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To estimate the effects of this reform we use differences-in-differences and administrative data on the universe of the Dutch elderly population.

Employment increases by about one third of the drop in retirement.
The use of social insurance also increases by about one third of this drop.
Net budgetary savings are about 80% of direct savings on retirement benefits.

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Abstract

We study the effects of the recent shift in the statutory retirement age in the Netherlands. The retirement age increased stepwise from 65 years in 2013 to 65 years and 9 months in 2017. We estimate the effects of this reform using differences-in-differences and administrative data on the universe of the Dutch elderly population. We find an increase in the employment rate of 16 percentage points and an increase in participation in social insurance of 20 percentage points for the additional months before the new retirement age. Net budgetary savings are about 80% of direct savings on retirement benefits.

JEL codes: J14, J26

Keywords: Retirement age, differences-in-differences, employment, social insurance, public finances, Netherlands

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1 Introduction

The sustainability of public finances is a major concern in many countries, due to aging populations and lower fertility rates. In the Netherlands, these phenomena are expected to increase the age-dependency ratio[1] from 32 percent in 2019 to 51 percent in 2040 (Statistics Netherlands, 2019). To alleviate the financial pressure such developments exert on the pension system, the Dutch government implemented numerous reforms over the past decades. An emblematic example is the reform of the statutory retirement age of the Dutch public pension system, the AOW-age (*Algemene Ouderdomswet leeftijd*). While the AOW age was fixed at 65 up to and including 2012, it started increasing stepwise from 2013 onward. With this reform, the government intends to improve the sustainability of public finances, by reducing expenditures on social security and increasing income tax receipts from higher participation of the elderly. However, the implementation of this reform can also bring about adverse effects. Older workers tend to have weaker employment opportunities, which may render them unable to continue to work. Furthermore, workers that would normally have retired at the old statutory retirement age may substitute towards other social security programs. This may limit the savings on social benefits and the additional tax revenues.

In this paper we exploit the recent cohort-based changes in the statutory retirement age in the Netherlands to study the effect on employment and the use of different types of social insurance. Furthermore, we also estimate the net effect of these changes on the government budget, accounting for behavioral effects.

We study the effects of this reform using a differences-in-differences design, exploiting the cohort-based shift in the retirement age. We estimate the effect of the reform on the probability of being in retirement, employment and other states in the labor market such as disability or unemployment insurance. We use administrative data on different types of income for the universe of the Dutch elderly population. This data also allows us to study the effects of the reform on the government budget, taking into account behavioral effects. Precise estimates for a large set of placebo treatment dummies before the actual shift in the statutory retirement age show that we cannot reject that the treatment and control cohorts share common time effects. Also, we show how one can convert the estimates of the differences-in-differences model into an effect on the average retirement age and average claiming age. Furthermore, we compare the estimated effects of the differences-in-differences design with the estimated effects using a regression discontinuity design.

[1] Defined as the number of indviduals 65 years of age and older over the number of individuals 20 to 64 years of age.

Our main findings are as follows. First, we find a strong drop in the share of individuals in retirement at the old retirement age (–51 percentage points), reflecting the importance of the AOW in shaping retirement behavior in the Netherlands. Second, one third of this drop in retirement results in an increase in employment (+16 percentage points), and more than one third results in an increase in various types of social benefits (+20 percentage points), disability benefits in particular. In our dataperiod we find hardly any evidence of active substitution – for example, individuals moving from employment to disability or unemployment – following the reform. Individuals merely remain in their previous state longer when the retirement age increases. Third, a shift in the statutory retirement age by 3 months increases the average claiming age by 1.8 months according to both the DID and RDD models, and increases the average retirement age by 1 month (DID) to 1.3 months (RDD). Finally, about 47% of direct savings on retirement (AOW) benefits is lost to additional expenditures on social insurance benefits, whereas additional tax receipts are in the order of 28% of direct savings on retirement benefits. This leaves a net effect of 81% of the direct savings on retirement benefits for the government budget.

Our analysis relates to the growing body of literature analyzing the effect of reforms of the early retirement age (ERA) and normal retirement age (NRA). As pension claiming at the AOW is universal and automatic, with a fixed amount that is unrelated to labor supply decision, it shares characteristics with both types of retirement ages. Evaluations of shifts in the ERA, pioneered by Staubli & Zweimüller (2013) for Austria,[2] find strong effect on retirement and employment, as well as important substitutions effects towards social insurance schemes. Despite some variations in the point estimates, the results are qualitatively consistent across the literature: individuals stay longer in their initial state when the ERA increases, hence employment effects are increasing with the share of the population retiring exactly at the ERA. Similar results are found in the case of an increase in the NRA: increases in the average retirement age, pioneered by Mastrobuoni (2009) for the US, are largely driven by shifts in the bunching in retirement at the NRA age (see also Behaghel & Blau, 2012).[3]

We make the following contributions to this literature. We provide a clean and global assessment of the effects of the increase in the AOW reform. We improve on

[2]Other studies include Atalay & Barrett (2015) for Australia, Cribb et al. (2016) for the UK, Seibold (2017) and Geyer & Welteke (2019) for Germany, Manoli & Weber (2018) for Austria and Rabaté & Rochut (2019) and Rabaté (2019) for France.

[3]This shift in the retirement distribution following a change in the NRA is also documented by Brown (2013), Seibold (2017) and Lalive et al. (2017).

De Vos et al. (2018), who recently estimated the effects of the reform on employment using DID and survey data from the Dutch Labor Force Survey, by estimating the effect of the reform on a wide range of outcomes, making use of the full universe of the Dutch population and calculating the effects on the government budget. We also make some useful methodological contributions to the literature. We first build a framework for the computation of the effect of the reform on average retirement and claiming age, which are key parameters of interest for policymakers but cannot be directly inferred from the differences-in-differences estimates. We also compare the DID results with estimates from a RDD, both for the effect around the statutory retirement age and the effect on the average retirement age. This paves the way for a more comprehensive comparison of the different results found in the literature. Finally, we contribute to the literature on bunching close to the retirement age. We find that the bunching at the retirement age shifts with the retirement age. Since the shift in the retirement age is essentially a wealth effect, this suggests that norms, job protection and/or liquidity constraints play an important role in shaping retirement behavior in the Netherlands.

