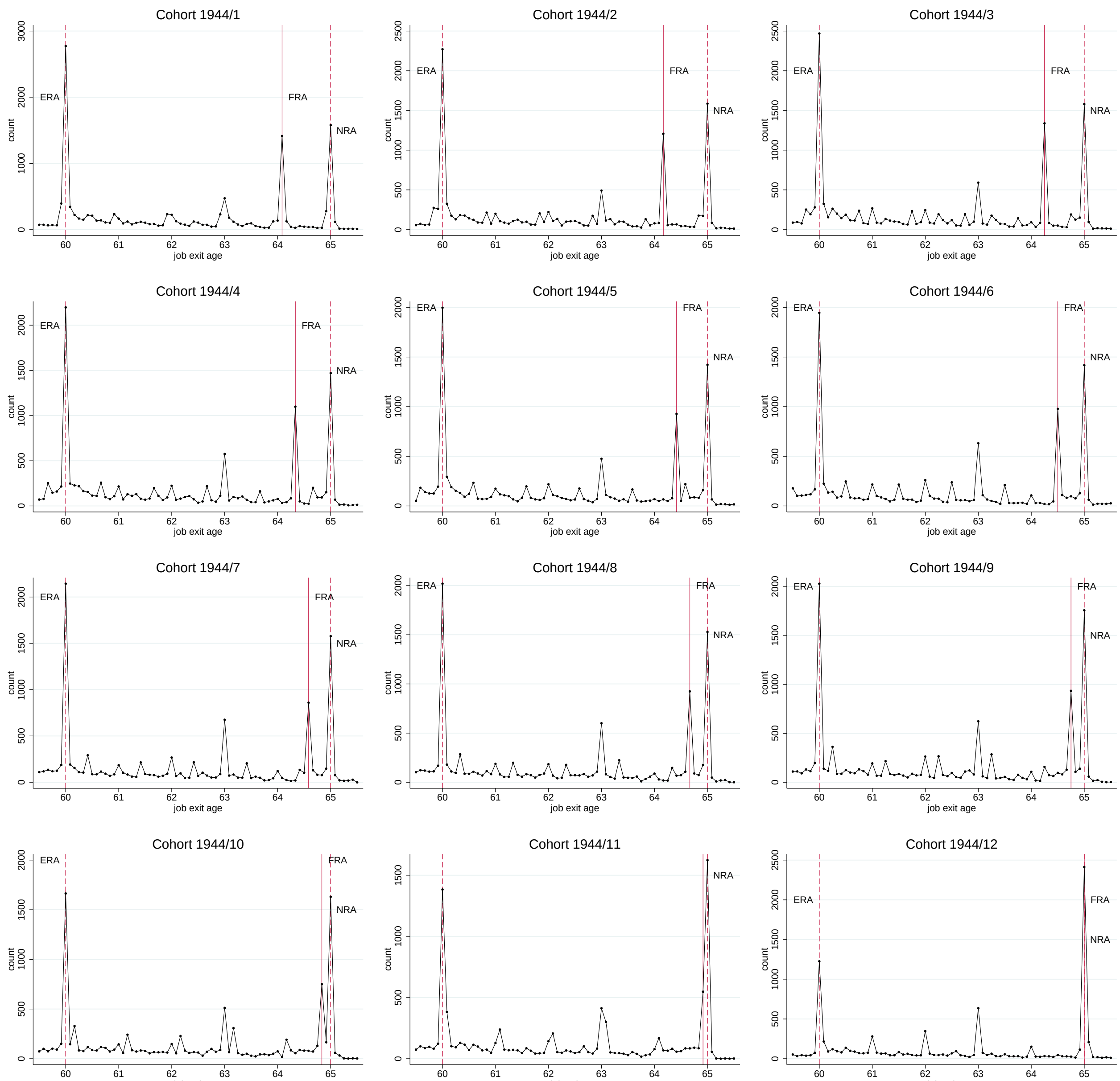
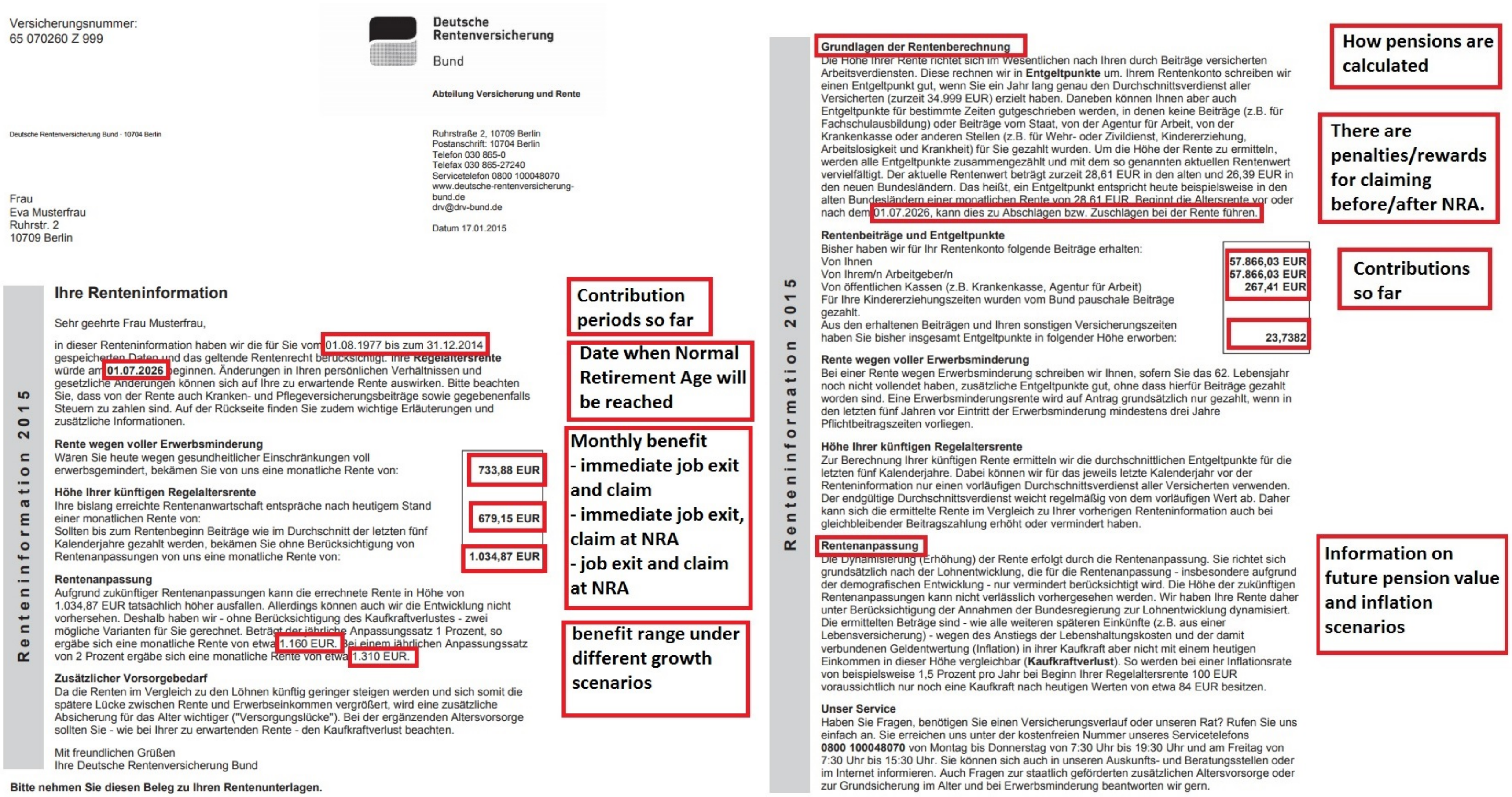


Figure A6: The Effect of Increasing the Full Retirement Age (continued)



Notes: 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 6 which shows selected monthly birth cohorts.

Figure A7: 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

Datum 17.01.2015

Frau
Eva Musterfrau
Ruhrstr. 2
10709 Berlin

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.

