Online Appendix to "Reference Points for Retirement Behavior: Evidence from German Pension Discontinuities"

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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.

* 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).

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.

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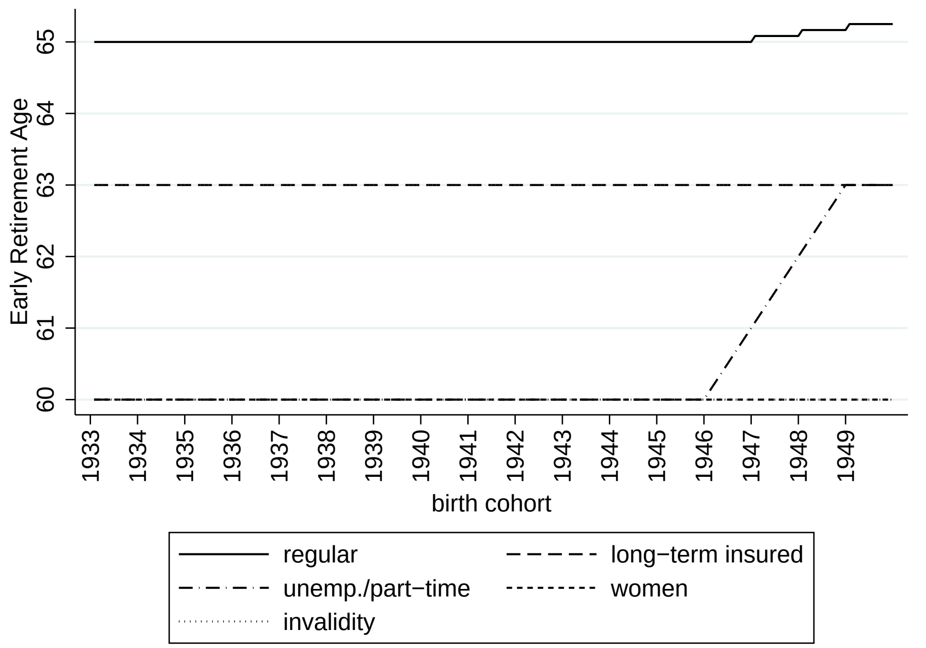
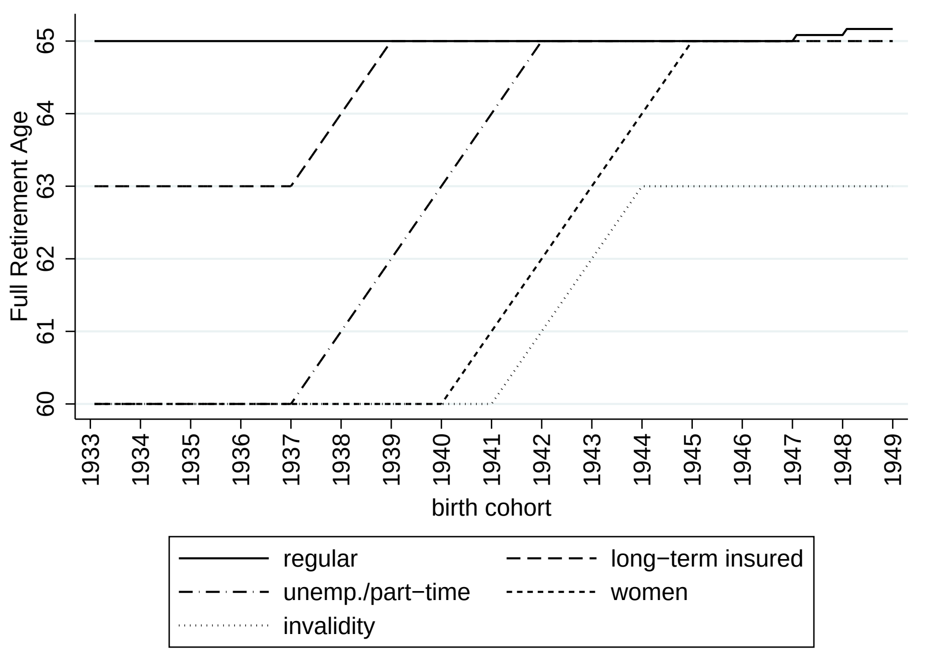
Notes: The figure shows excerpts of an information leaflet that informs workers about a future pension reform where the Normal Retirement Age will be increased to 67. Explanation of the main points is provided in the red boxes on the right. The bottom right panel on this page is taken from an information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



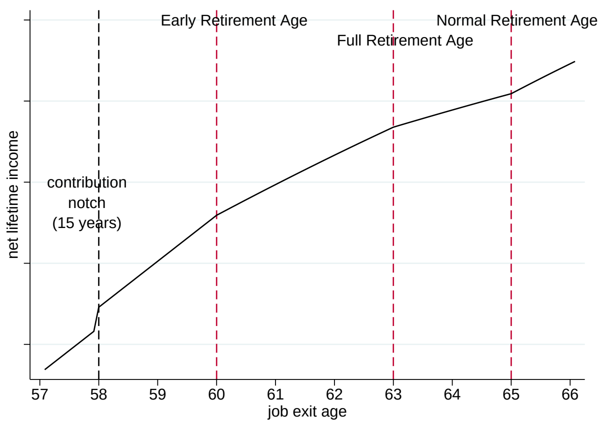
Panel B: Full Retirement Ages



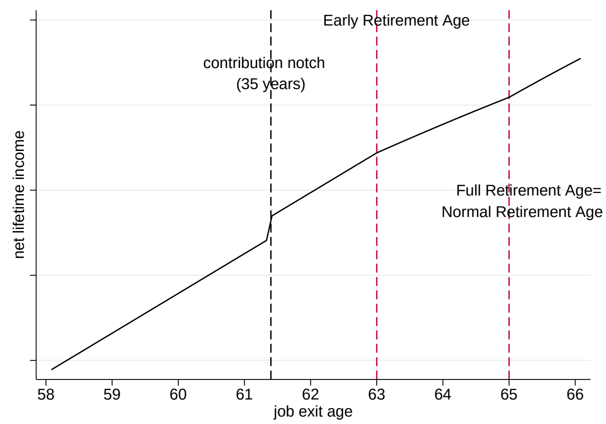
Notes: The figure shows the evolution of Early Retirement Ages (ERA) and Full Retirement Ages (FRA) of different pathways across monthly birth cohorts. In Panel A, the regular ERA is increased from 65 to 65/3 between 1947 and 1949 and the unemployed/part-time ERA is gradually increased from 60 to 63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

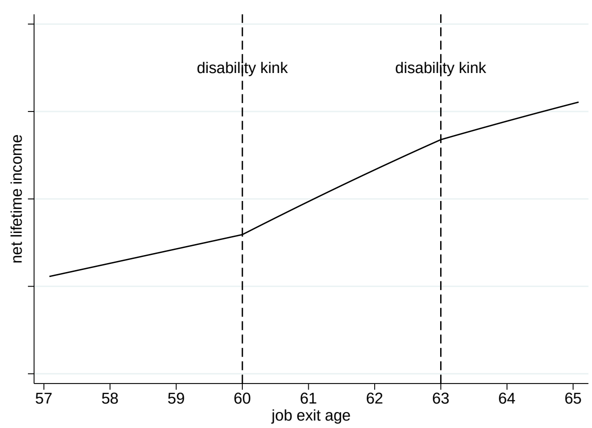
Panel A: Female, born December 1942



Panel B: Male, born March 1939

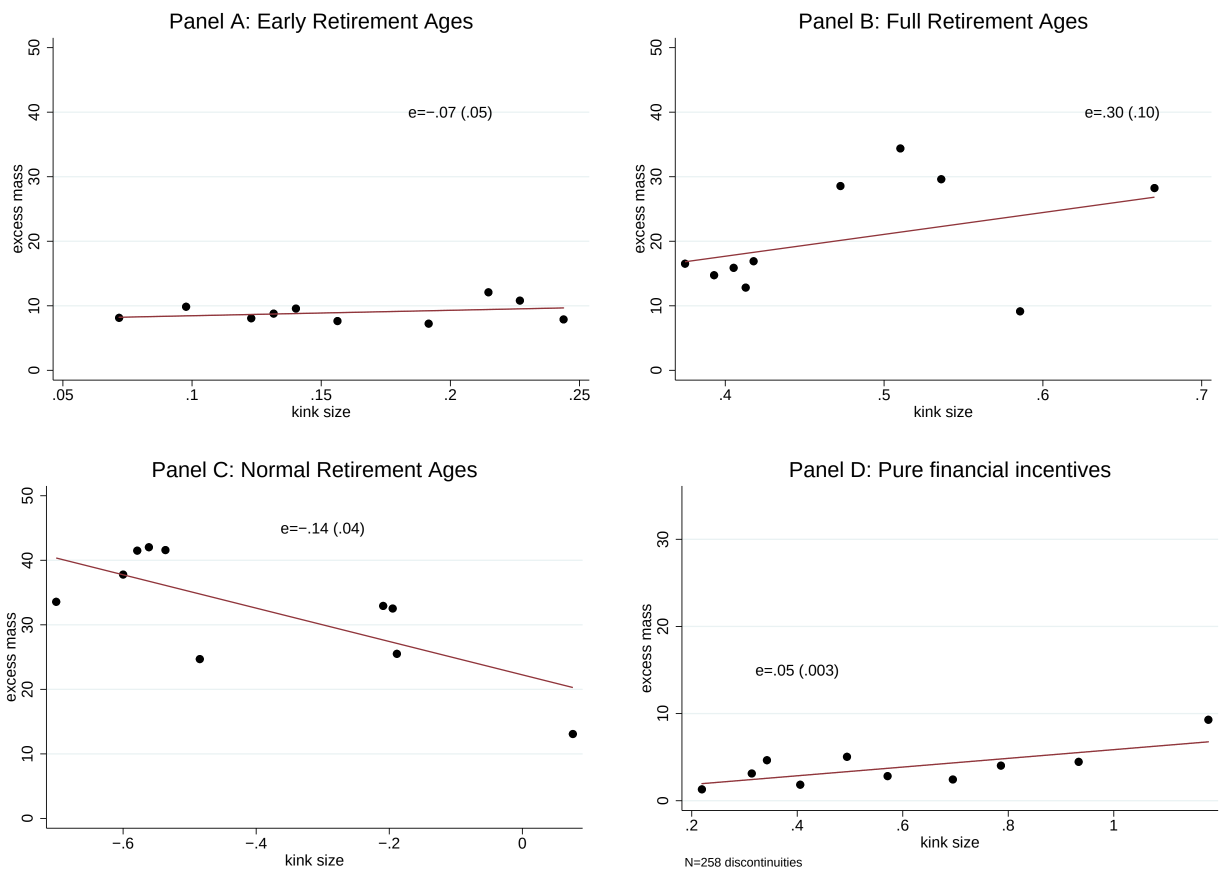


Panel C: Male, born January 1946, satisfies disability requirement



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.