The remainder of this paper is organized as follows. In Section 2, we give an overview of the institutional context, the retirement-age reform and reforms in early retirement and social insurance schemes that could potentially interfere with our analysis. Section 3 outlines the empirical methodology, discusses the data used in the analysis and presents descriptive statistics. Section 4 presents graphical evidence on the effects of the reform, regression results, a number of robustness checks and the effects of the reform for the government budget. Section 5 discusses our findings and concludes. An appendix contains supplementary material.

2 Institutional setup and reforms

The Dutch pension system consists of three pillars, which together allow workers to accumulate pension rights in the order of 70% of their average gross wage for retirement (Knoef et al., 2017).

The first pillar consists of pay-as-you-go old age pension benefits (AOW, *Algemene Ouderdomswet*). Individuals accumulate 2 percent of the full first pillar pension per year of residence in the Netherlands (up to a maximum of 100% of the full benefit). The benefits are linked to the social minimum and also depend on partnership status (a retired single person gets 70% of the social minimum, a retired couple gets 100% of the social minimum).[4] Individuals start receiving the

[4] On July 1st 2019, the (gross) AOW for a single person was EUR 1,228 and for a couple it was

first pillar pension once they have reached their birth-cohort specific 'AOW age'. Individuals cannot bring any first pillar pension benefits forward when they retire earlier. Furthermore, at the AOW age, employment contracts end by law and need to be renewed if an individual worker wants to continue to work. Also, beyond the AOW age individuals are no longer eligible for benefits from other social insurance programs like unemployment insurance and disability insurance.

The second pillar consists of firm- and sector-specific occupational funded pension schemes. The benefits from the second pillar supplement the first pillar benefits. Pension savings in the second pillar depend on an individual's wage income and the pension arrangement that is provided by the firm or sector. Employees and employers pay monthly premiums to the pension fund of the respective firm or sector. These premiums are paid over a certain income threshold and exempt from income taxation up to a maximum income threshold (EUR 107,543 in 2019), and there is no wealth tax on second pillar pension savings. The second pillar pension benefits are indexed to average wages, although indexation may be stalled, or benefits may even be reduced, when the assets of the pension fund drops below a certain percentage of its projected future obligations.[5] Individuals can decide to retire earlier (or later), before the AOW age, and bring part of the second pillar pension benefits forward, with an actuarial fair reduction (increase) in the monthly benefits (De Vos et al., 2018).

The third pillar consists of individual savings for retirement. Individuals can accumulate 1.875% of their average wage income for the expected retirement period per year tax free, via earmarked personal savings or life insurance schemes. Over a working life of 40 years this amounts to 75% of the average wage income.

Knoef et al. (2017) calculate replacement rates for a representative sample of the Dutch population, combining data on first, second and third pillar pension in the Income Panel dataset of Statistics Netherlands. The median replacement rate of expected retirement income from first and second pillar pensions for individuals 60–65 years of age when they turn 67 is 68 percent.[6] 39 percentage points come from the first pillar and 29 percentage points come from the second pillar. Adding third pillar pension savings and other assets (including housing wealth), raises the

EUR 1,688 (www.svb.nl).

[5] Indeed, many pension funds have not fully indexed benefits to wage growth following the financial crisis and the drop in interest rates, raising the discounted value of future pension obligations, and may be forced to cut benefits in the near future (CPB, 2019).

[6] They calculate an annuity based on all income and assets projected to be available to the individual at the age of 67, and divide this by gross primary income observed at the age the individual is observed.

median replacement rate to 82 percentage points.[7] There is substantial variation in the replacement rate, ranging from 62 percent at the 25th percentile of the distribution to 106 percent at the 75th percentile of the distribution (Knoef et al., 2017, Table 4). The replacement rate is higher for individuals with a relatively low household income and for employees (when compared to self-employed) (Knoef et al., 2017, Table 11), and slightly higher for immigrants (due to their relatively low primary income) and singles (Knoef et al., 2017, Table 12).

At the introduction of the first pillar pension in the Netherlands in 1957, the retirement age was set at 65. This continued to be the retirement age all the way up to the end of 2012. In 2011, faced with public finances that were no longer sustainable in the long run, the Dutch government adopted a reform package that included an increase in the AOW age from 2013 onwards (see Table 1). The second column shows the planned increase in the AOW age for the different birth cohorts of the reform announced in 2011. In 2012 this reform was amended to allow the AOW age to increase at a faster pace from 2015 onward (third column of Table 1). Furthermore, from 2021 onward the increase in AOW age was linked to the increase in life expectancy.[8] These reforms in the AOW age will be the focus in the analysis below.

There are a number of related earlier reforms in early retirement schemes and the second pillar pension system that are relevant as well, see Table 2. These reforms are important for understanding noticeable upward 'jumps' we observe in the birth-cohort specific labour participation profiles of older workers. Until 2006, workers could opt for an early retirement scheme several years before the AOW age, which was financed via a sectoral or firm specific pay-as-you-go system. This scheme was abolished in 2006, although individuals that would reach the official retirement age before 2015 could use a compensation scheme called the Life Course Saving scheme (*Levensloopregeling*).[9] Consequently, cohorts affected by changes in the AOW age before 2015 are not directly comparable to cohorts affected by changes in the AOW age from 2015 onwards, as we will see in the next section.[10] This is also why we

[7]The median net income replacement rate is 100 percent, as retired individuals pay less taxes than working individuals for the same income.

[8]A new reform was announced in May 2019, and accepted by Parliament in July 2019 (Ministry of Social Affairs and Employment, 2019). In 2020 and 2021 the retirement age will be kept at 66 years and 4 months (similar to 2019). In 2022 it will increase to 66 years and 7 months. In 2023 it will increase to 66 years and 10 months and in 2024 it will become 67 years (which in the 2012 reform would already happen in 2021).

[9]The Life Course Saving scheme, offered tax free savings for, amongst other things, retirement before the AOW age. Saving into this scheme was abolished in 2012, but individuals could still use the accumulated savings to retire early in years beyond 2012.

[10]See e.g. Lindeboom & Montizaan (2018) for an analysis of this earlier reform.

Table 1: Reforms in AOW-age in the Netherlands

Year	2011 reform	2012 reform	AOW age	Affected birth cohort
2012	-	-	65	Before 01-01-1948
2013	1 month	1 month	65+1 month	After 31-12-1947 and before 01-12-1948
2014	1 month	1 month	65+2 months	After 30-11-1948 and before 01-11-1949
2015	1 month	1 month	65+3 months	After 31-10-1949 and before 01-10-1950
2016	2 months	3 months	65+6 months	After 30-09-1950 and before 01-07-1951
2017	2 months	3 months	65+9 months	After 30-06-1951 and before 01-04-1952
2018	2 months	3 months	66	After 31-04-1952 and before 01-01-1953
2019	3 months	4 months	66+4 months	After 31-12-1952 and before 01-09-1953

Source: Tweede Kamer der Staten-Generaal (2012, 2014).

will focus on the reforms from 2015 onwards in the Results section.