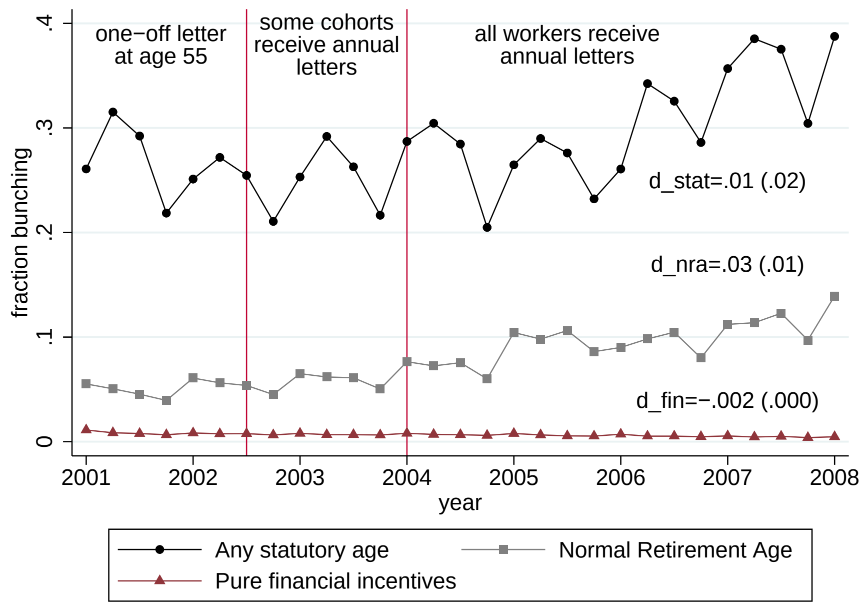
Rentenanpassung
Die Dynamisierung (Erhöhung) der Rente erfolgt durch die Rentenanpassung. Sie richtet sich grundsätzlich nach der Lohnentwicklung, die für die Rentenanpassung - insbesondere aufgrund der demografischen Entwicklung - nur vermindert berücksichtigt wird. Die Höhe der zukünftigen Rentenanpassungen 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.

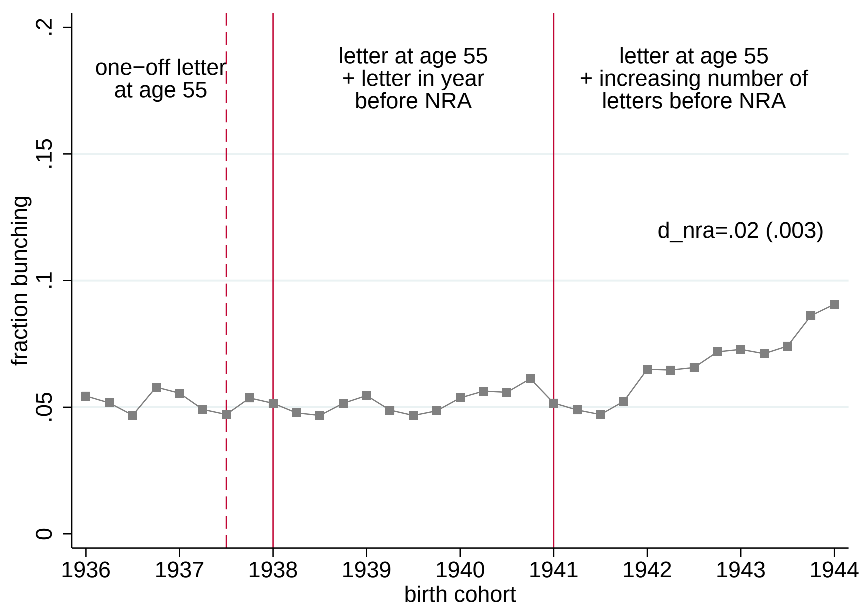
Notes: The figure shows an example of an information letter (*Renteninformation*) sent to workers by the German State Pension Fund. The number of letters of this kind was increased throughout the reform described in section 5.2. Red boxes on the right provide a summary and explanation of the content of the letter. See Appendix B.4 for further details of the letter content and the reform.

Figure A8: The Effect of Information Letters

Panel A: By Calendar Year

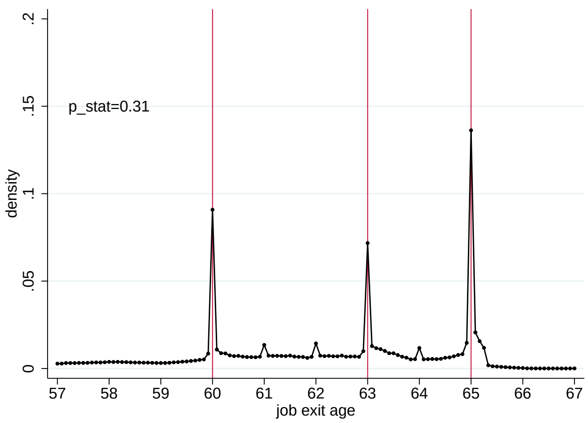


Panel B: By Birth Cohort

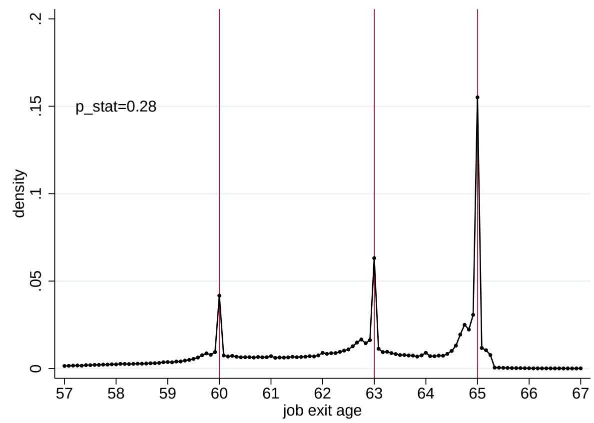


Notes: The figure shows the fraction of workers bunching at at different types of discontinuities throughout a reform period, where the number of information letters sent to workers increases. Panel A shows the fraction of workers bunching at any statutory age (black dots), the Normal Retirement Age (gray squares), and pure financial incentive discontinuities (red triangles) by calendar quarter. Before mid-2002, workers receive only one letter at age 55. 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 bunching at the Normal Retirement Age (NRA) by quarter of birth. Cohorts born before mid-1937 receive only a letter at age 55. 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 year before the NRA. The second solid vertical line marks the start of cohorts who receive more than one letter before the NRA, where the number of letters increases 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.

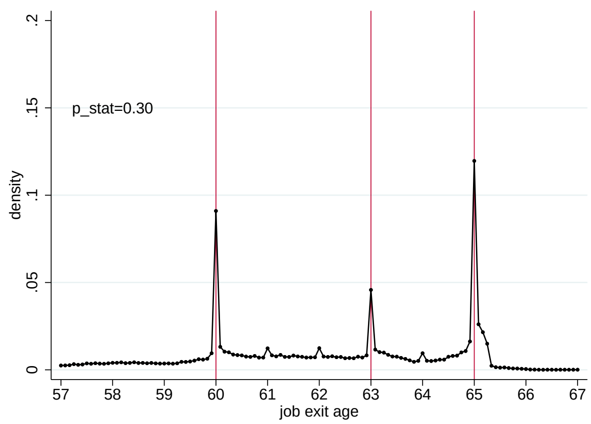
Figure A9: Self-Employed and Small Firms