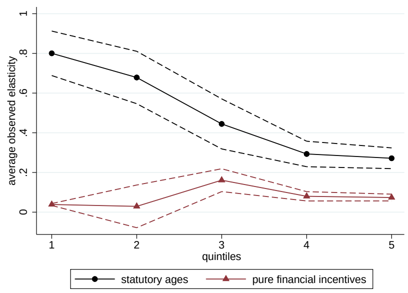
Figure A4: Bunching by Size of Financial Incentive



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.

Figure A5: Heterogeneity: Additional Graphs

(A) Lifetime Earnings



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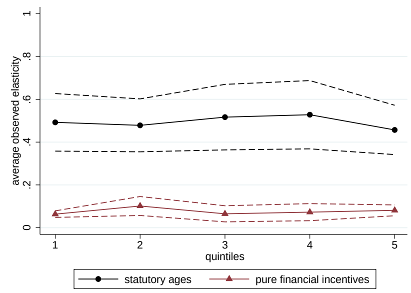
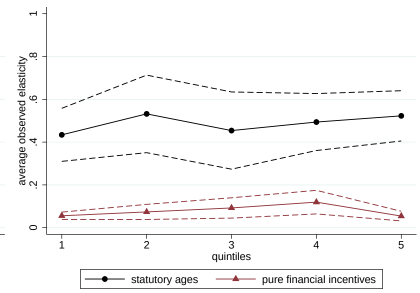
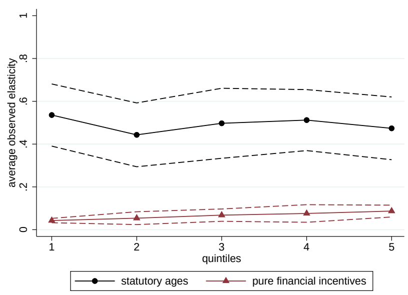


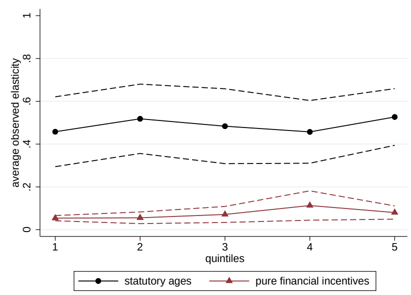
(ii) Limited characteristics



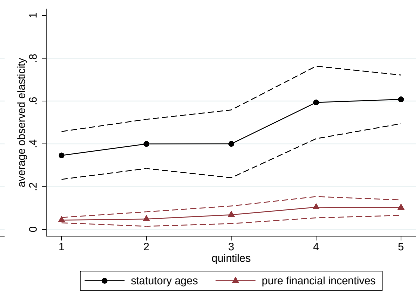
(iii) Baseline characteristics



(iv) Extended characteristics

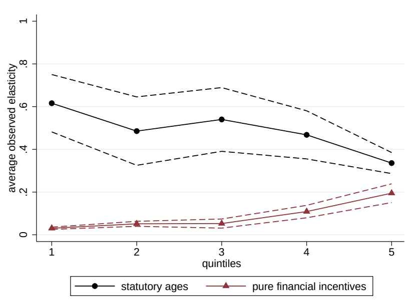


(v) Baseline+cohort FE



(vi) Baseline+cohort/pathway FE

(B) Education



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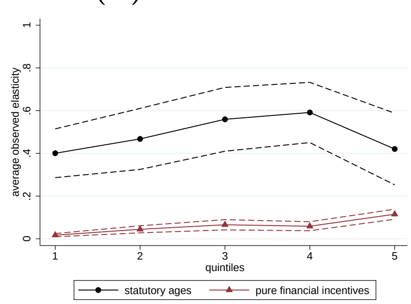

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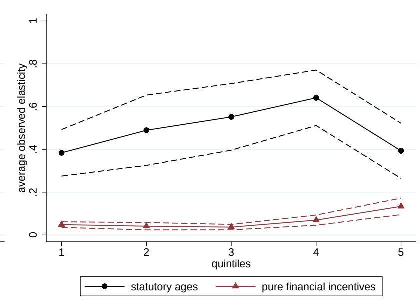

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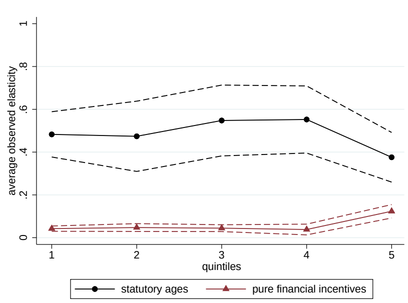

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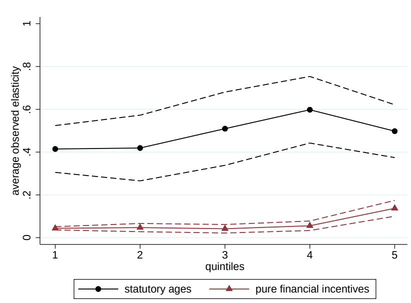
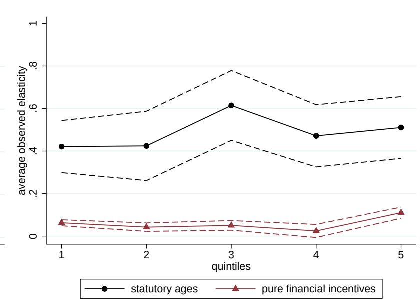


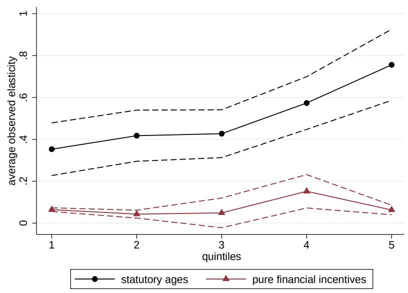
(v) Baseline+cohort FE



(vi) Baseline+cohort/pathway FE

Figure A5: Heterogeneity: Additional Graphs (continued)

(C) Health (5=healthiest)



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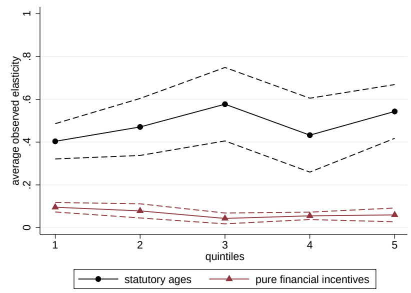

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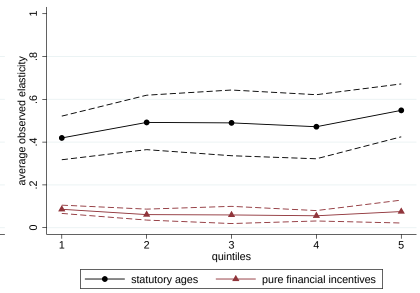
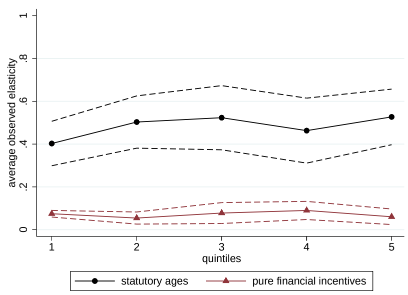


(iii) Baseline characteristics



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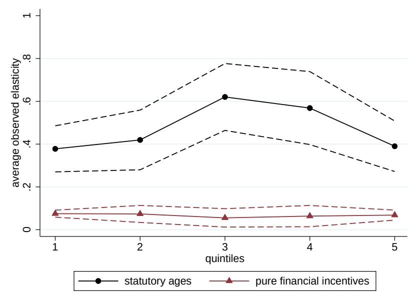
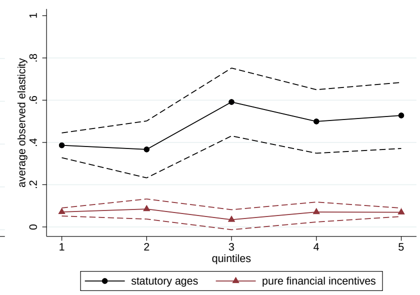
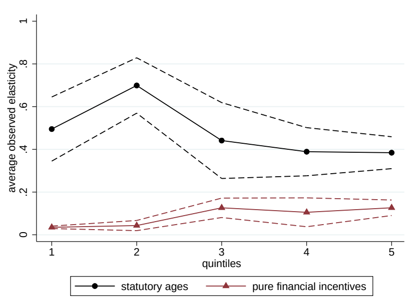


(v) Baseline+cohort FE



(vi) Baseline+cohort/pathway FE

(D) Firm Size



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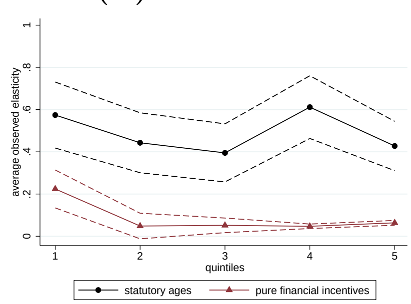