Individuals can also exit the labor force before the AOW age using so-called alternative pathways, most importantly unemployment insurance (UI) and disability insurance (DI).[11] A change in the AOW age may, therefore, lead to increased substitution toward other social security programs (OECD, 2019). It is important to take these spillover effects into account when assessing the effectiveness of an increase in the AOW age. Unemployed individuals are entitled to UI if they did not quit their job and worked at least 26 weeks in the last 36 weeks of employment. The minimal duration of the UI benefits is three months. The maximum duration of UI benefits was cut from 5 years to 3 years and 2 months in 2006, and in 2016 it was cut to a maximum of 2 years (although the last reform will not 'bite' in the data period we consider). The individual receives a benefit that is based on the previously earned wage. The replacement rate is 75 percent in the first two months, after which it drops to 70 percent for the remainder of the entitlement to UI. Individuals may also exit the labour force via DI. An individual is eligible for DI of 75% of the previous wage when he or she is fully and permanently disabled. When the individual is partially and/or temporarily disabled, benefits are less generous and depend on the previous wage, number of weeks worked before, the current wage (if applicable) and the 'remaining earnings capability' of the individual.[12] The last major reform of disability insurance was in 2006, when the system became much more strict, as a

[11]See CPB (2015) for an overview of the system of social insurance in the Netherlands.

[12]See e.g. CPB (2015) for further details.

Table 2: Overview of related reforms

Year	First pillar	Second pillar and early retirement	Unemployment Insurance	Disability Insurance
2006		ER tax exemptions abolished, Life Course Saving Scheme introduced	Reduction of max. benefit duration	Stricter distinction between partially, fully and permanently disabled
2008				Experience rating abolished
2009		Deferred Pension Bonus introduced		
2012		Life Course Saving Scheme abolished		
2013	Gradual increase AOW age		New calculation of employment period	
2015	Accelerated gradual increase AOW age			
2016			Gradual shortening of benefit period	

Source: Jongen (2016) and De Vos et al. (2018) .

distinction was made between fully and permanently disabled persons and partially and/or temporarily disabled persons (see Koning & Lindeboom, 2015). After this reform the inflow into DI dropped significantly. Previous studies have shown that these reforms in UI and DI have reduced participation in these schemes, see e.g. De Groot & Van der Klaauw (2019) and Koning & Lindeboom (2015), respectively. However, the different cohorts we focus on in the empirical analysis below would be affected in much the same way by these reforms, and hence are unlikely to interfere with our results.

3 Data and empirical strategy

We use administrative data of the universe of the Dutch elderly population for the period 1999–2017. Our outcome variables are the different states individuals can be in on and off the labor market. Specifically, individuals are classified according to their main source of income, e.g. wage income (employees), profit income (self-

Table 3: Sample description

	AOW = 65 y + 3 m	AOW = 65 y + 6 m	AOW = 65 y + 9 m
Demographic variables			
Age	63.99	63.99	63.96
Share single	0.0930	0.0945	0.0952
Share foreigners	0.114	0.0975	0.102
Share female	0.502	0.503	0.504
Share public	0.116	0.116	0.115
Outcome variables			
Share retired	0.373	0.315	0.253
Share employment	0.303	0.335	0.368
Share in welfare	0.0298	0.0299	0.0347
Share in unemployment	0.0280	0.0349	0.0416
Share in disability	0.102	0.107	0.117
Share in oth transfers	0.0213	0.0238	0.0261
Number of observations	6893000	6654000	6665000

employed), disability insurance benefits, unemployment insurance benefits, welfare benefits, pension benefits, other benefits or no income (typically women in couples). As demographic control variables we have month of birth (to select individuals into treatment and control groups), gender (male/female), migration background (with/without) and household position (single/couple). Furthermore, we use information on sector of employment (public/private), based on individual's situation at age 60.

In the analysis we focus on cohorts born between January 1950 and April 1952 (see below for explanations for this sample selection). We consider the full Dutch population and have approximately 375 thousand individuals. Table 3 presents some summary statistics for the different AOW cohorts we consider. While the shares of employment, unemployment, disability, self-employed and labour force participation (LFP) are increasing over cohorts, retirement is shown to be decreasing. The remaining outcomes stay fairly equal. In the results of the empirical analysis we will indicate what part of these changes observed in the outcome variables across cohorts can be attributed to the AOW reforms.

Following Staubli and Zweimüller (2013), we estimate the effect of the increase in the AOW by comparing the trajectories for e.g. retirement and employment of different cohorts facing different AOW ages. Specifically, we use the following baseline specification in the differences-in-differences analysis:

$$y_{iact} = \beta_0 + \delta_c + \theta_a + \beta_1 \text{I}(\text{age} < \text{AOW})_{iact} + X'_{iat}\beta_2 + \epsilon_{iact}. \tag{1}$$

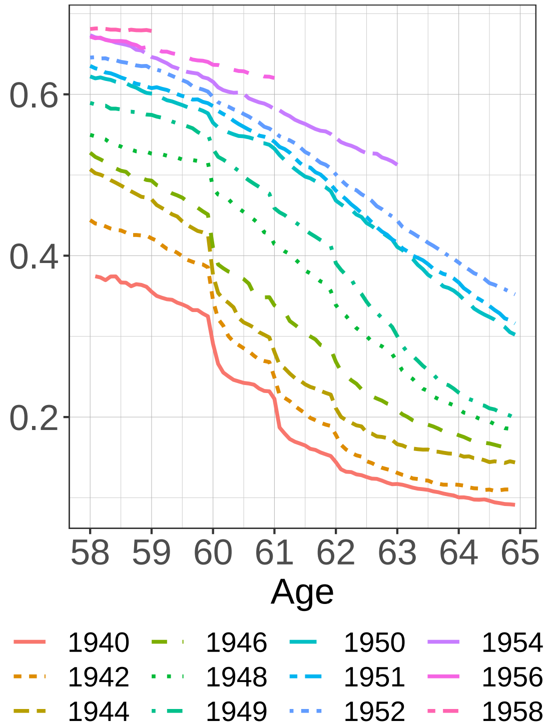
In this specification, δ_c are AOW cohort dummies and θ_a are age dummies (in months). X_{iat} represent demographic and macroeconomic controls. In our main specification, we include two cohorts effects, before and after the AOW age, as the cohort effects exhibit different patterns from both sides of this age.