(A) All occupations



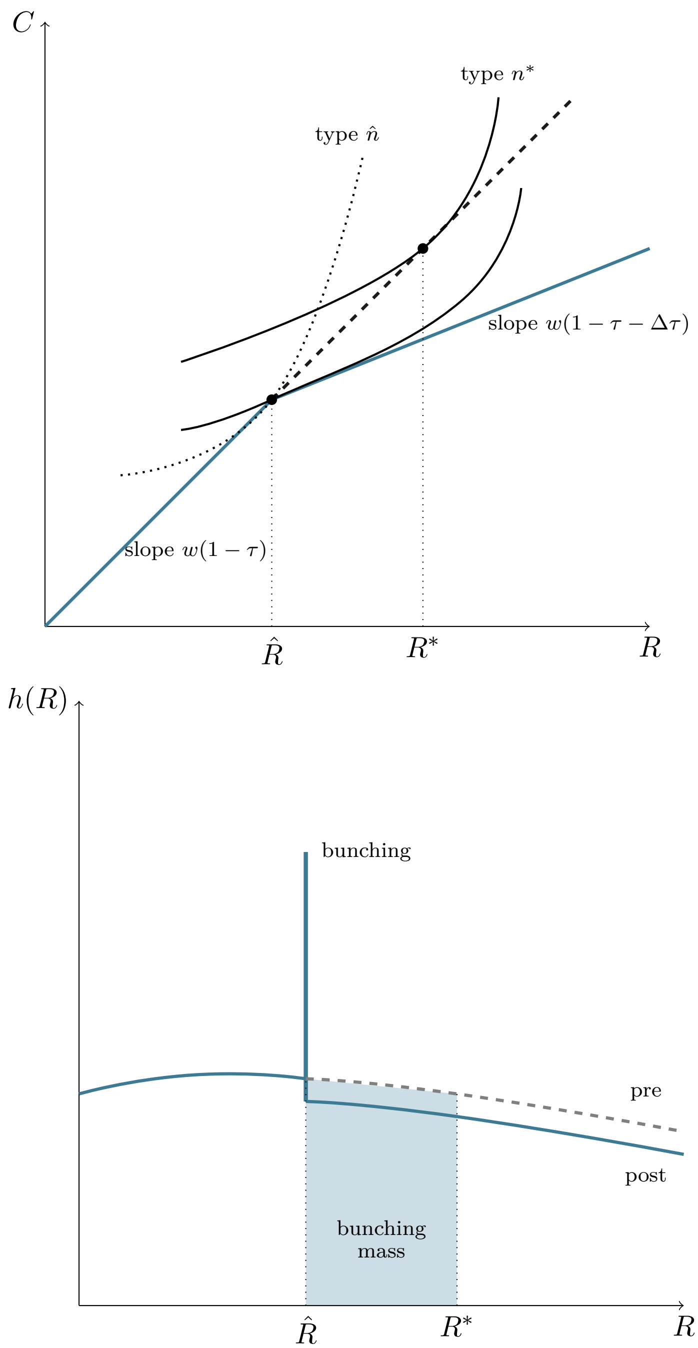
(B) Self-employed



(C) Most frequently in small firms

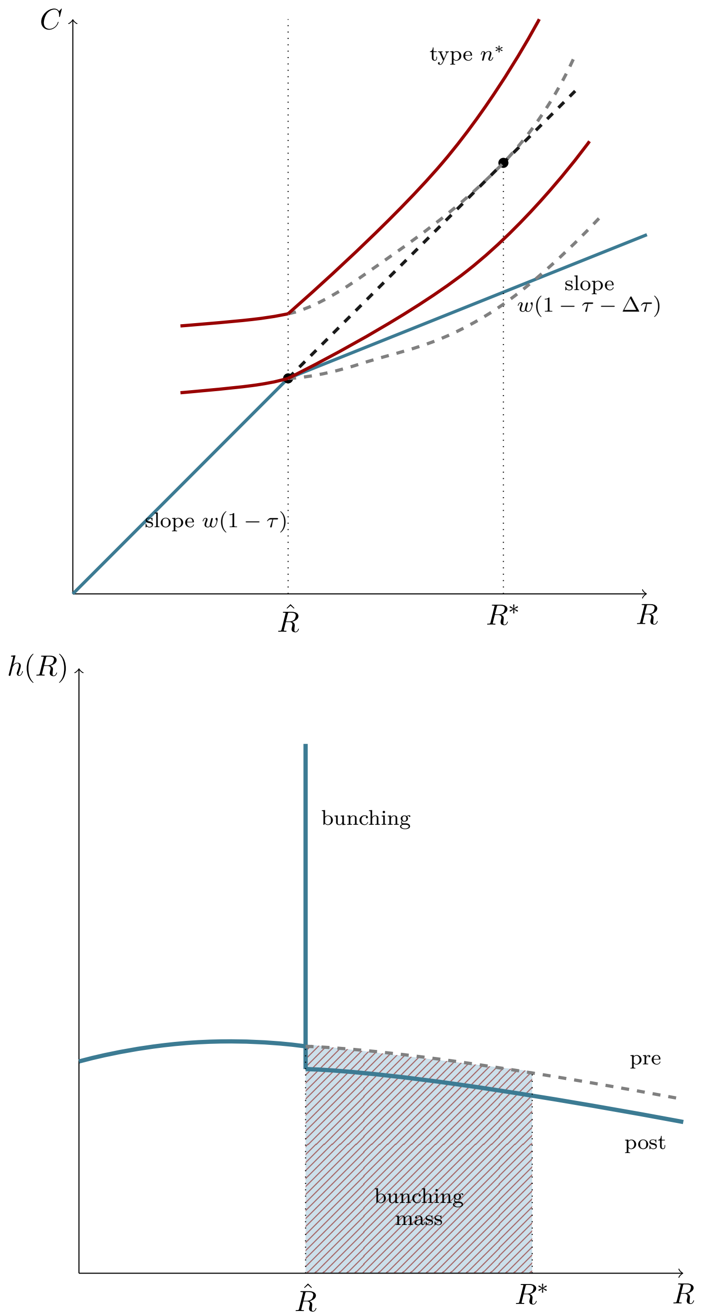
Notes: The figure shows the pooled distribution of job exit ages for all workers in the occupation-matched sample (Panel A), self-employed workers enrolled in the public pension system (Panel B), and the 20 occupations most frequently in small firms with less than 20 employees (Panel C). Self-employed individuals in Panel B include a small set of occupations who are mandated to participate, such as self-employed craftspersons, workmen, teachers, nurses and artists, as well as other self-employed workers who are voluntarily enrolled in the public system. Occupations in Panel C include medical receptionists, hairdressers, pharmacists, florists and dental technicians, for instance. The connected dots show the count of job exits within monthly bins. Vertical red lines indicate the main locations of statutory retirement ages throughout the sample period. *p_stat* indicates the fraction of workers bunching at statutory ages among the group in each panel.

Figure A10: Retirement Bunching at a Budget Constraint Kink



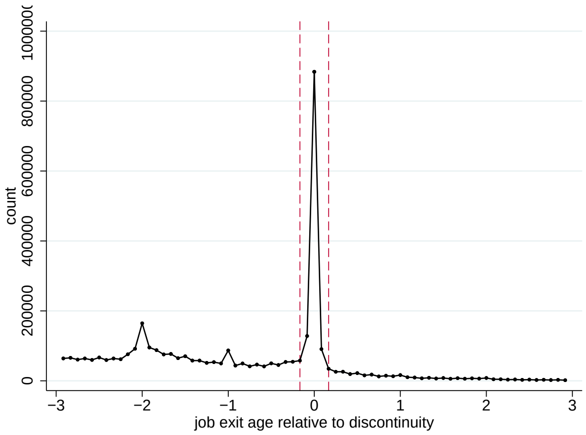
Notes: The figure shows retirement bunching responses to a budget set kink in an indifference curve diagram (upper panel) and a density diagram (lower panel). In the upper panel, the blue line is the post-kink budget set, whereas the dashed gray line is the pre-kink budget set. The dotted curve is an 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 dashed 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 A11: Bunching at a Joint Budget Constraint Kink and Reference Point

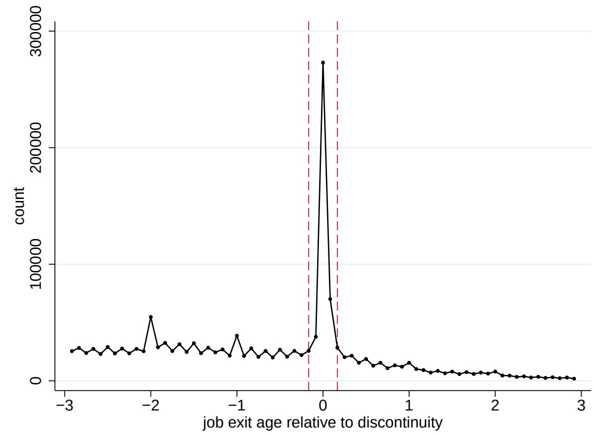


Notes: The figure shows bunching responses to a retirement age threshold combining a budget set kink and a reference point in an indifference curve diagram (upper panel) and a density diagram (lower panel). In the upper panel, the blue line is the kinked budget set, and the dashed black line is the initial 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. The marginal buncher's initial indifference curve is tangent to the pre-kink budget set at R^*, and her new 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"), whereas the dashed line denotes the initial density ("pre"). 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.

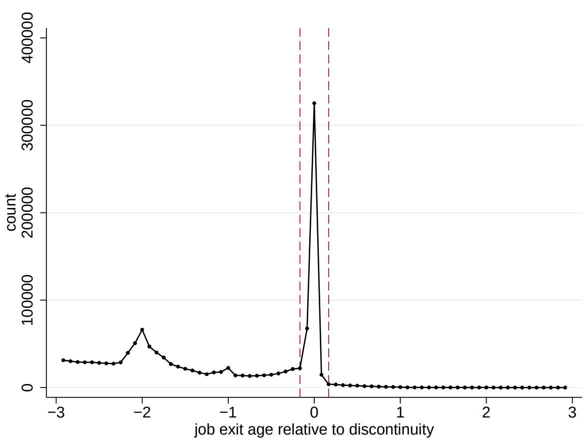
Figure A12: Pooled Empirical Density: Additional Graphs



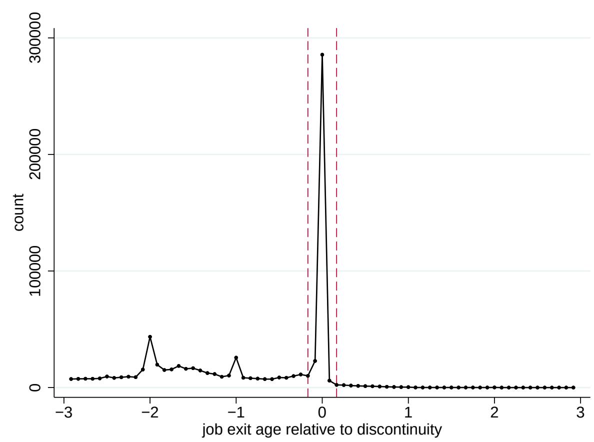
(A) Pooling All Full and Normal Retirement Ages