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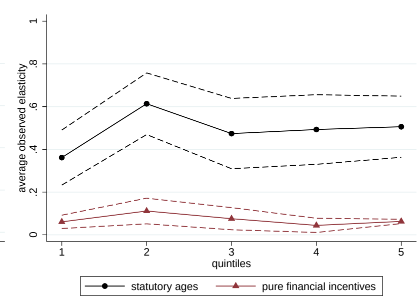

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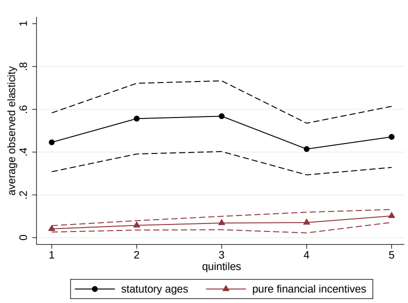

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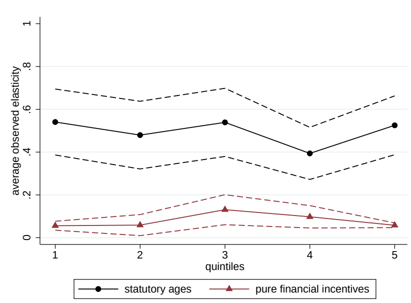
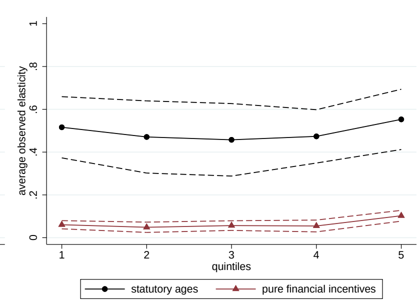


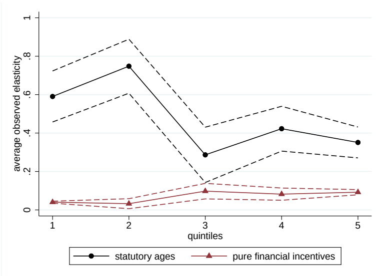
(v) Baseline+cohort FE



(vi) Baseline+cohort/pathway FE

Figure A5: Heterogeneity: Additional Graphs (continued)

(E) Unionization



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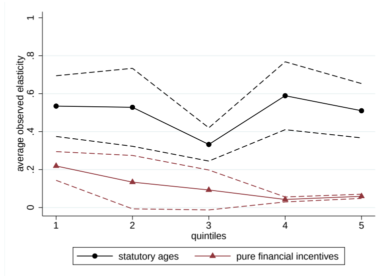

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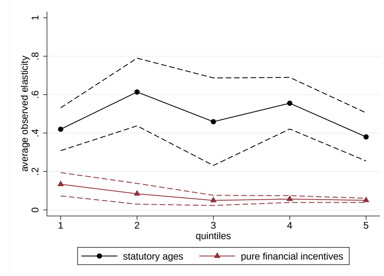

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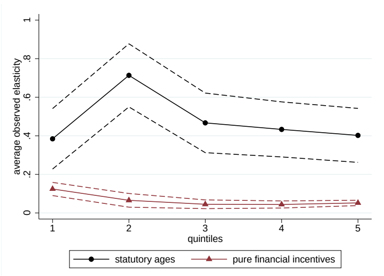

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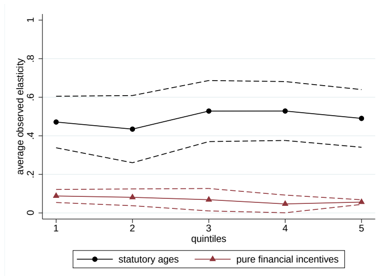

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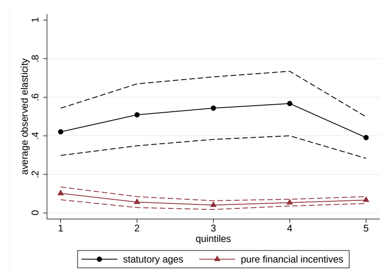
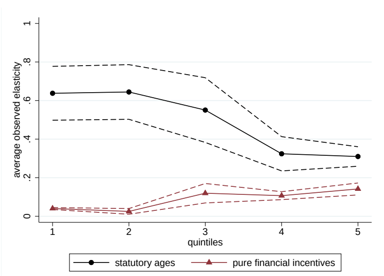


(vi) Baseline+cohort/pathway FE

(F) Tenure



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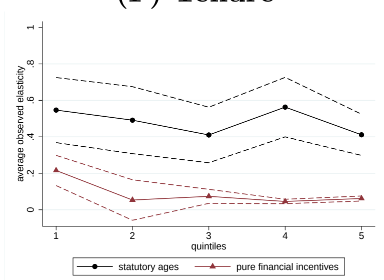

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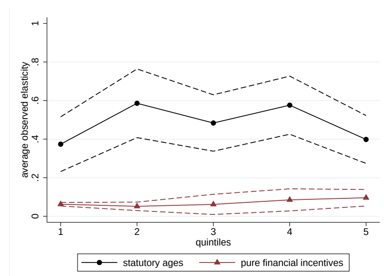

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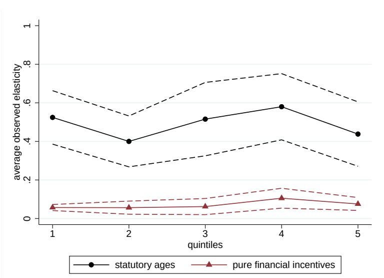

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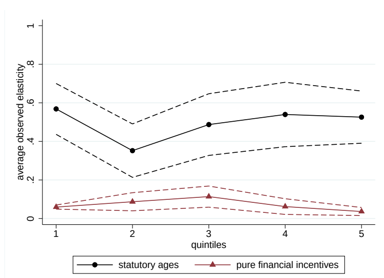

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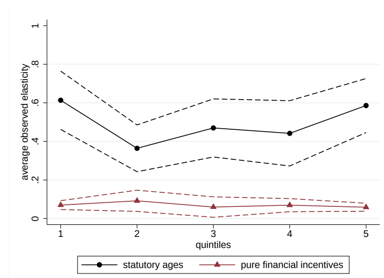


(vi) Baseline+cohort/pathway FE

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

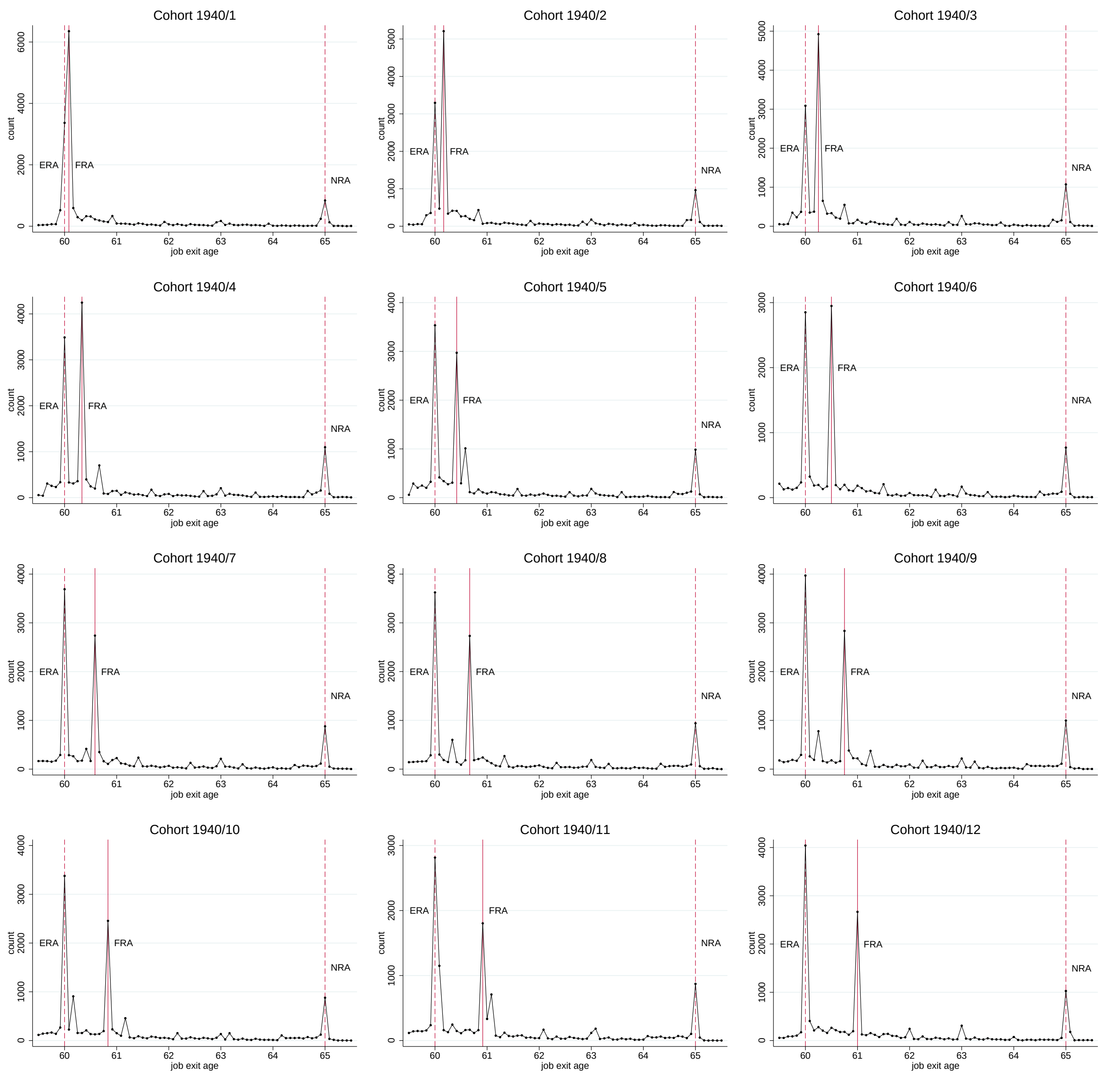


Figure A6: The Effect of Increasing the Full Retirement Age (continued)