The parameter of interest is β_1, which indicates the difference in the outcome variable before and after individuals reach the AOW age, between different cohorts. This parameter can be estimated by including a dummy variable that indicates the interaction between the age of an individual and the AOW age cohort that he or she belongs to. In equation (1), the $\text{I}(\text{age} < \text{AOW})_{iact}$ variable represents this interaction. This dummy variable equals one for individuals below the AOW age that is applicable within their cohort, and zero for individuals that have reached this age. As individuals are affected by the reform at different ages depending on the cohort, the value of this variable changes over cohorts as well as over time. Note that the outcomes are binary variables, and we estimate linear probability model. As a result, β_1 can be interpreted as the percentage point difference in the probability that an individual is in a particular state for a cohort for which the age is below the AOW age compared to a cohort for which the age is above or equal to the AOW age.

The key identifying assumption underlying this difference-in-differences strategy is that, conditional on cohort- and age-fixed effects and the demographic and macroeconomic control variables, in the absence of the reform the outcomes by age would be similar across cohorts with different AOW ages. If this assumption holds, β_1 can be interpreted causally.

There are some potential identification threats. First, part of the effect we attribute to the reform could be related to the macroeconomic cycle. Due to the linear relation between the age, period and cohort, we cannot directly control for the cycle at the monthly level. One way of accounting for period effects is to test the sensitivity of the estimation to the inclusion of period-related variables (like the unemployment rate or yearly dummies), this is done in the robustness analysis of section 4.2. Second, other reforms that take place at the same period of time may bias the estimated effect (Rabaté & Rochut, 2019). As explained in section 2, the main change interacting with the AOW increase is the 2006 really retirement reform. According to previous studies, this reform had a strong impact of the average retirement age (e.g. Lindeboom & Montizaan, 2018). This is a problem for

Figure 1: Employment rate by age and birth year



our identification strategy if it affects the age profile of the outcome variables. Figure 1 shows the employment rate by age for a selection of the cohorts born between 1940 and 1958. We observe large cohort effects: over time, the employment rate increases steadily, due to a combination of higher initial employment level and the end of some early retirement schemes, especially at age 60 and 62. We observe a clear discontinuity in the trend by age before and after the cohorts born in 1950. This is likely to be driven by the 2006 early retirement reform mentioned in the previous section. This implies that the parallel trend assumption does not hold for cohorts born in 1950 or after when compared to cohorts born before 1950. Therefore, in our main analysis we focus on cohorts born in 1950 or thereafter. For those cohorts, we expect to have valid pre-trends according to Figure 1. This can be tested formally by estimating the following fully interacted differences-in-differences specification:

$$y_{iact} = \alpha_0 + \delta_c + \theta_a + \alpha_1(\delta_c \times \theta_a) + X_{iat}\alpha_2 + \epsilon_{iact}, \tag{2}$$

where we expect the α_1 coefficients to be small and statistically insignificant before the age of the change in the AOW, and significant for the ages a for which different cohorts c face a different AOW-age.

Note that this test for the absence of effect before the AOW-age is also a test for the existence of upstream or horizon effects. As discussed in the results section below, an increase in the AOW-age can also have employment effects before this age, as increasing the horizon of retirement can induce both labor demand and supply changes that can affect e.g. the employment rate (Hairault et al., 2010). We expect some of the pre-AOW α_1 coefficients for employment to be significant in the presence of (positive) upstream effects.

4 Results

4.1 Graphical evidence

Figure 2 and 3 shows the age profiles for retirement (the share of individuals for which pension income is the main source of income) and employment (the share of individuals for which wage or profit income is the main source of income) for the different birth cohorts grouped by their respective AOW age. We observe a clear parallel pattern before age 65 and 3 months, and a steep rise and drop, respectively, beyond this age. Furthermore, the increase and drop appear to shift to the right with each cohort, suggesting that it moves with the AOW-age. This can be considered as direct evidence of a causal effect of the AOW-age change on employment and retirement profiles. With the chosen empirical strategy, we attribute these changes to the change in the AOW-age. We consider the patterns in Figure 2 and 3 as supportive of the assumption of common trends for these cohorts. Note that we also observe some residual bunching at age 65.[13]

We also observe that not all individuals that postpone retirement end up in employment. Figure 4 shows which states make up the difference. Individuals persist in the state of unemployment, disability, welfare or no income. Again, we see parallel trends before the age of 65 and 3 months (the AOW-age of the control group), and a sudden drop beyond that age.

4.2 Regression results

Main results

Table 4 gives the regression results for the shift in the AOW-age on the probability of being in different states in the labor market, using equation (1). All estimates are statistically significant at the 0.1 percent level. Consistent with the graphical evidence, we observe a steep drop in the share of individuals that are retired, 51 percentage points on average, for the months in between the old and new AOW-

[13] This is also observed in the US, see Behaghel & Blau (2012).