(B) Only Full Retirement Age



(C) Only Normal Retirement Age

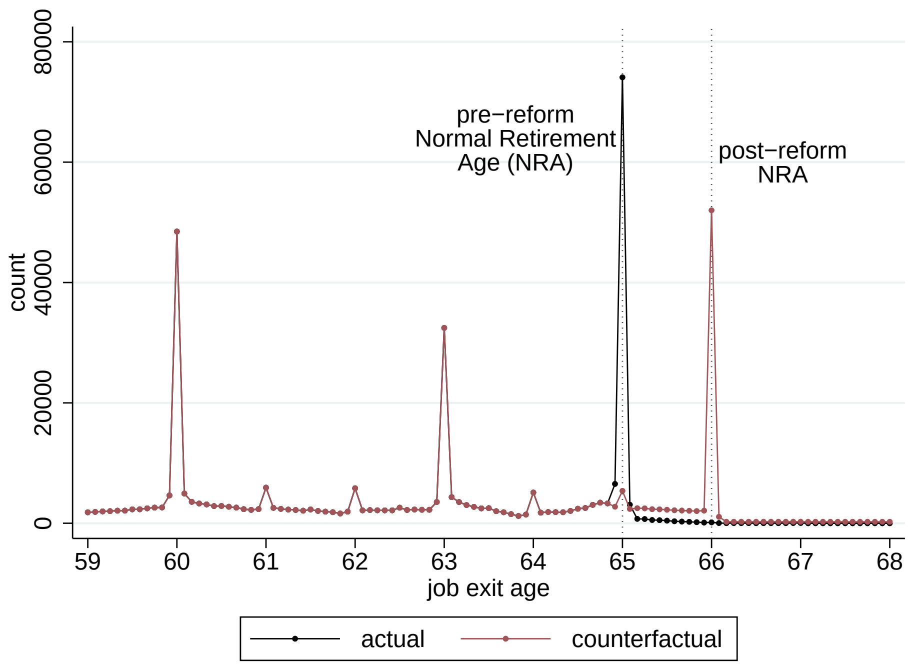


(D) Coinciding Full=Normal Retirement Ages

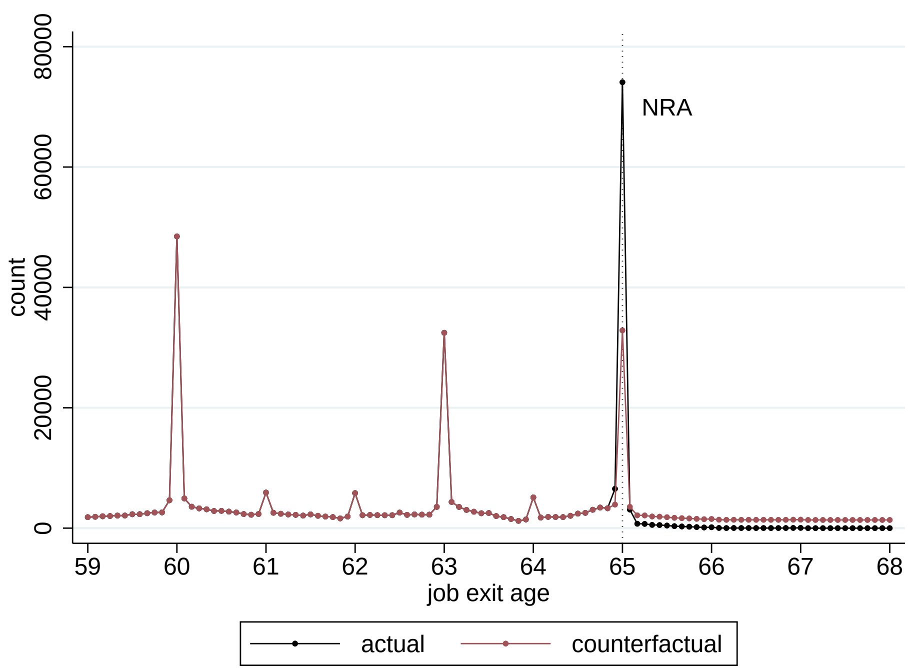
Notes: The figure shows the pooled empirical density around Full and Normal Retirement Ages, with the age at the discontinuity normalized to zero. Panel A shows the pooled density around all Full and Normal Retirement Ages as in Figure 8. Panel B shows the density around discontinuities featuring only a Full Retirement Age, Panel C around discontinuities featuring only a Normal Retirement Age, and Panel D around discontinuities where the Full and Normal Retirement Age coincide. In all panels, the black connected dots show the count of job exits within monthly bins. Vertical dashed lines indicate the bunching region.

Figure A13: Counterfactual Simulations

Policy 1: Normal Retirement Age Increase from 65 to 66



Policy 2: Stronger Financial Incentives for Late Retirement



Notes: The figure shows 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 also Table 5 for results of the simulation.

Table A1: Oaxaca-Blinder Bunching Decomposition

	(1)
Excess mass difference between pure financial incentives and Statutory Retirement Ages	-16.0
Explained by	
financial incentives	-0.58
%	3.6%
worker variables	-2.37
%	14.8%
firm variables	0.44
%	-2.7%
Unexplained	-13.5
%	84.4%
Obs. (discontinuities)	629

Notes: The table shows results from a Oaxaca-Blinder decomposition, where differences in excess mass between pure financial incentive discontinuities and statutory retirement ages in the bunching sample are attributed to differences in explanatory variables and an unexplained component. Pure financial incentive discontinuities are used as the reference category. "Financial incentives" include kink size and an indicator for non-convex kinks. "Worker variables" include dummies for female, married and East Germany, education years, lifetime earnings, last income before retirement, career length, sick leave years, parental leave years and retirement age at the discontinuity. "Firm variables" include the following occupation-level variables: firm size index, unionization rate, tenure in the firm, fraction in unlimited contracts, active union member rate, fraction receiving severance pay, fraction of involuntary job exits.

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 $\Delta\tau/(1-\tau)$	0.160	0.028	0.077	0.058	0.002
	(0.021)	(0.004)	(0.017)	(0.003)	(0.001)
Statutory age at kink:					
Early Retirement Age	0.026	0.070	0.033	0.109	
	(0.007)	(0.007)	(0.006)	(0.005)	
Full Retirement Age	0.021	0.151	0.026	0.031	
	(0.020)	(0.015)	(0.010)	(0.004)	
Normal Retirement Age	0.309	0.263	0.081	0.266	
	(0.016)	(0.033)	(0.020)	(0.010)	
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 $\Delta\tau/(1-\tau)$	0.028	0.021	0.035	0.059	0.067	0.060
	(0.090)	(0.090)	(0.008)	(0.016)	(0.015)	(0.020)
Statutory age at kink:						
Early Retirement Age	0.149	0.184	0.038	0.072	0.070	0.080
	(0.084)	(0.092)	(0.054)	(0.018)	(0.015)	(0.016)
Full Retirement Age			0.034	0.156	0.031	0.059
			(0.005)	(0.027)	(0.091)	(0.013)
Normal Retirement Age	0.231	0.230	0.135	0.487	0.283	0.195
	(0.087)	(0.067)	(0.074)	(0.180)	(0.105)	(0.046)
Discontinuities	15	15	46	58	23	37

Notes: 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 columns (6) to (8) of Table 4. 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. Interactions between statutory age dummies are also included in all specifications. Regressions are weighted by group size and bootstrapped standard errors in parantheses.

Table A3: The Effect of Increasing the Full Retirement Age

	(1)	(2)
Dependent variable: Job exit age (years)		
post-reform	1.75	1.70
	(0.01)	(0.01)
Pre-reform mean dep. var.	61.0	61.0
Observations	905,488	905,488
R-squared	0.17	0.27
Year-of-birth FE	yes	yes
Controls	no	yes

Notes: The table shows results from individual-level regressions 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 the following control variables: gender, education (years), marital status, lifetime earnings, last income before retirement, a dummy for East Germany, career length, sick leave years, parental leave years. Standard errors clustered at the pathway × month of birth level.

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	0.029	0.015	0.032	0.029	-0.002	-0.002
	(0.016)	(0.015)	(0.012)	(0.011)	(0.000)	(0.000)
Pre-reform mean dep. var.	0.25	0.25	0.06	0.06	0.01	0.01
Observations	1,578,964	1,578,964	1,578,964	1,578,964	1,578,964	1,578,964
R-squared	0.001	0.08	0.004	0.09	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	0.016	0.016
	(0.008)	(0.003)
Pre-reform mean dep. var.	0.05	0.05
Observations	3,002,902	3,002,902
R-squared	0.000	0.07
Controls & Pathway FE	no	yes

Notes: The table shows results from individual-level regressions 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 (years), marital status, lifetime earnings, last income before retirement, a dummy for East Germany, career length, sick leave years, parental 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. Health status is proxied by the negative of sick leave periods. Standard errors clustered at the pathway × month of birth level.