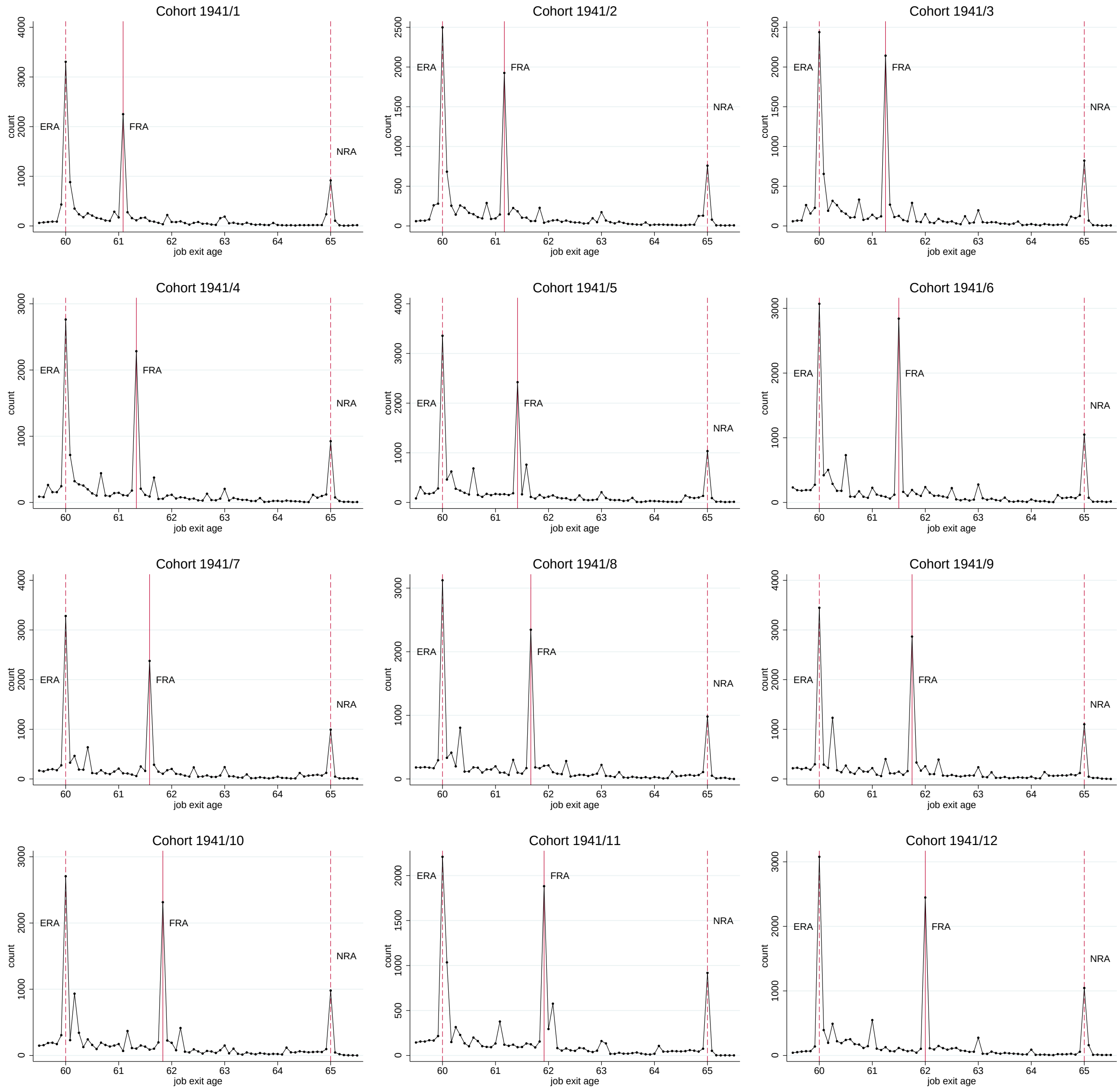


Figure A6: The Effect of Increasing the Full Retirement Age (continued)

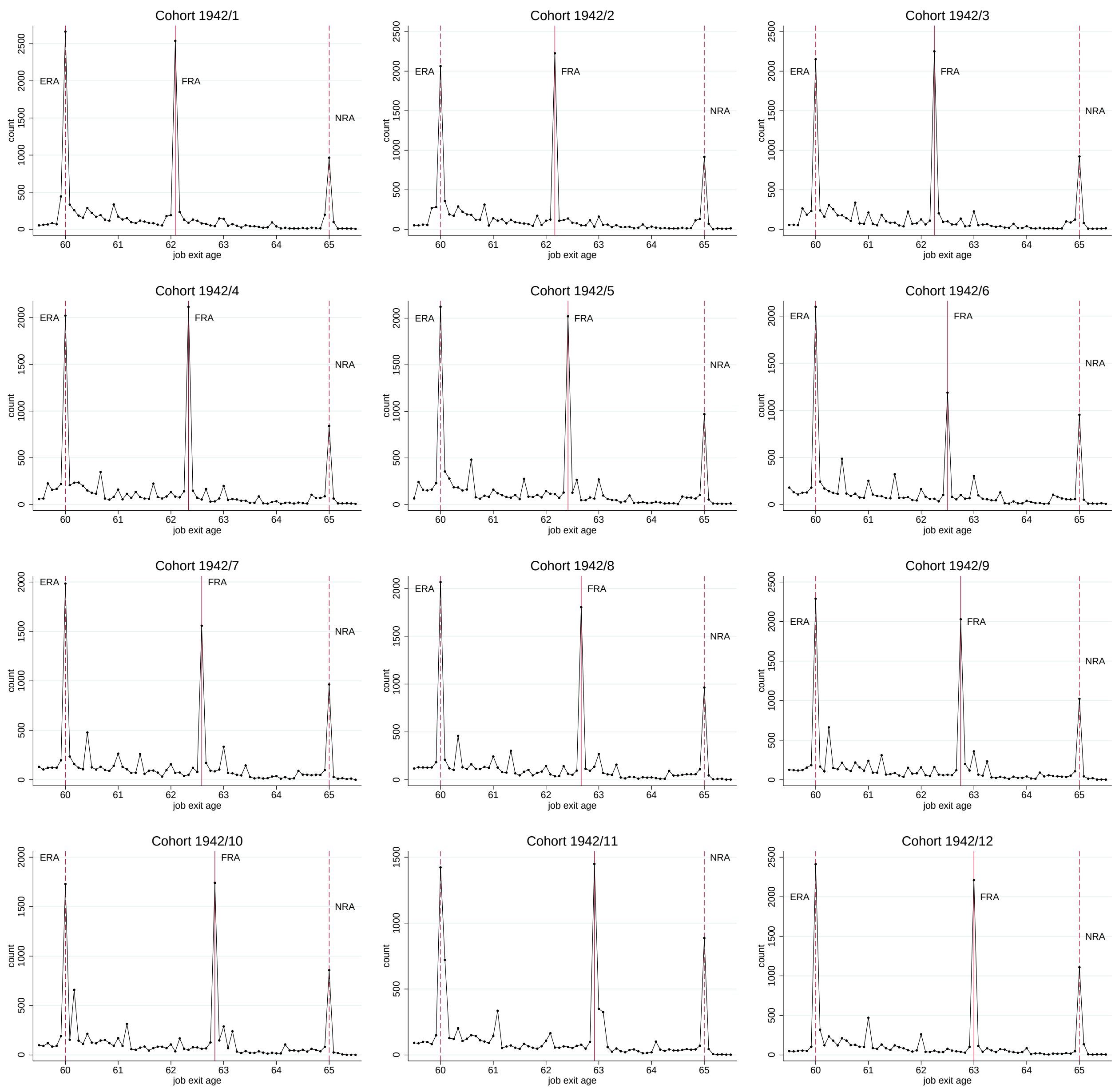


Figure A6: The Effect of Increasing the Full Retirement Age (continued)