Figure 2: Shares in retirement by age and AOW-age

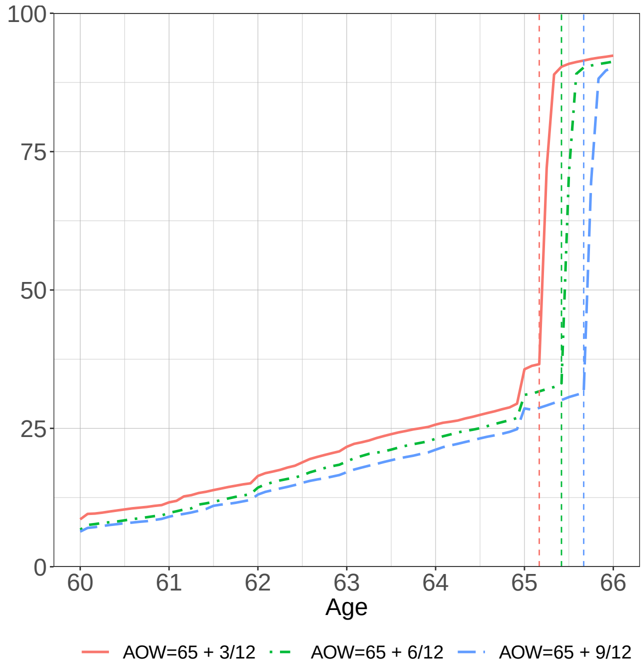


Figure 3: Shares in employment by age and AOW-age

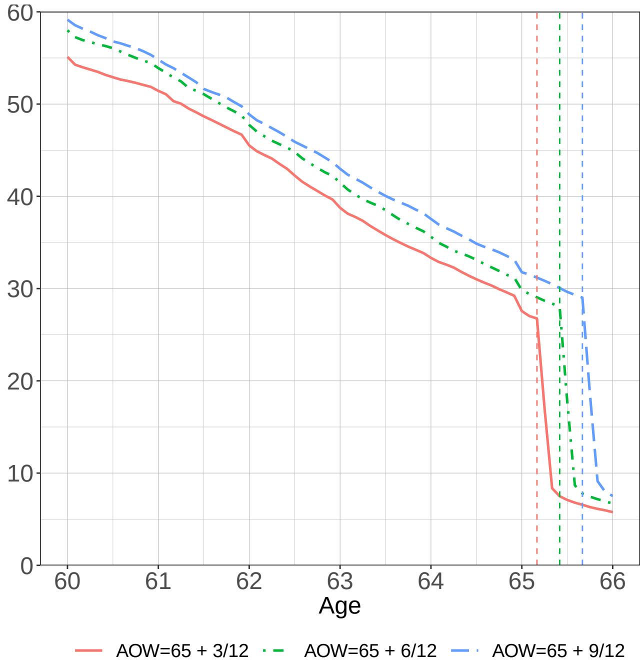
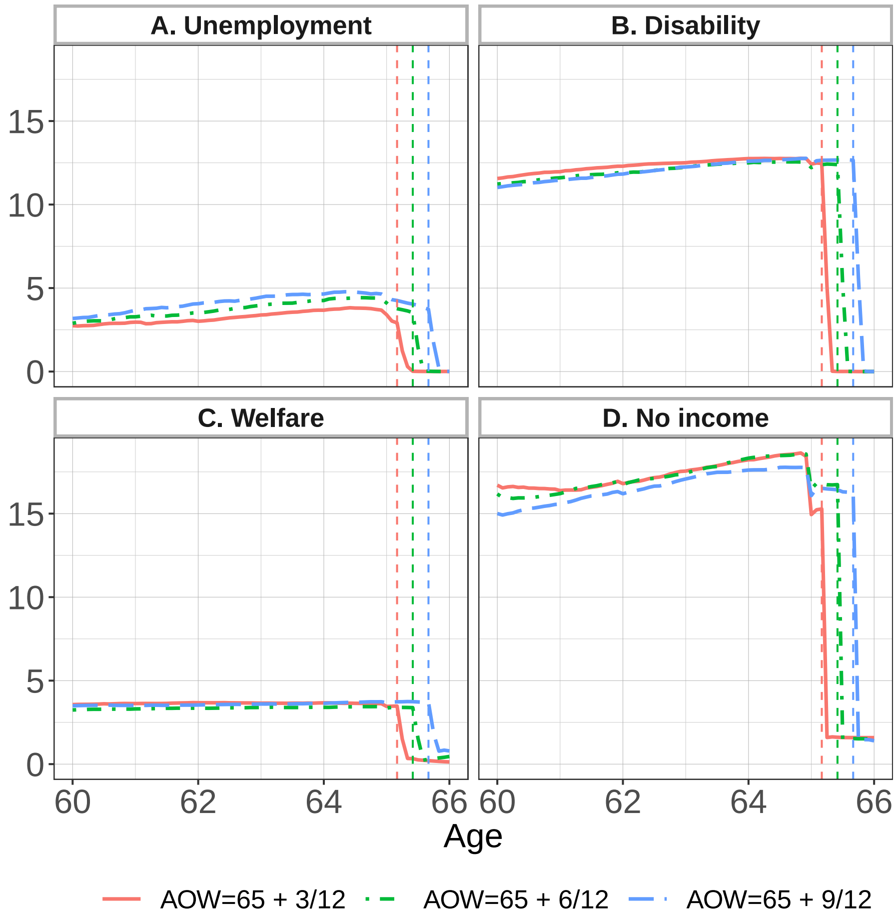


Figure 4: Shares in other workstates by age and AOW-age



age. The employment rate increases by 16 percentage points (32% of the decrease in retirement). The share of individuals with as their main source of income disability benefits, unemployment benefits, welfare benefits and other benefits increases by 11, 3, 3 and 2 percentage points, respectively. Hence, in total, the share of individuals on (other) social insurance increases by 19 percentage points (38% of the decrease in retirement). Moreover, the share of individuals that have no other income before reaching the AOW-age increases by 15 percentage points (30% of the decrease in retirement).

The reform hence generated important employment effect, but also large substitution effects towards other social insurance schemes. Those effects are the sum of two different effects: passive substitution – individuals in disability or unemployment insurance stay longer in this state instead of retiring – and active substitution – individuals would change their labor force participation due to the reform and enter those schemes. We disentangle those two dimension in Section 4.3.

Table 4: Main result: effect of the increase in the AOW-age

	Ret.	Emp.	Unemp.	Dis.	Welf.	Oth.	Noinc
Under AOW	-51.34***	16.24***	2.582***	11.57***	2.383***	3.180***	15.38***
	(0.563)	(0.283)	(0.101)	(0.136)	(0.0642)	(0.379)	(0.220)
Observations	19975673	19975673	19975673	19975673	19975673	19975673	19975673
Pre-reform mean	20.09	40.27	4.33	12.48	2.7	3.55	16.59

NOTES: Cluster-robust standard errors in parentheses (clustered by month of birth), * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Pre-reform means correspond to the average computed for the treatment cohorts for age group 62–65.

Robustness checks

In this subsection, we present three types of robustness tests. We first test the sensitivity of our main estimation results to alternative specifications. Next, we estimate the fully interacted version of the DD model, tesing for common time effects. Finally, we estimate the effect of the reform using a regression discontinuity design instead of differences-in-differences.