Table A5: Individual-Level Correlates of Bunching

	(1)	(2)	(3)
	Dependent variable: Indicator for bunching at...		
	Statutory Retirement Age		pure financial incentive discontinuity
	all workers	within +/- 1 year of statutory age	
education (years)	0.007	0.009	0.0001
	(0.001)	(0.001)	(0.0000)
lifetime earnings (log)	0.27	0.12	-0.017
	(0.006)	(0.007)	(0.001)
last earnings before retirement(log)	0.085	0.11	0.001
	(0.002)	(0.003)	(0.0001)
pension wealth/annual earnings	0.039	0.017	-0.0004
	(0.001)	(0.001)	(0.0000)
health status	-0.009	-0.012	0.001
	(0.001)	(0.002)	(0.0002)
female	-0.028	-0.047	-0.004
	(0.006)	(0.007)	(0.0004)
married	-0.17	-0.094	0.005
	(0.004)	(0.005)	(0.0003)
East Germany	0.008	-0.010	0.002
	(0.004)	(0.008)	(0.0004)
parental leave	0.002	0.002	-0.001
	(0.002)	(0.002)	(0.0001)
economic training	0.014	0.018	0.001
	(0.002)	(0.003)	(0.0002)
firm size index	0.027	0.038	-0.001
	(0.001)	(0.002)	(0.0002)
unionization	-0.023	-0.045	0.003
	(0.005)	(0.006)	(0.001)
tenure	-0.001	-0.001	0.0000
	(0.0002)	(0.0003)	(0.0000)
unlimited contract	-0.038	-0.062	0.001
	(0.005)	(0.006)	(0.0005)
labor market tightness	0.36	0.27	0.038
	(0.043)	(0.055)	(0.005)
Mean dependent variable	0.31	0.47	0.004
Observations	3,933,052	2,630,400	3,933,052
R-squared	0.15	0.09	0.02
Year of birth & pathway FE	yes	yes	yes

Notes: The table shows results from individual-level regressions of dummies for job exits at statutory retirement ages (columns 1 and 2) and pure financial incentive discontinuities (column 3) on a number of characteristics. In column (2), the sample is limited to workers whose retirement age is within +/-12 months of the closest statutory age. 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. Labor market tightness is constructed based on annual vacancy and unemployment data at the state level. Standard errors clustered at the pathway × month of birth level.

Table A6: Structural Bunching Estimation: Main Estimates

	(1)	(2)
	Statutory Retirement Ages:	
	Full	Normal
Reference dependence λ^s	0.225	0.384
	(0.009)	(0.015)
Kink size equivalent	0.507	1.200
	(0.061)	(0.234)
Elasticity ε	0.047 (0.003)	

Notes: The table presents parameter estimates from a non-linear least squares estimation based on equation (12), 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. The estimation also allows for interaction effects between different types of statutory ages, which are shown in Table A7.

Table A7: Structural Bunching Estimation: Alternative Specifications

	(1)	(2)	(3)	(4)
	Statutory Retirement Ages:			
	Full	Normal	Full ×Normal	any
Baseline				
Reference dependence λ^s	0.225	0.384	-0.156	
	(0.009)	(0.015)	(0.017)	
Kink size equivalent	0.507	1.200	-0.390	
	(0.061)	(0.234)	(0.038)	
Estimating kink equivalent directly				
Kink size equivalent	0.541	1.313	-0.690	
	(0.022)	(0.113)	(0.116)	
Estimation without interaction effects				
Reference dependence λ^s	0.071	0.384		
	(0.017)	(0.016)		
Kink size equivalent	0.160	1.199		
	(0.036)	(0.234)		
Separate estimation for each stat. age type				
Reference dependence λ^s	0.237	0.384		
	(0.006)	(0.015)		
Kink size equivalent	0.533	1.200		
	(0.036)	(0.234)		
Single reference dependence parameter				
Reference dependence λ				0.244
				(0.003)
Kink size equivalent				0.657
				(0.137)

Notes: The table shows results from a range of alternative specifications in addition to the main parameter estimates shown in Table A6. All estimates result from non-linear least squares estimations based on equation (12) using the bunching sample. The first alternative specification estimates parameters scaled as kink equivalents $\lambda^s/(1-\tau)$ 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.

B Institutional Details

This section provides additional details on the institutional setting. See also Börsch-Supan and Schnabel (1999) and Börsch-Supan and Wilke (2004) for a more comprehensive overview of the German public pension system.

B.1 Pathways and Statutory Retirement Ages

Over the sample period, the German public pension system has six main pathways into retirement, which differ in their statutory retirement ages. The multiple pathways are the result of a number of historical pension reforms before the 1990s. These reforms had established an increasing number of special rules allowing certain groups of workers to retire before the NRA, when they would be eligible to claim a pension in the regular pathway. Thus, while the NRA applies to all workers, different pathways vary in their ERA and FRA. For instance, the long-term insured pathway introduced in 1972 featured an ERA and FRA lower than the NRA of 65. Due to the lower ERA, eligible workers can claim their pension earlier, and due to the lower FRA, they can claim a "full" pension already before the NRA. Note that in some cases, different types of statutory ages can occur at the same age. In the long-term insured pathway, for instance, the FRA coincides with the NRA for cohort 1939 onwards after a reform that increases the FRA. In the following, I give a more detailed overview of the pathways and associated statutory ages (see also Appendix Figure A2).

Public pensions (*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*, literally 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 with at least 35 years of contributions are eligible. 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*[38]) 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 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 potential earnings", 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. For workers claiming before age 60, contribution points are "filled up" (*Zurechnungszeit*) as if the worker had kept on earning their average pre-retirement income until 60. Hence, disability pensions feature an additional insurance element compared to other pathways since benefits are less dependent on lifetime contributions, but from the end of the filling period onwards pension calculation is the same as in all other pathways.

B.2 Pension Adjustment

Direct 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 a worker's monthly pension benefits, which are are framed as penalties or rewards 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 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.

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

B.3 Benefit Calculation

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

$$B_i(R_i) = V \cdot \alpha(\max(R_i, ERA)) \cdot \sum_{t=0}^{R_i-1} \frac{w_{it}}{\bar{w}_t} \tag{13}$$

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. Note that the accumulation of contribution points itself does not change around statutory ages. Second, the worker is assigned an *adjustment factor* α as a function of her benefit claiming age. The adjustment factor is a multiplier directly applied to monthly benefits. 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. The FRA is used as a reference point for pension adjustment, 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 to 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 substantially increased between June 2002 and December 2003. During this transition period, the pension fund conducted surveys of workers and adapted the design of letters 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 A7 shows an example of the type of letter sent annually after the reform. 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 implementation period, the number of information letters a worker receives before the NRA depends on their year of birth (see Dolls et al. 2018[39]). 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 at most one year 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 in the two years before they turn 65, cohort 1942 receives three letters in the three years before the NRA, 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 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 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 around 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. 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

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

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 procedure is arguably conservative in the sense that job exit ages are imputed uniformly which, if anything, could over-smoothe the distribution and attenuate observed bunching. Moreover, note that the imputation is mostly relevant for job exits before the ERA since gaps between job exits and benefit claiming occur in these cases. From the ERA onwards, most workers claim benefits right after their job exit such that last contribution dates correspond directly to the job exit age in most cases. In particular, bunching, i.e. job exits directly at different types of discontinuities are relatively unaffected by the imputation procedure. Only 2% of job exits at statutory ages are subject to the correction described above. The corresponding fraction is 11% of job exits at disability kinks, while there is no imputation at all around contribution notches as contributions are directly observed.

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, parental leave, 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 (13) using a sample period average pension value V, a worker's observed sum of earned points $\sum_{t=0}^{R_i-1} w_{it}/\bar{w}_t$ 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 are taken from mortality tables by the German Federal Statistics Office considering 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 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 pension 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 find claiming a regular pension easier or more natural than claiming a a pension from a pathway with additional requirements. 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. The extent to which eligibility can be observed directly varies by pathway. 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 workers retire 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. For 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 the same notion of pathway eligibility as described above. However, 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, are not yet eligible to claim in 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 occupations are 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 observed 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. 6% have two 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 bins in the bunching region at the discontinuity itself. 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 in the immediate neighborhood of 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 below the kink and the rate just above (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 below 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. In all bootstrapping procedures, the respective data is re-sampled 500 times.

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	32
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	16
Invalidity	1941-1943	55-67	monthly	moving FRA	kink	36
Disability	1938-1949	55-67	annual	pension adjustment around age 63	kink	11
Disability	1938-1943	55-67	monthly	adjustment introduction in 2001	kink	67
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						644

Note that a further 11 discontinuities that exist over the sample period but 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

In this section, I discuss a number of extensions to the framework in section 6 that 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). Section E.1 discusses how this standard argument of the bunching literature can be applied to a model with reference points. Second, the presence of potential income or wealth effects at larger kinks is discussed in section E.2. In this case, bunching identifies a mixture of compensated and uncompensated parameters.