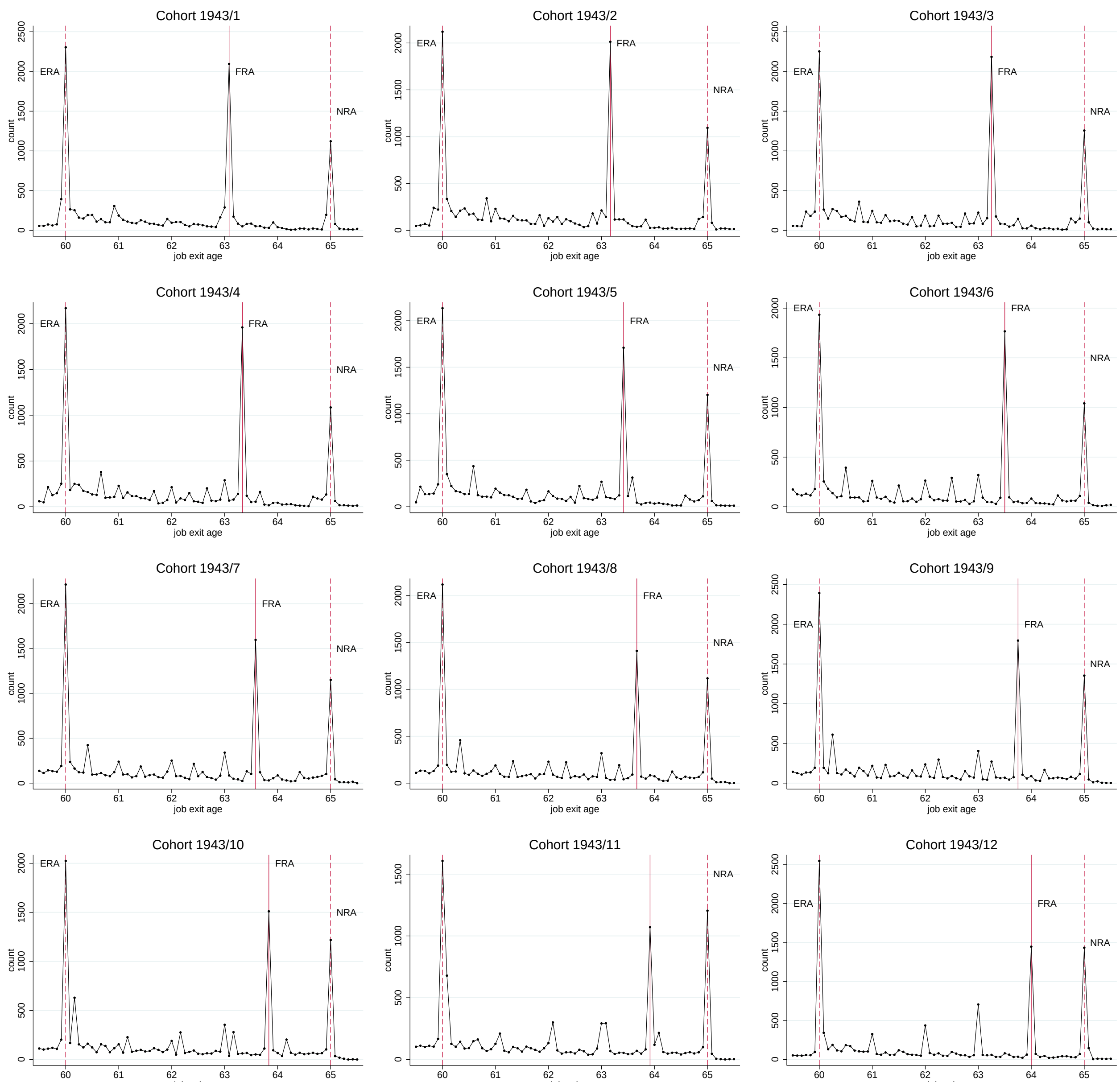
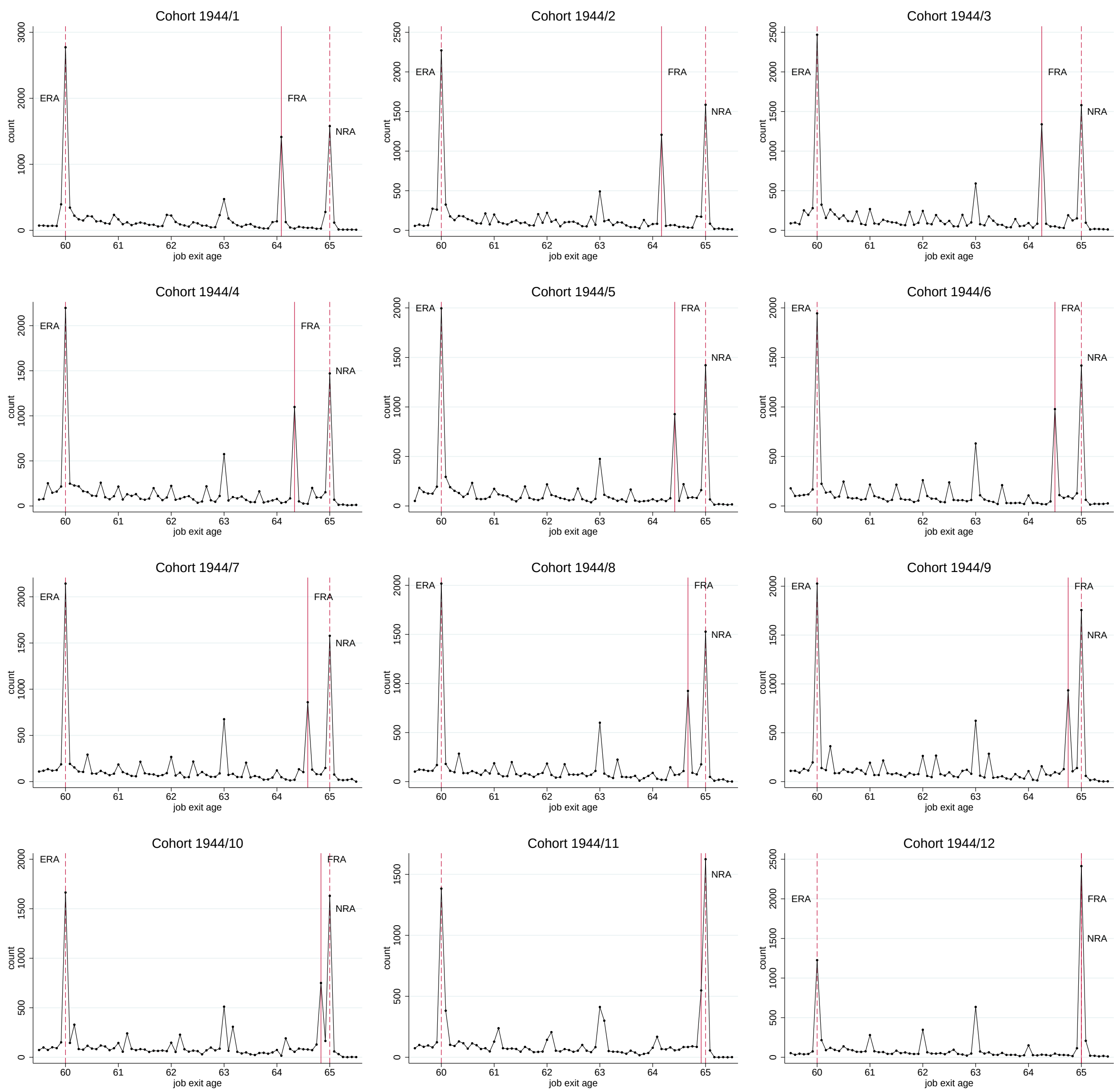
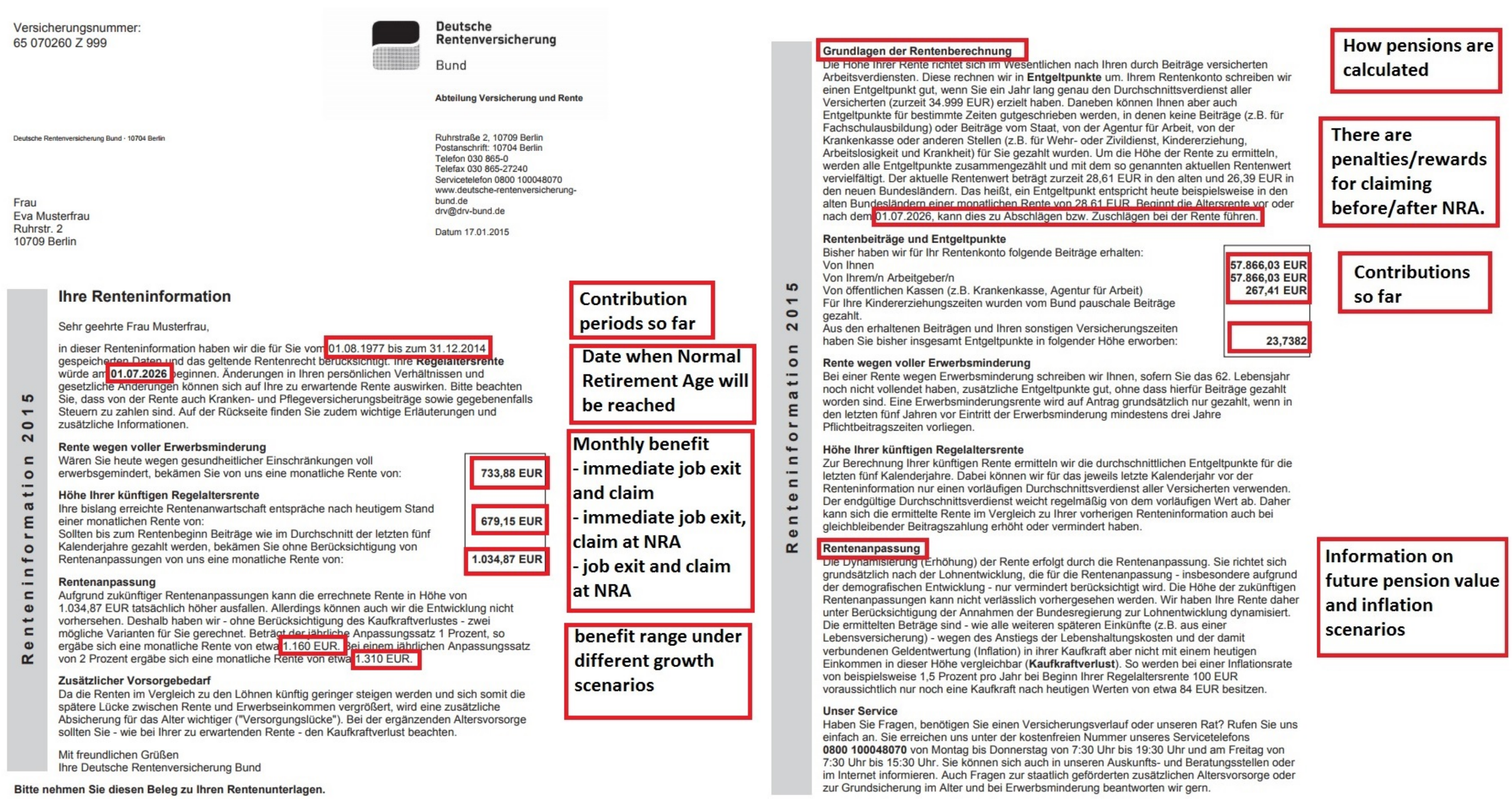


Figure A6: The Effect of Increasing the Full Retirement Age (continued)



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

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Frau
Eva Musterfrau
Ruhrstr. 2
10709 Berlin

Datum 17.01.2015

Renteninformation 2015

Ihre Renteninformation

Sehr geehrte Frau Musterfrau,

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

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

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

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

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

Mit freundlichen Grüßen
Ihre Deutsche Rentenversicherung Bund

Bitte nehmen Sie diesen Beleg zu Ihren Rentenunterlagen.