Table 5 presents a number of robustness checks for employment as the outcome variable. The different columns correspond to the following models. Column (1) is the main specification reported in Table 4. Columns (RT1) to (RT3) show that we get similar results when we add demographic controls and when we cluster the standard errors by month of birth. Columns (RT4) to (RT6) test for the sensitivity to time effects and the inclusion of macro-economic variables that capture the state of the business cycle. Including the unemployment rate as a proxy for the business cycle, or quarter or year dummies hardly affects the results. Indeed, the results are very stable over the different types of controls and clustering of the standard error. Lastly, column (RT7) estimates the model only for the first increase in the AOW age, from 65 and 3 months to 65 and 6 months. The estimated effect is only slightly lower for this subpopulation.

Figure 5 presents the estimated coefficients with a full set of interaction terms with the different cohorts from the age of 63 onwards using equation (2), to test for common time effects and possible 'upstream' effects (where people respond to the new AOW-age also before the old AOW-age, also known as horizon or distance-to-retirement effects). The coefficients are small and statistically insignificant before the age of 65 and 3 months (the AOW-age for the control cohort), and positive and statistically significant after this age. Hence, we cannot reject that the cohorts with different AOW-ages share common time effects and that the upstream effects are

Table 5: Robustness check: effect on share employed

	Ref	RT1	RT2	RT3	RT4	RT5	RT6	RT7
Under AOW	16.24***	16.43***	16.43***	16.44***	16.13***	16.17***	16.06***	15.43***
	(0.283)	(0.066)	(0.172)	(0.173)	(0.204)	(0.169)	(0.188)	(0.297)
Observations	19975673	19975673	19975673	19975673	19975673	19975673	19975673	13379389

NOTES: First column corresponds to the specification used in Table 4.2. The next columns correspond to the seven robustness tests (see the text for details):
Column (1): Reference model, with demographic and time effect proxy with unemployment rate, different cohort effects before and after 65 and clustering at the month of birth level.
Column (2): Estimation without controls without clustering
Column (3): Column (2) + clustering.
Column (4): Column (3) + demographic controls.
Column (5): Column (4) + time effect proxy with unemployment rate.
Column (6): Column (5) + quarter dummies.
Column (7): Column (6) + year dummies.
Column (8): Reference model with sample restriction for the first increase in the AOW only.

Figure 5: Robustness check: fully interacted DID, effect on share employed

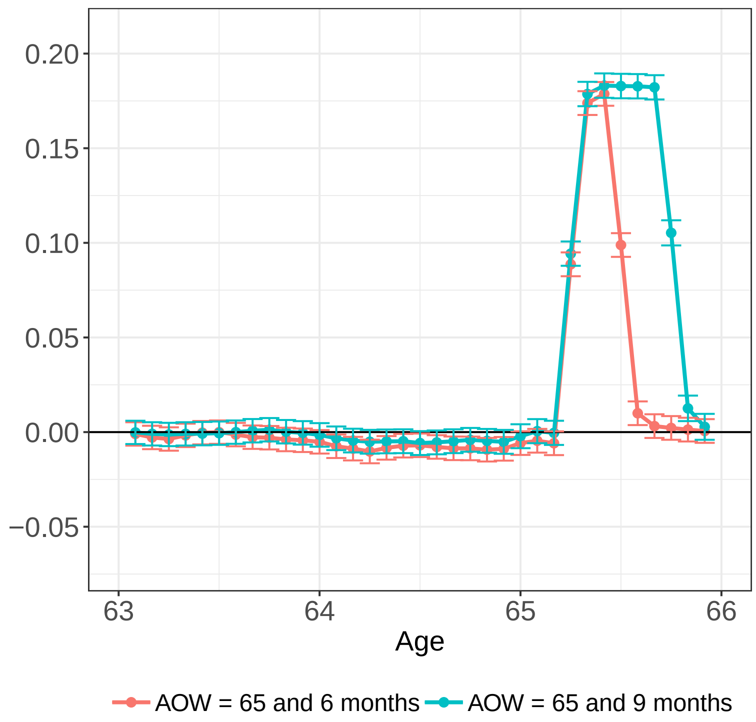
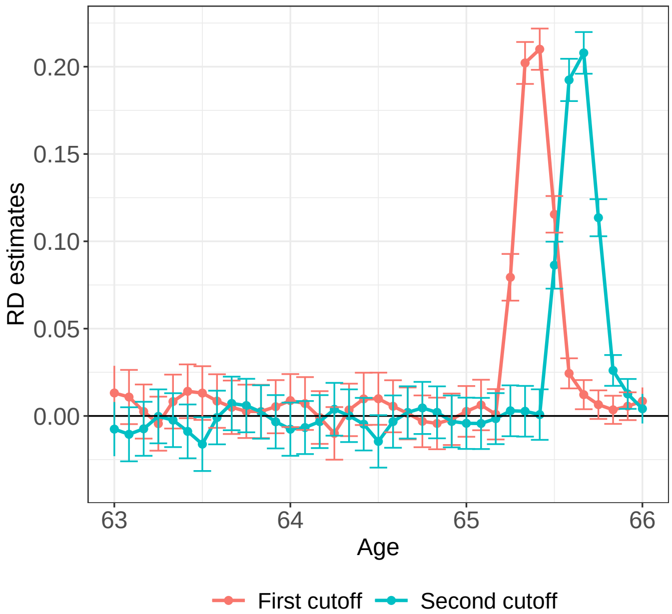


Figure 6: Robustness check: RDD estimates effect on share employed



limited for these cohorts. The absence of an upstream effect is hard to reconcile with a standard economic model with a trade-off between income and leisure (see e.g. Hairault et al., 2010), but it is consistent with the results found in similar settings (see e.g. Staubli & Zweimüller, 2013). One explanation to the absence of upstream effects could be that we only measure the short-run effects of the reform, and that the mechanisms underlying the distance to retirement have effects on younger ages only in the longer run. However, also for the longer run effects, the evidence on upstream effects is mixed: Geyer & Welteke (2019) find no upstream effect of a German reform of the early retirement age announced 10 years in advance, whereas Carta & De Philippis (2019) find significant labor market effects for middle-aged women of an Italian reform of the early retirement age.[14]