Third, retirement decisions are dynamic problems and often modeled as such. Section 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. In this paper, I focus 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 indicate that dynamic uncertainty may 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.

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 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 (7) 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 (10) and (11).

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

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 (10) is identified off the average response $E[\Delta R^*_{\varepsilon,\lambda}]$.

One example of such heterogeneity is when there are multiple potential reference points, and different individuals "choose" different reference points. In this case, bunching at each reference point is informative of the average degree of reference dependence with respect to this threshold among the individuals located in its neighborhood.

E.2 Income/Wealth Effects

The standard bunching formula (8) applies to small kinks where income effects are small (Saez 2010). Equivalently, the formula can be derived from a quasi-linear utility function in section 6. 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 observed 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 (10) would be 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 (7), (10) and (11) 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 discusses 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[40] 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

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

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.[41] 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

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

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

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

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.

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 implicit net wage, the marginal gain in lifetime consumption from postponing retirement given by the budget constraint.

F Derivation of Bunching Predictions

F.1 Bunching at a Pure Budget Constraint Kink

Consider the setup from section 6.1, and suppose 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 A10 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

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

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

$$\frac{R^*}{\hat{R}} = \left(\frac{1-\tau}{1-\tau-\Delta\tau}\right)^\varepsilon \tag{14}$$

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 (14) implies

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

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.

F.2 Alternative Model with a Fixed Utility Gain from Retiring at Statutory Ages

I argue in this paper that statutory retirement ages are perceived as reference points for retirement behavior. Such reference dependence is commonly modeled as loss aversion, with a kink in marginal utility at the reference point as in section 6. Alternatively, the large responses to statutory ages could be generated by a model where individuals put a discrete utility premium on retiring at the statutory age relative to other retirement ages. This could be driven by individuals perceiving statutory ages as implicit advice or as a social norm. Under this alternative model, preferences can be written as

$$U = u(C) - v(R,n) + \mathbb{1}(R = \hat{R}) \cdot \pi \tag{15}$$

The worker receives additional utility π when retiring at the statutory age, or equivalently, incurs a utility cost when deviating from the statutory age. Equation 15 differs from the standard reference dependence formulation with loss aversion from section 6.2 in two ways. First, there is a fixed utility gain from retiring at the statutory age, rather than a change in marginal utility as under reference dependence with loss aversion. Second, the extra utility from retiring at the statutory age is lost when deviating in any direction, while the model in section 6.2 features an asymmetry around the reference point.

This utility specification can be interpreted as a reduced-form to capture alternative mechanisms where individuals derive a utility premium from retiring exactly at a statutory age compared to other retirement ages. For instance, workers may find it difficult to make optimal retirement decisions and perceive statutory ages as an implicit suggestion or advice by the government. The implied utility cost of deviating from this advice may also encompass a cognitive (or other) cost of choosing an individually optimal retirement age. Moreover, the model could capture a social norm in favor of retiring exactly at statutory ages, where workers derive a fixed utility gain from following the norm.

F.2.1 Bunching Responses with a Fixed Utility Gain

The model implies bunching at statutory retirement ages, and as in section 6.2, bunching responses can be characterized theoretically. In the upper panel of Figure F1, an individual with ability $\hat{n}$ is initially located at $\hat{R}$, n^*_+ is located at R^*_+, and n^*_- at R^*_-. When the utility premium on retiring at $\hat{R}$ is introduced, indifference curves become discontinuous at $\hat{R}$. The individual initially located at R^*_+ is now indifferent between R^*_+ and $\hat{R}$ and the individual initially at R^*_- is now indifferent between R^*_- and $\hat{R}$. These two are the the upper marginal buncher and the lower marginal buncher, respectively. All workers initially located between R^*_- and R^*_+ bunch at the statutory age, while individuals initially to the left of R^*_- or the right of R^*_+ do not alter the choice. Hence, bunching at the statutory age occurs from both sides, and there is a hole in the density between R^*_- and R^*_+.

Bunching at the threshold is

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

With quasi-linear preferences, utility of the lower marginal buncher at $\hat{R}$ is

$$\hat{U} = (1-\tau)\hat{R} - \frac{n_-^*}{1+\frac{1}{\varepsilon}}\left(\frac{\hat{R}}{n_-^*}\right)^{1+\frac{1}{\varepsilon}} + \pi$$

Using the first-order condition $R_-^* = n_-^*(1-\tau)^\varepsilon$, utility at the initial interior solution R_-^* can be expressed as

$$U_I = \frac{1}{1+\varepsilon} n_-^*(1-\tau)^{1+\varepsilon}$$

The indifference condition $\hat{U} = U_I$ then implies

$$\frac{1}{1+\varepsilon}\frac{R_-^*}{\hat{R}} + \frac{\varepsilon}{1+\varepsilon}\left(\frac{R_-^*}{\hat{R}}\right)^{-\frac{1}{\varepsilon}} = 1 + \frac{\pi}{C(\hat{R})} \tag{16}$$

where $C(\hat{R}) = (1-\tau)\hat{R}$. Similarly, the upper marginal buncher is indifferent between the interior solution at R_+^* and the statutory age such that

$$\frac{1}{1+\varepsilon}\frac{R_+^*}{\hat{R}} + \frac{\varepsilon}{1+\varepsilon}\left(\frac{R_+^*}{\hat{R}}\right)^{-\frac{1}{\varepsilon}} = 1 + \frac{\pi}{C(\hat{R})} \tag{17}$$

Hence, R_+^* and R_-^* are two solutions to the same non-linear equation, where $R_+^* \geq \hat{R}$ and $R_-^* \leq \hat{R}$. Equation (16) and (17) are the analogue to equation (10) in the reference dependence model. They define bunching in response to a retirement age age threshold with a fixed utility premium attached to it, although there is generally no closed-form solution for $R_-^*/\hat{R}$ and $R_+^*/\hat{R}$. Note that the solutions given by equation (16) and (17) are conceptually similar to bunching at tax notches.

F.2.2 Combining Financial Incentives and a Fixed Utility Gain

To gauge total bunching at a statutory retirement age, the effect of the utility premium on $\hat{R}$ and local financial incentives need to be analyzed jointly. Figure F2 illustrates this simultaneous effect. The individual initially located to the left of the threshold at R_-^* is now indifferent between R_-^* and $\hat{R}$. This individual is the lower marginal buncher. To the right of the threshold, the individual whose indifference curve is initially tangent to the budget set with slope $1-\tau$ at R_+^* is now indifferent between the point of tangency to the new budget set with slope $1-\tau-\Delta\tau$ at R_+ and the threshold $\hat{R}$. This worker is the upper marginal buncher. Thus, bunching again occurs from both sides, with a hole in the density between R_-^* and R_+.

As in equation (16), the indifference condition for the lower marginal buncher $\hat{U}_- = U_{I-}$ implies

$$\frac{1}{1+\varepsilon}\frac{R_-^*}{\hat{R}} + \frac{\varepsilon}{1+\varepsilon}\left(\frac{R_-^*}{\hat{R}}\right)^{-\frac{1}{\varepsilon}} = 1 + \frac{\pi}{C(\hat{R})}$$

The upper marginal buncher's utility at $R_+ = n_+^*(1-\tau-\Delta\tau)^\varepsilon$ can be written as

$$U_{I+} = \Delta\tau R + \frac{1}{1+\varepsilon} n^*(1-\tau-\Delta\tau)^{1+\varepsilon}$$

The indifference condition $\hat{U}_+ = U_{I+}$ implies

$$\frac{1}{1+\varepsilon}\frac{R_+}{\hat{R}} + \frac{\varepsilon}{1+\varepsilon}\left(\frac{R_+}{\hat{R}}\right)^{-\frac{1}{\varepsilon}} = 1 + \frac{\pi}{C(\hat{R})}\frac{1-\tau}{1-\tau-\Delta\tau} \tag{18}$$

However, $R_+/\hat{R}$ relates to the additional retirement response to the utility premium, given that there is a budget set kink. In order to capture the entire density shift due to the joint effect, the tangency condition $R^*_+ = n^*_+(1-\tau)^\varepsilon$ can be combined with the tangency condition at R_+ to yield

$$\frac{R^*_+}{R_+} = \left(\frac{1-\tau}{1-\tau-\Delta\tau}\right)^{\varepsilon}$$