Renteninformation 2015

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

Rentenbeiträge und Entgeltpunkte

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

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

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

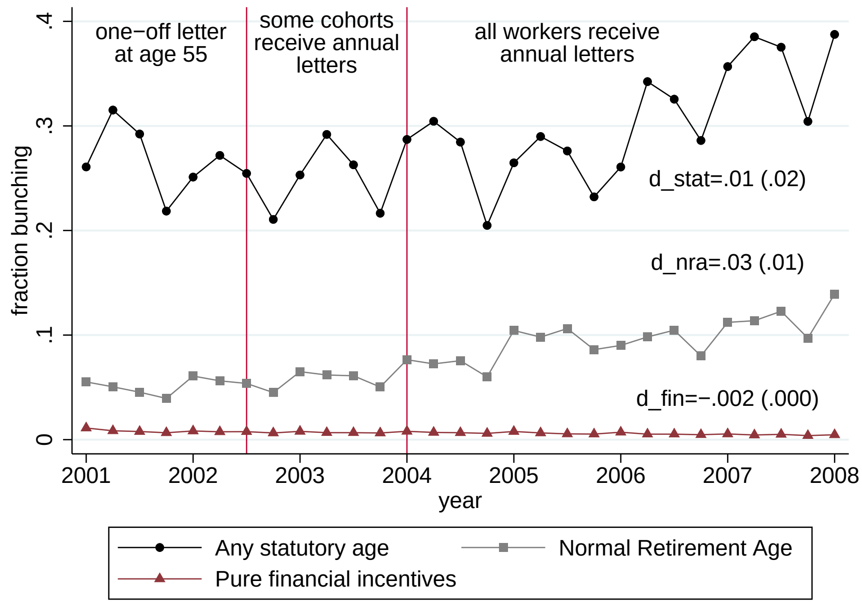
Rentenanpassung
Die Dynamisierung (Erhöhung) der Rente erfolgt durch die Rentenanpassung. Sie richtet sich grundsätzlich nach der Lohnentwicklung, die für die Rentenanpassung - insbesondere aufgrund der demografischen Entwicklung - nur vermindert berücksichtigt wird. Die Höhe der zukünftigen Rentenanpassungen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

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

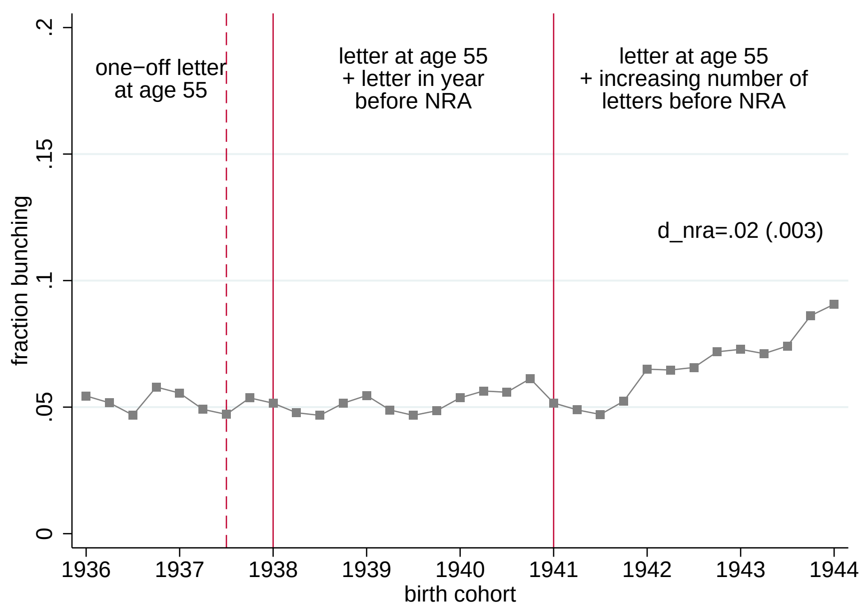
Notes: The figure shows an example of an information letter (*Renteninformation*) sent to workers by the German State Pension Fund. The number of letters of this kind was increased throughout the reform described in section 5.2. Red boxes on the right provide a summary and explanation of the content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

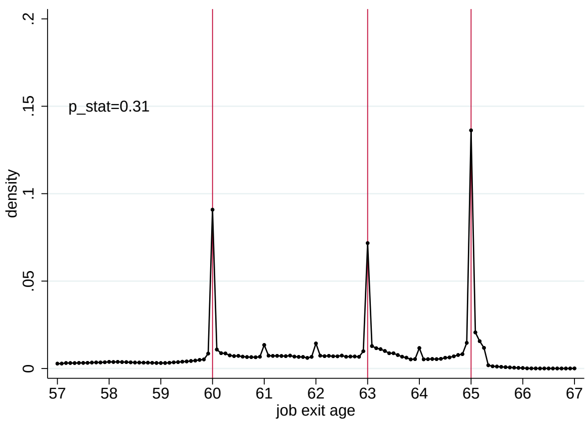


Panel B: By Birth Cohort

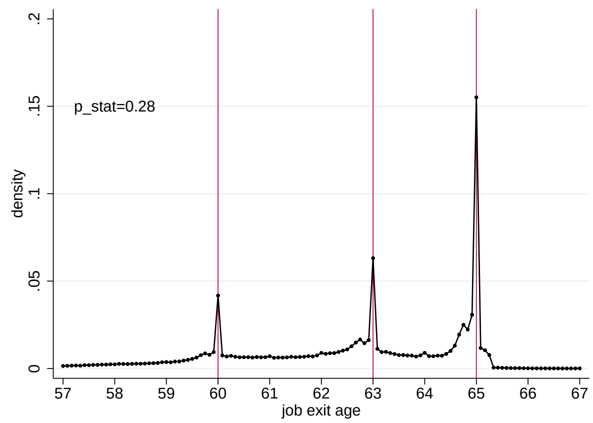


Notes: The figure shows the fraction of workers bunching at at different types of discontinuities throughout a reform period, where the number of information letters sent to workers increases. Panel A shows the fraction of workers bunching at any statutory age (black dots), the Normal Retirement Age (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.

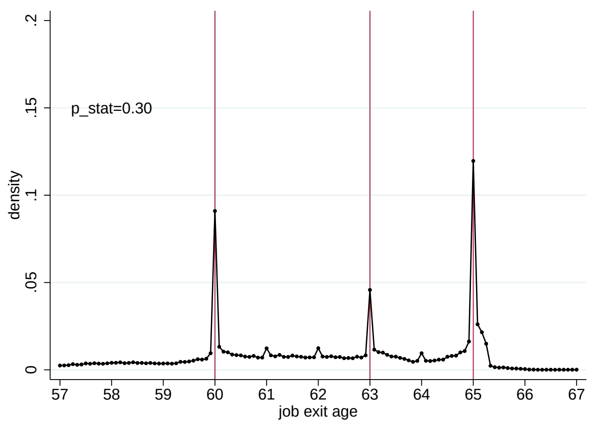
Figure A9: Self-Employed and Small Firms