Lastly, we estimate the effect of the increase in the AOW-age on the employment

[14] To explore longer term effect of the reform, Figure C.1 presented in the Appendix shows the estimated coefficient using equation (2) for younger cohorts. These are cohorts that have not yet reached their new AOW-age in our data period, with cohort 1951 taken as the control group. These cohorts faced further increases in the AOW-age, and they were younger when the increase was announced and therefore had more time to adapt their labor supply decision. For women we do not observe an upstream effect for these younger cohorts. However, for men we do observe an increase in the employment probability as early as from the age of 62, which could potentially be attributed to an upstream effect of the shift in the AOW-age. However, this increase in employment could also be explained by other factors, such as the macroeconomic cycle (there is a rebound in employment at this time that may not be captured by our unemployment rate proxy), age-specific cohort effects or reforms of the second pillar pension. We are not able to distinguish between those different explanations at this stage. The stability of the estimates to different specifications for the time effects, shown in Figures C.2, however suggests that macroeconomic conditions do not drive this result.

rate using a regression discontinuity design. Using month of birth as the running variable and the stepwise increases in the AOW-age as treatment we estimate the effect of the reform on the probability of being employed at different ages. We provide details on the RDD in Appendix B. Figure 6 presents the estimated effects of the increase in the AOW, for the two different jumps we consider and for different ages. We find significant effects of the increase in the employment probability for the ages directly concerned by the reforms, and only for them. Reassuringly, the pattern we observe is very similar to the one given by the DID approach in Figure 5. Point estimates seem to be slightly higher with the RDD for the employment probability (about 20 percentage points). This may be related to the fact that we compare more similar groups in the RDD, when part of the effect is captured by the cohort effects in the DID approach.

Effect on the average retirement age

One limitation of the DID estimates is that they only give the causal effect of the AOW-reform on the probability of being employed, retired, unemployed, etc. They do not give directly the effect of the reform on the effective retirement age, which may be a more relevant elasticity parameter for the evaluation of the effect of pension reforms. We remedy this shortcoming by deriving an effect of the reform on the average retirement age from our DID estimates.

We use two definitions of the retirement age. The first one corresponds to the first time pension income becomes your main source of income, which corresponds to our definition of the retirement state in the estimations. We refer to this definition as pension claiming, even though pension can be claimed before the moment it becomes the main source of income. One issue with this definition is that it may not correspond to the age of withdrawal form the labor force, as some individuals can stop working before they start to claim their (first and/or) second pillar pension, e.g. through disability or unemployment insurance. We therefore present results also for a second definition where retirement corresponds to the month after the last age with earnings as the main source of income.[15]

Under some assumptions for the effect of the reform at older ages, we can use the estimates of the fully interacted differences-in-differences specification to compute the effects of the reform on the average retirement age for our two definitions of the retirement age.The methodology is described in detail in Appendix A. The effect of the reform on the average claiming age can be computed as the sum of coefficients

[15]We implement this as the first age at which we observe a transition from work to a period of out of employment for at least 6 months, after the age of 56.

when estimating equation (2) with the *retired* workstate as the y variable. Similarly, the effect of the reform on the average retirement age can be expressed as the sum of the coefficients when using employment as the outcome. The intuition behind these results is the following: the DID estimates can be interpreted as the difference between the cumulative distribution of retirement and claiming age caused by the change in the AOW, from which we can retrieve the impact on the averages (see also Mastrobuoni, 2009).

Figure A.1 of Appendix A presents the estimated coefficients and the associated average claiming and retirement age. A 6 month increase in the AOW-age increases the average claiming age by 3.5 months and the average retirement age by 1.1 months (or an elasticity of 0.6 and 0.2 for the claiming and retirement age, respectively). The effect is then much stronger for the claiming age. This is expected as individuals already out of the labor force may not be able to go back into employment as a result of the reform, hence their claiming age may change while their retirement age is not affected.

In order to assess the robustness of our estimation of the effect of the reform on the average retirement and claiming age, we compare our differences-in-differences approach to a regression discontinuity design. Details of the results are presented in Appendix B. We estimate the effect of the increase in the AOW-age from 65 years and 3 months to 65 years and 6 months using a RDD (Lee & Lemieux, 2010), with the date of birth (in months) as the running variable, and comparing the average retirement and claiming age of individuals from both sides of the AOW-discontinuity. To do so, we need to restrict our sample to individuals for which both the claiming and retirement age are observed. We find robust effects of the effect of the reform on the pension claiming age. The results for the retirement age are more sensitive to the specification (because of the inclusion of controls and degree of the polynomial used), but are nonetheless positive and significant for most specifications (Table B.2).

We then compute the effect on average claiming and retirement age using the DID approach presented above, on the same sample as the one used for the RDD estimation (see Figure A.2 of Appendix A). Table 6 compares the results obtained with the two approaches. The reference taken for the RDD estimations is the specification with controls and second degree polynomial form (Column 3 and 7 of Table B.2). The results for both methods are very similar regarding the effect of the reforms on the claiming age. The effect on the retirement age is somewhat larger for the RDD than for the DID.

Note that our estimates of the effect of the reform on the average retirement

Table 6: Effect on the average retirement and claiming age: RDD vs. DID estimates

	Claiming age		Retirement age	
	DID	RDD	DID	RDD
Effect of the reform (AOW +3m)	+1.8 m	+1.8 m	+1.0 m	+1.3m
		(4.28)		(2.30)

NOTES: Results for the DD estimations (resp. RDD estimations) are presented in Figure A.2 (resp. Table B.2, columns (3) and (7)) of the Appendix. T-stat are presented for the RD estimates. We do not compute them for the DID calculation.

and claiming age are similar in terms of magnitude to the ones found by Manoli & Weber (2018) for Austria, using a regression kink design. They find an elasticity of 0.4 for retirement and 0.5 for claiming, for a one year increase in the ERA. As they restrict to a sample of individuals working at age 53, their result should be compared to the ones reported in Table B.2, as the sample restriction is more comparable. For this sample we find an elasticity of 0.33 and 0.6 for the retirement and claiming age, respectively.