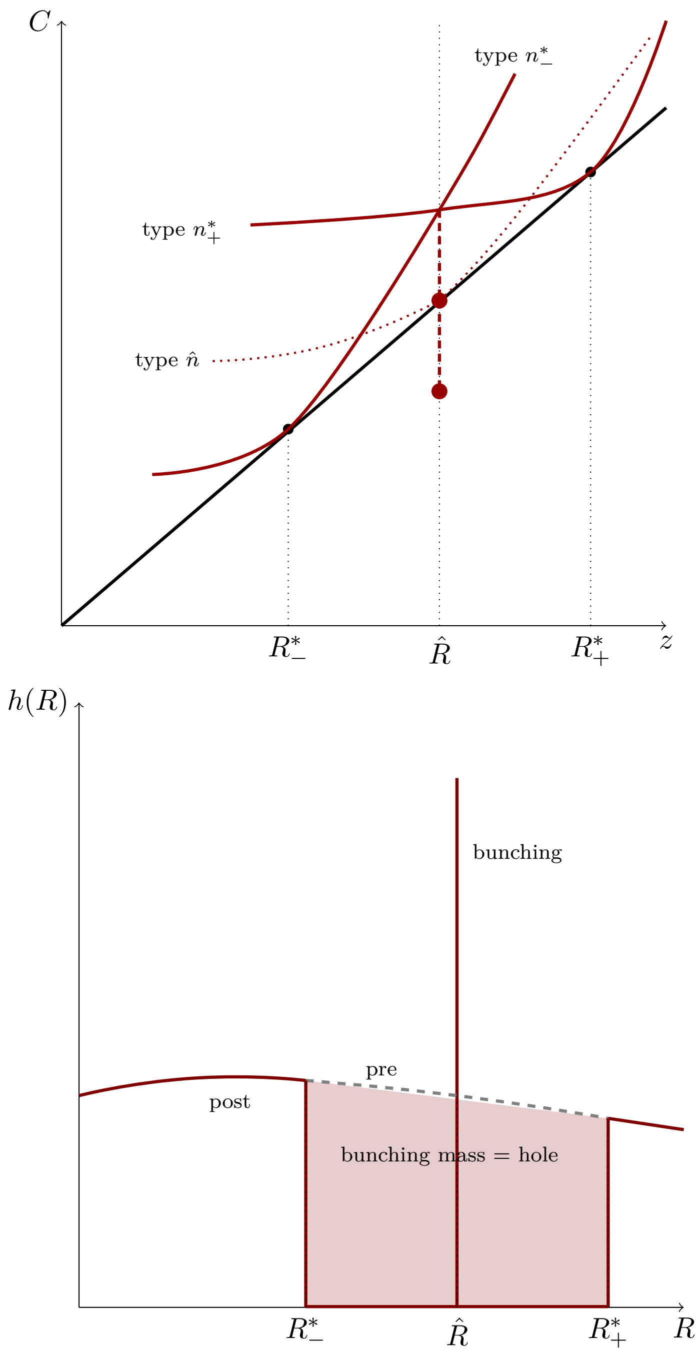
and plugging this into the above indifference condition yields

$$\frac{1}{1+\varepsilon}\frac{R^*_+}{\hat{R}}\left(\frac{1-\tau}{1-\tau-\Delta\tau}\right)^{-\varepsilon} + \frac{\varepsilon}{1+\varepsilon}\left(\frac{R^*_+}{\hat{R}}\left(\frac{1-\tau}{1-\tau-\Delta\tau}\right)^{-\varepsilon}\right)^{-\frac{1}{\varepsilon}} = 1 + \frac{\pi}{C(\hat{R})}\frac{1-\tau}{1-\tau-\Delta\tau} \tag{19}$$

Hence, while bunching from the left occurs only due to the utility premium, bunching from the right is due to a combined effect of the utility premium and the budget constraint kink. Compared to a situation with the utility premium only, the budget set kink leads to some additional bunching, and a small additional density shift occurs on the right beyond the missing mass region, but overall there is no major qualitative change in the expected shape of the distribution around the threshold.

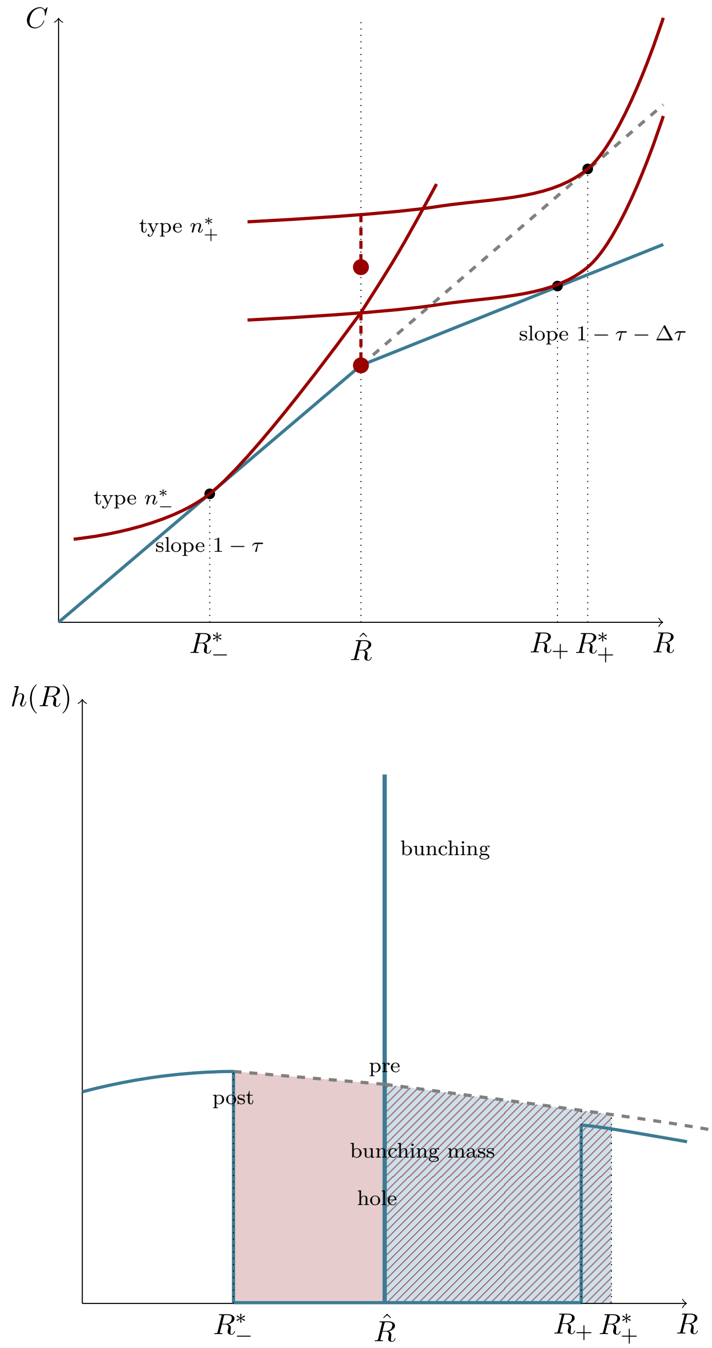
To sum up, when individuals put a fixed utility premium on retiring at statutory ages, this can also induce sharp bunching. However, the model implies a shape of the density around statutory ages that differs from the predicts of reference dependence with loss aversion. Missing mass emerges on both sides of statutory ages, as retirement responses occur symmetrically from the neighborhood of the threshold. In the case of a fixed utility gain from retiring at statutory ages, one would also not expect a clearly visible leftward density shift towards the threshold..

Figure F1: Bunching with a Fixed Utility Gain



Notes: The figure shows an indifference curve diagram and a density diagram of bunching responses when individuals put a fixed utility premium on retiring at a statutory age. In the upper panel, the solid curves are the initial indifference curves of the lower marginal buncher with ability n^*_- and the upper marginal buncher with ability n^*_+. With the utility premium, the red dots become parts of the indifference sets to which they are connected with the dashed lines. The dotted curves is an indifference curve of an individual with ability $\hat{n}$ who chooses $\hat{R}$ before and after the change. The lower (upper) marginal buncher is tangent at R^*_- (R^*_+) in the absence of the utility premium and becomes indifferent between R^* (R^*_+) and $\hat{R}$ with the utility premium. In the lower panel, the solid red line denotes the density with the utility premium (post), whereas the dotted line denotes the initial density (pre). The red shaded area is the initial location of the mass of workers bunching in response to the utility premium.

Figure F2: Bunching with a Fixed Utility Gain and a Budget Set Kink



Notes: The figure shows an indifference curve diagram and a density diagram on bunching responses to a combination of a fixed utility premium and a budget set kink. In the upper panel, the blue line is the kinked budget set, whereas the dashed grey line is the initial budget set. The solid red curves are the initial indifference curves of the lower marginal buncher with ability n_-^* and the upper marginal buncher with ability n_+^*. With the utility premium, the red dots become parts of the indifference sets to which they are connected with the dashed lines. The lower marginal buncher is indifferent between R_-^* and $\hat{R}$ with the utility premium and the budget set kink. The upper marginal buncher is tangent at R_+^* in the absence of the budget set kink, and tangent at R_+ with the budget set kink, where she is indifferent between this point and $\hat{R}$ due to the utility premium. In the lower panel, the solid blue line denotes the density with the kink and the utility premium, whereas the dotted line denotes the initial density. The red shaded area is the initial location of the mass of workers bunching from the left, and the red and blue shaded area is the initial location of the bunching mass originating from the right.