(A) All occupations



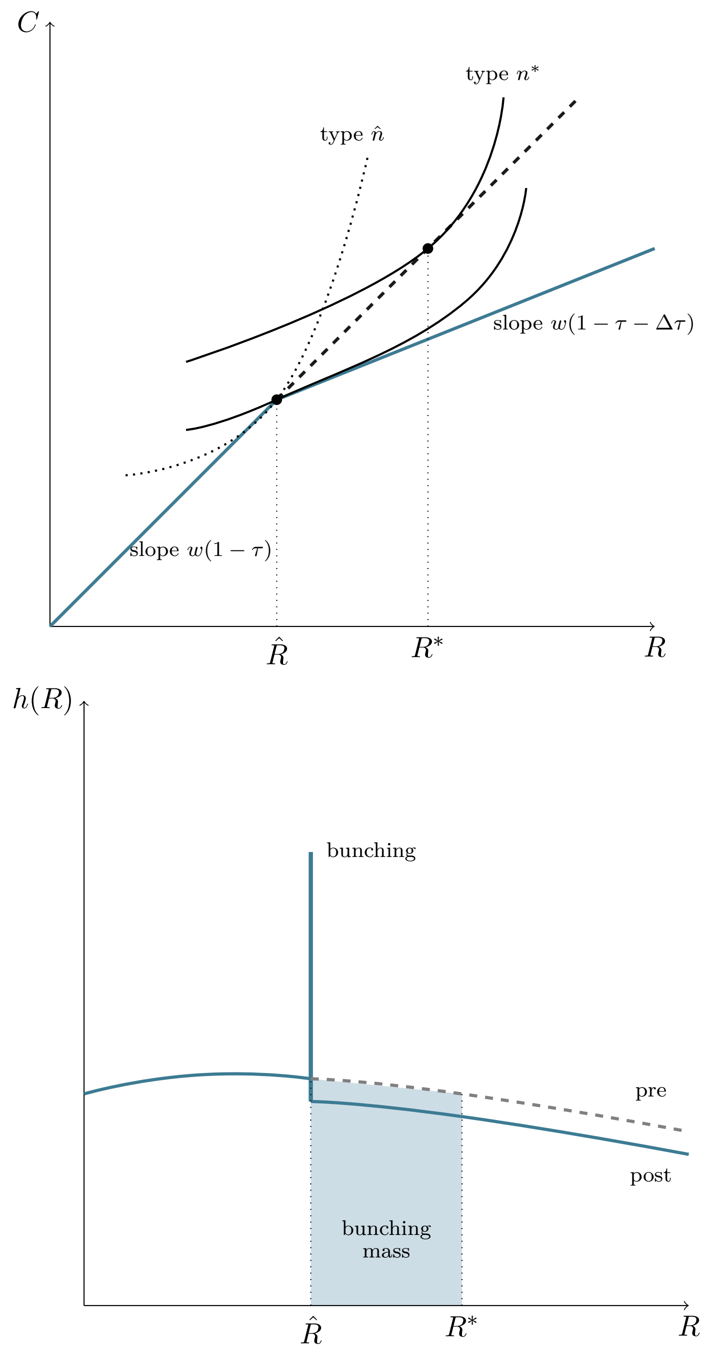
(B) Self-employed



(C) Most frequently in small firms

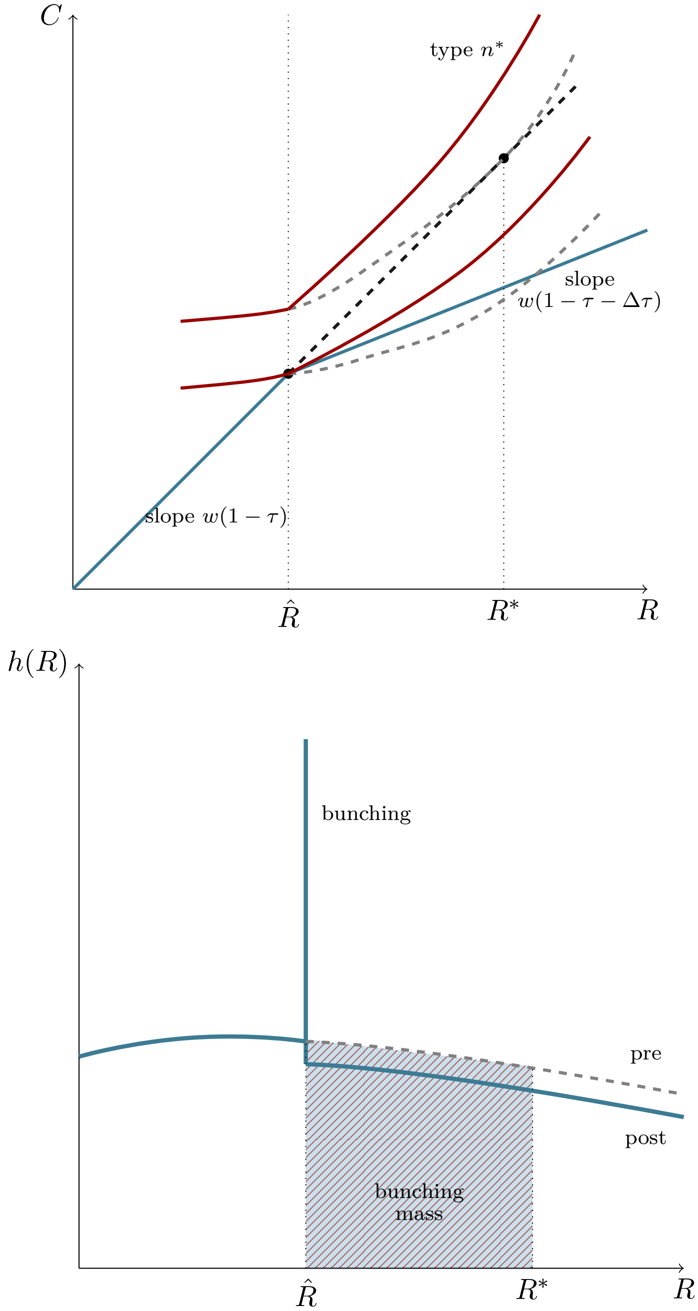
Notes: The figure shows the pooled distribution of job exit ages for all workers in the occupation-matched sample (Panel A), self-employed workers enrolled in the public pension system (Panel B), and the 20 occupations most frequently in small firms with less than 20 employees (Panel C). Self-employed 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



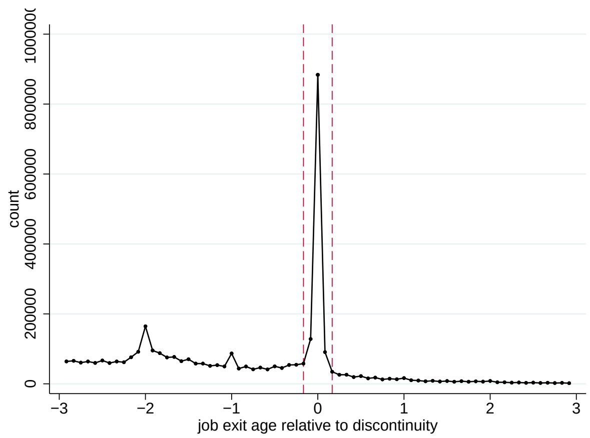
Notes: The figure shows retirement bunching responses to a budget set kink in an indifference curve diagram (upper panel) and a density diagram (lower panel). In the upper panel, the blue line is the post-kink budget set, whereas the dashed gray line is the pre-kink budget set. The dotted curve is an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

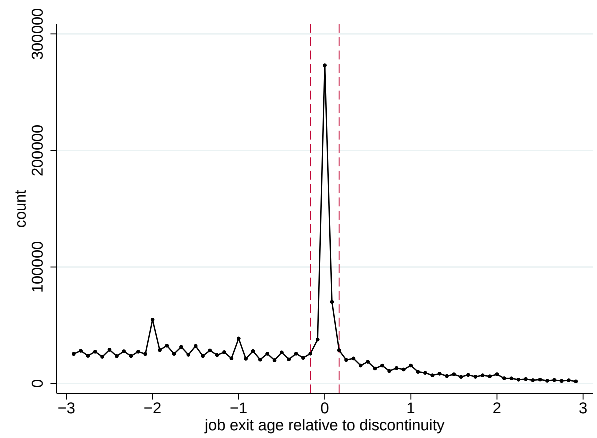


Notes: The figure shows bunching responses to a retirement age threshold combining a budget set kink and a reference point in an indifference curve diagram (upper panel) and a density diagram (lower panel). In the upper panel, the blue line is the kinked budget set, and the dashed black line is the initial 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.

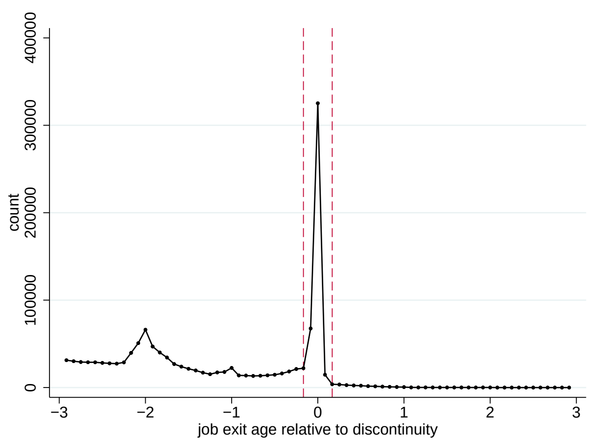
Figure A12: Pooled Empirical Density: Additional Graphs



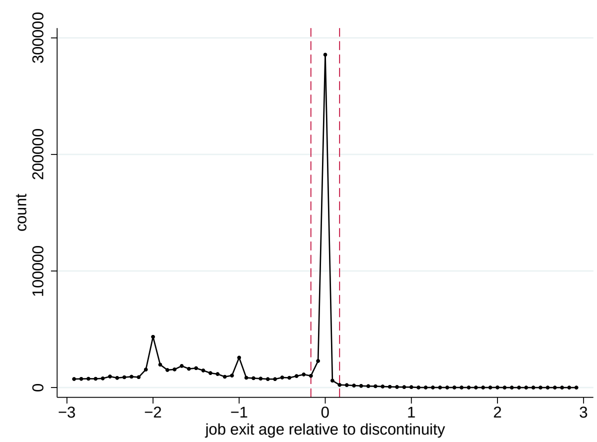
(A) Pooling All Full and Normal Retirement Ages



(B) Only Full Retirement Age



(C) Only Normal Retirement Age

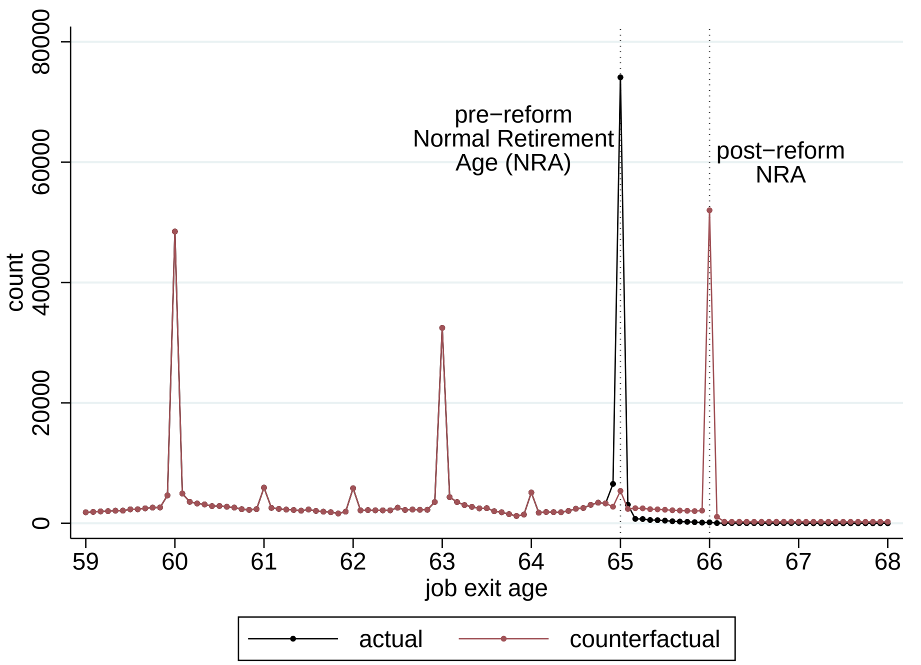


(D) Coinciding Full=Normal Retirement Ages

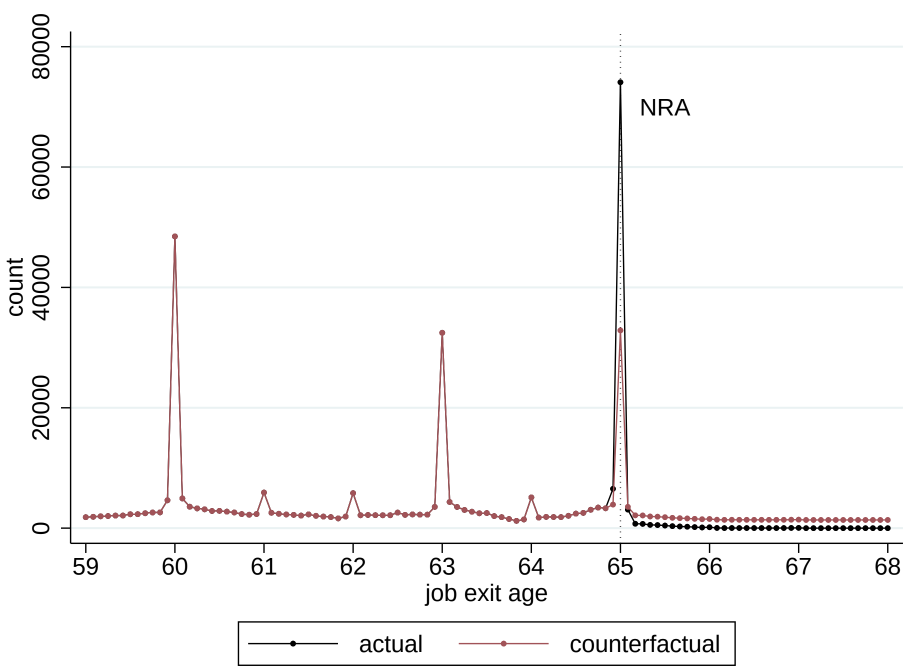
Notes: The figure shows the pooled empirical density around Full and Normal Retirement Ages, with the age at the discontinuity normalized to zero. Panel A shows the pooled density around all Full and Normal Retirement Ages as in Figure 8. Panel B shows the density around discontinuities featuring only 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 11.4% 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 $\times$ 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*[1]) 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.

[1] 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[2]). 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 (FDZ-RV 2015). The main data set is constructed from 23 cross-sections, each of which covers all new public pension claimants in one calendar year. 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 20 months before benefit claiming and category 4 8 months before retirement, her job exit is age

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

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 (Statistisches Bundesamt 2011). 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 Additional Data Sources

Survey Data and Variables. The German Socioeconomic Panel is a panel household survey, of which the waves 1984 to 2013 are used (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.

Additional Aggregate Data. The measure of labor market tightness used in Online Appendix Table A5 is based on based on annual vacancy and unemployment data at the state level from the German Federal Employment Agency (Bundesagentur für Arbeit 2020*a*, Bundesagentur für Arbeit 2020*b*).

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[3] 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.[4] 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

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

[3]The starting age can be interpreted as the beginning of "old age" where retirement is considered.
[4]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

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

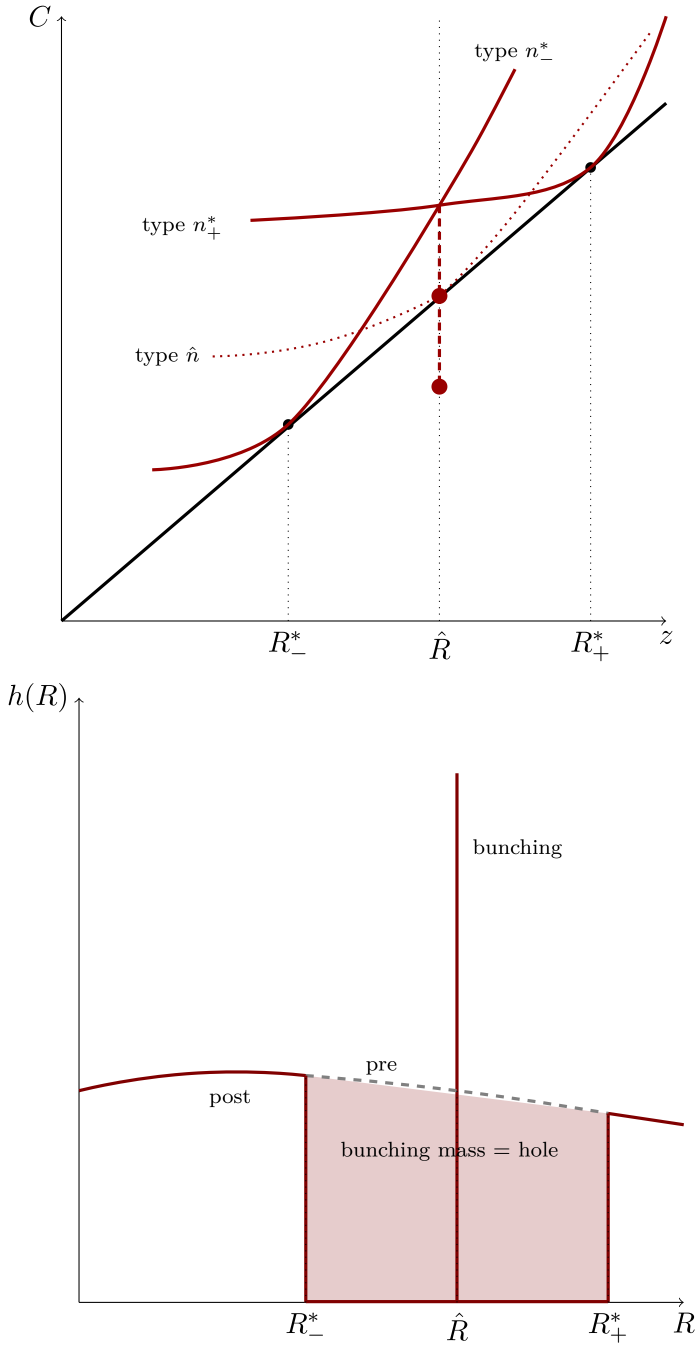
and plugging this into the above indifference condition yields

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

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.

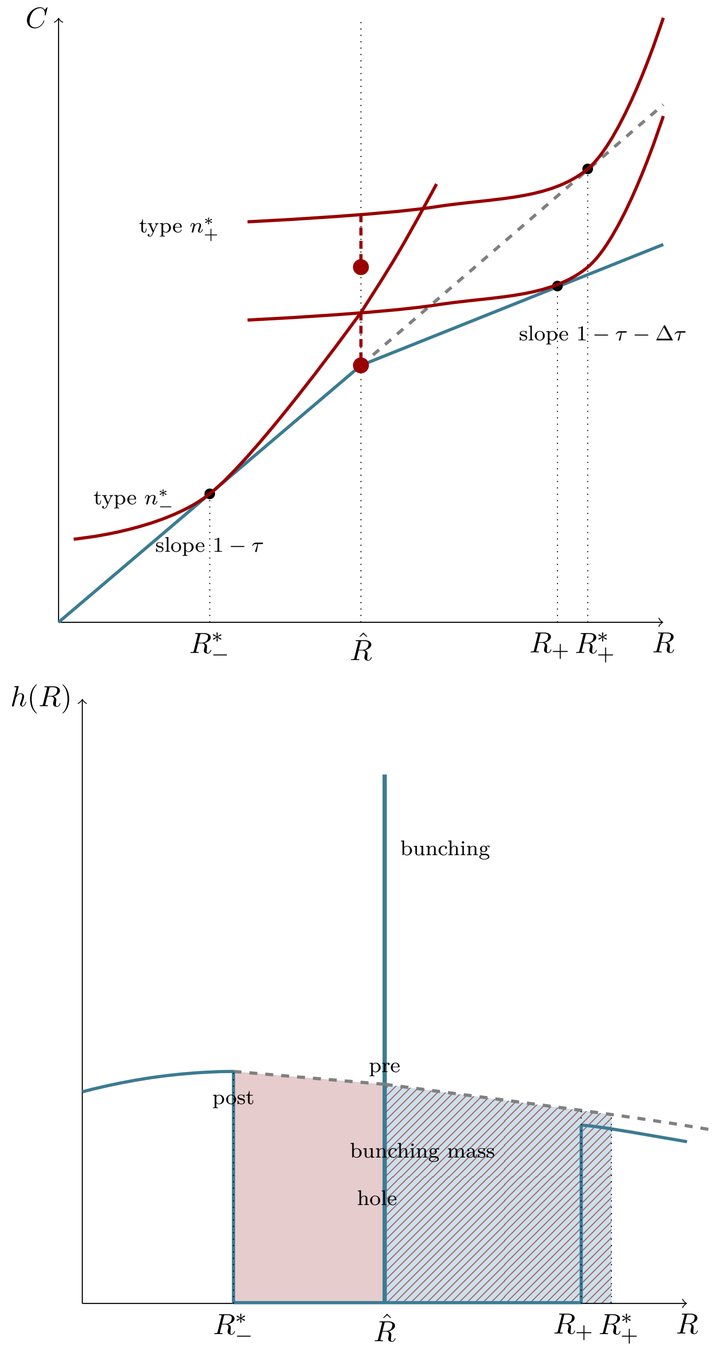
To sum up, when individuals put a fixed utility premium on retiring at statutory ages, this can also induce sharp bunching. However, the model implies a shape of the density around statutory ages that differs from the predicts of reference dependence with loss aversion. Missing mass emerges on both sides 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 +€1134m for the first reform, and an annual impact of −€970m 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 +€23m 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 −€27m, 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 11.4%
Baseline fiscal effects (NPV for birth cohort 1946)		
Total effect	+€1048m	−€420m
contributions collected	+€425m	+€425m
benefits paid	−€623m	+€845m
Mechanical effect	+€23m	−€27m
Long-run annual impact on pension system		
Total effect	+€1134m	−€970m
contributions collected	+€523m	+€523m
benefits paid	−€611m	+€1494m

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.

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