G Counterfactual Policy Simulations

In this section, I provide additional details on the counterfactual policy simulations described in section 7.2.

G.1 Simulations

The first reform is an increase in the NRA from age 65 to 66. In order to isolate the effect of shifting the NRA as a reference point, no explicit additional financial rewards are provided between the old and the new NRA in the counterfactual. From the new NRA onwards, marginal financial rewards for late retirement are of the same magnitude as before the reform. Note that this differs from some NRA reforms in practice as they are often linked to a cut in the level of pension benefits across the board, including at younger retirement ages. Such a benefit cut would emerge when a full pension is available only at the higher NRA after the reform, such that workers receive lower benefits at any given retirement age below the new NRA. Thus, the simulation arguably yields a lower bound on the fiscal effect of increasing the NRA, since a benefit cut across the board would imply an additional positive mechanical effect.

The second reform provides higher financial rewards for late retirement, but leaves the NRA at age 65. This is done in the form of a higher Delayed Retirement Credit, that is a larger annual percentage increase in benefits for retiring after the NRA, corresponding to a steeper adjustment function $\alpha(R_i)$ for $R_i > NRA$ in equation (13). Other than this, both reforms do not entail any further changes to the pension formula. The reforms are simulated for workers born in 1946, the last cohort not subject to a planned gradual increase in the NRA to 67 by 2031, such that the actual NRA is still 65 for these workers.

I simulate the retirement age distribution under the first reform in three steps. First, a counterfactual distribution over the relevant age range is generated by simulating un-bunching at age 65 in the absence of the NRA, and distributing the disappearing bunching mass uniformly across bins at and above the threshold in each pathway. This is based on the result that bunching at the NRA is driven by a shift of the counterfactual density from above described in section 6. Second, bunching at the new NRA of 66 over this counterfactual distribution is simulated in each pathway based on parameters estimated as in section 7. In order to match the shape of the bunching mass observed in the data, some dispersion of bunching into one bin to the right and one bin the left of the threshold is allowed for. Moreover, some round-number bunching that would emerge at age 65 even in the absence of the NRA is taken into account by augmenting the distribution at the old NRA by the average amount of round-number bunching at ages where no statutory ages are located for birth cohort 1946, namely 61, 62 and 64.

In order to make the reforms comparable, the second reform is designed to match the increase in retirement ages from the first scenario. Hence, I calibrate the increase in the Delayed Retirement Credit in order to yield the same increase in the average job exit age shown in Table 5. The calibration proceeds in four steps. First, the reduction in bunching at the NRA and the corresponding rightward shift of the density above the NRA that would entail the same average job exit age increase as the first reform is solved for. Second, the size of the lifetime budget constraint kink at the NRA that would generate this amount of (un-)bunching at the NRA in each pathway is computed. Third, using the individual-level pension benefit simulator described in Appendix C.2, the delayed retirement credit is increased from its actual level of 6% for each individual until the required kink size at the NRA is achieved. Fourth, remaining bunching at the NRA and the distribution of retirement ages above the NRA is simulated under the increased financial rewards.

G.2 Fiscal Effects

The fiscal effects of the counterfactual policies shown in Table 5 are computed in terms of net present value at age 65 for the birth cohort 1946. The total fiscal effect has several components. On the one hand, there is an increase in contributions to the pension system due to the delay in job exits in both scenarios. On the other hand, the net present value of pension benefits paid to affected workers changes due to three factors. First, workers receive pensions for a shorter duration because they work longer and thus claim their pension later. Second, due to longer contribution periods, there is a slight increase in monthly pension benefits as the pension formula is an increasing function of lifetime contributions. These two effects arise under both reforms. Third, in the second scenario, the higher Delayed Retirement Credit constitutes a direct change to the pension formula, substantially increasing pension benefits paid to workers who delay retirement beyond the NRA. Both the NPV of additional contributions and the change in the NPV pension benefits are calculated with a discount factor of 3%, using the corresponding parts of the lifetime budget constraint simulator. The effects are computed for each worker and then summed across the entire birth cohort 1946 to obtain total fiscal effects.

The main reason why I focus on fiscal effects for one birth cohort in Table 5 is that they are straightforward to simulate, as all the relevant characteristics of the workers in cohort 1946 can be observed. However, it may also be interesting to consider a measure of fiscal effects more directly related to the balance of the pension system, such as the total annual impact on the system. Suppose that the increase in the NRA or the Delayed Retirement Credit are implemented such that cohort 1946 and all subsequent cohorts are subject to the respective reform. Again, the annual fiscal effect consists of several parts. First, those workers who would have retired in a given year pay contributions for longer. Second, the same workers start receiving pension benefits later. Third, all workers that have retired under the post-reform regime receive a different amount of benefits in each year as long as they are alive. Hence, the total annual impact of the reform is the sum of the first two effects for the cohort currently retiring, plus the third effect for all cohorts that are already retired and receiving benefits.

Table G1 shows the long-run annual fiscal impact of the two reforms based on a simple back-of-the-envelope calculation. I calculate the change in the fiscal balance of the pension system once the respective reform is fully phased in, assuming that the stock of retirees is made up of a series of cohorts identical to the 1946 cohort who were all subject to the new regime. This yields an annual impact of around +€1.1bn for the first reform, and an annual impact of −€1.2bn for the second reform. Hence, the annual fiscal impact on the pension system is qualitatively similar to the effects in terms of NPV for one cohort. To explain differences between the annual fiscal impact and the NPV effects, the timing of payments matters. The effect of the NRA reform is relatively similar, as most of the changes occur immediately: workers pay contributions for longer and receive benefits for a shorter period around the time of retirement. Longer-lasting effects on the level of benefit payments are small as there is no explicit change to benefit adjustment. In the second reform, however, there is a substantial increase in future benefit payments which accumulates over time as more cohorts retire under the new regime. Thus, the long-run annual impact is more negative than the NPV effect for one cohort.

Finally, Table G1 also shows the mechanical fiscal effects of both reforms in addition, i.e. the total fiscal effect in the absence of any behavioral responses. The NRA increase only has a small mechanical fiscal effect of +€22m in NPV terms for cohort 1946. The positive mechanical effect arises because workers who retire at a given age after the old NRA would be paid smaller late retirement rewards. However, the magnitude of the effect is small as there are very few workers initially retiring beyond the NRA. The second reform, on the other hand, features a negative mechanical fiscal effect as benefit levels are increased for those workers retiring at a given age above 65. Although the benefit schedule changes beyond the NRA are substantial, the mechanical effect is only −€33m, again because only few workers would benefit from the increase in pension levels in the absence of behavioral responses.

Fiscal Effects and Actuarial Fairness An important implication of the counterfactual simulations is that shifting reference points effectively influences retirement ages, and such a reform can generate a positive fiscal impact. It is important to note that this does not necessarily imply that increasing statutory retirement ages always has positive fiscal impact regardless of the characteristics of the pension system. Rather, they should be interpreted in the sense that it is possibe to generate a positive fiscal effect as high financial rewards are *not* required in order to increase actual retirement ages. In the simulated NRA reform, the average retirement age increases although no explicit financial rewards are provided between the old and the new NRA. Furthermore, marginal pension adjustment is less than actuarially fair in the German pension system (Börsch-Supan and Wilke 2004) and in many other countries. Providing steeper pension increases for late retirement at the same time would naturally dampen the fiscal effect of increasing the NRA. At the extreme, there would be no behavioral fiscal effect of increasing retirement ages per se if benefits are increased in a fully actuarially fair way between the old and the new NRA. In such a scenario, only mechanical fiscal effects of the reform would arise only due other changes in the benefit schedule such as a benefit cut across the board (see section G.1).

Finally, the fiscal effect of the Delayed Retirement Credit reform is also related to actuarial fairness. The reason why the fiscal impact turns negative is because pension adjustment would have to be increased above the actuarially fair level in order to yield the same impact on retirement behavior as the NRA reform.

Table G1: Policy Counterfactuals: Additional Fiscal Effects

	(1)	(2)
Policy	Normal Retirement Age increase from 65 to 66	increase in rewards for late retirement from 6% to 12.6%
Baseline fiscal effects (NPV for birth cohort 1946)		
Total effect	+€1038m	−€572m
contributions collected	+€421m	+€421m
benefits paid	−€617m	+€993m
Mechanical effect	+€23m	−€33m
Long-run annual impact on pension system		
Total effect	+€1124m	−€1185m
contributions collected	+€518m	+€518m
benefits paid	−€606m	+€1703m

Notes: The table 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. Baseline fiscal effects are those shown in Table 5, calculated as the net present value for the birth cohort 1946 at age 65. "Mechanical effect" refers to the effect of the respective reform if there were no behavioral responses, and is calculated in NPV terms as the baseline effects. "Long-run annual impact on pension system" refers to the total impact on the fiscal balance of the pension system per year once the reform is fully phased in, that is when all retired cohorts have been subject to the post-reform regime, and is calculated in 2020 Euros.