4.3 Additional results

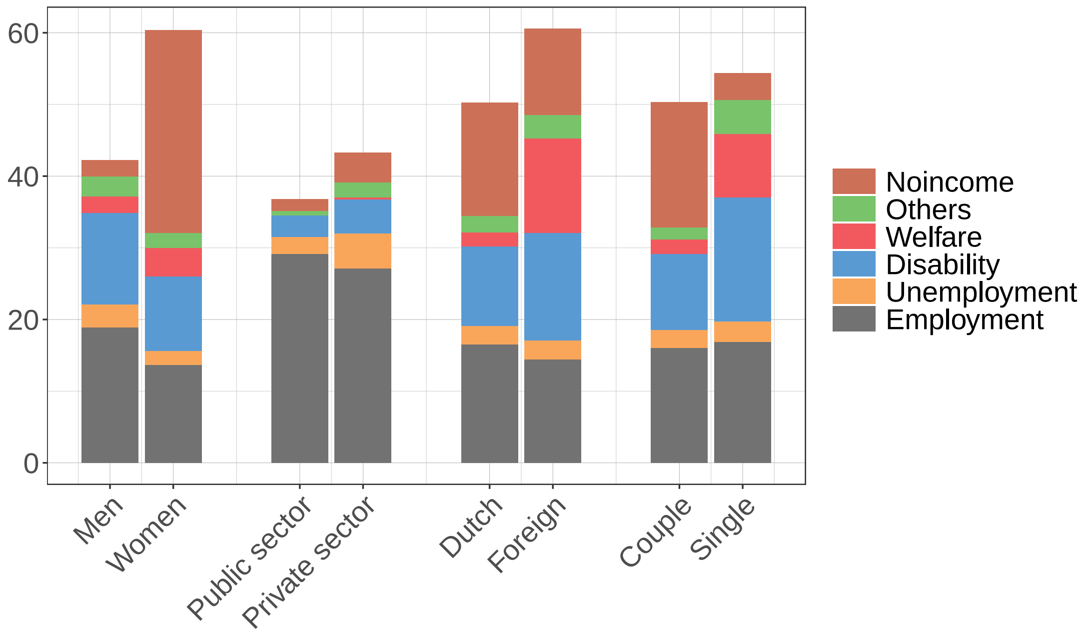
Effects for subgroups

To assess whether the effects differ for subgroups we estimate equation (1) separately by gender, for singles and couples, private and public sector employees, and individuals with and without a migration background. Figure 7 presents the results graphically.[16] We show the effects for all the states on the labor market. The effect on the probability of being retired is (minus) the sum of the effects on the shares in the other states (the total height of the bars). The different components of the bars show how much of the decrease in retirement is accounted for by an increase in the other states on the labor market.

For men we find a larger increase in the employment share than for women, as well as a slightly higher increase in the share on disability benefits, unemployment benefits and other types of benefits. For women we find a larger increase in welfare and without income. These patterns reflect the differences in participation in the different states on the labor market in the years before the retirement age, women are more likely to be out of the labor force, and also build up less second pillar pension. As a result, there is a stronger effect on the share switching to retirement

[16] Estimation results are presented in Table C.1 in the Appendix.

Figure 7: Effects for subgroups



(to pension benefits as the main source of income). Comparing individuals with a migration background ('Foreign')[17] to individuals without a migration background ('Dutch') we find quite similar effects for most categories except for a stronger effect on the participation in welfare, due to a lower attachment to the labor force in the years before retirement. The results are also quite similar for singles and individuals living in couples, though individuals in couples (mostly women in couples) are more likely to remain the state of no income and singles are more likely to be on disability benefits and welfare benefits (due to e.g. means testing of welfare benefits). Finally, we estimate equation (1) separately for individuals working in the private sector and the public sector when they turn 60. This implies that we condition on initial employment, hence the employment effects are by definition much stronger. Interestingly, the employment effects are stronger in the public sector. This could be related to a more systematic use of the automatic job termination at the AOW-age in the public sector than in the private sector.

Active substitution effects

As mentioned above, the increase in the probability of being in other social insurance schemes generated by the reform we exhibited in the previous subsection is the sum

[17]Individuals are defined by Statistics Netherlands as having a migration background when one of the parents was born outside of the Netherlands.

of passive substitution – individuals in disability or unemployment insurance stay longer in this state instead of retiring – and active substitution – individuals would change their labor force participation due to the reform. Even if the former effect is important to consider, in particular for a global assessment of the fiscal effects of the reform (see below), the latter is more meaningful as it entails a real behavioral response to the reform.

To test for active substitution effects, Table 7 shows the estimates for equation (1) when we condition on the labor market state when individuals turn 65 (a few months before the cohort-specific AOW-age for the different cohorts). All coefficients for retirement are statistically significant at the one percent level. The coefficients for retirement are large and negative for all initial states except for individuals that were initially retired. For all states, the increase in the probability to be in that same state increases by almost the same amount as the probability to retire decreases. Thus, the drops in retirement before the AOW-age seem to be induced by persistence in the previous state instead of substitution towards other states. Hence, although people retire at a later age, only individuals that were initially employed remain in the labour force. Individuals that previously were unemployed, disabled or on other social benefits continue their use of these social security programs as their main source of income (at least in the data period we observe). Although many of the other estimates are also significant, these coefficients are all very close to zero. Hence we can conclude that in the short run there is hardly any active substitution effect between labor market states due to the reform.

Effect on the government budget

Finally, we quantify the effect of the change in the AOW-age on the government budget in the data period, by estimating equation (1) with monthly income from each income sources as the dependent variables (including the zeros). The estimated coefficients can be interpreted as the difference in the monthly amount received from a certain source of income by individuals in between the AOW-age of the control cohort (65 and 3 months) and the new AOW age of the treated cohorts (65 and 6 months and 65 and 9 months, depending on the month of birth). Table 8 gives the estimated average effects on monthly income, estimated over all individuals. Unsurprisingly, average income from AOW pensions benefits decreases, whereas income from employment, unemployment insurance, disability insurance, welfare and other social insurance programs increases. Again, all coefficients are statistically significant at the 0.1 percent level.

Table 7: Substitution effects

t-1		Emp.	Ret.	Unemp.	Dis.	Welf.	Oth.	Noinc
Emp.	Under AOW	0.327***	-0.332***	0.000895***	-0.00141***	0.0000176	0.000726***	0.00396***
		(626.80)	(-765.86)	(5.74)	(-11.74)	(-0.55)	(7.15)	(19.96)
	Nb obs.	6738143	6738143	6738143	6738143	6738143	6738143	6738143
Ret.	Under AOW	-0.00262***	0.00381***	0.0000706	-0.00157***	-0.000309***	0.000684***	0.0000950
		(-17.98)	(18.18)	(1.03)	(-20.03)	(-7.45)	(10.43)	(1.12)
	Nb obs.	5980002	5980002	5980002	5980002	5980002	5980002	5980002
Unemp.	Under AOW	-0.00448***	-0.653***	0.654***	0.000654	0.0000164	0.00253**	0.00147*
		(-4.11)	(-412.25)	(281.55)	(-0.74)	(-0.09)	(3.06)	(2.17)
	Nb obs.	701546	701546	701546	701546	701546	701546	701546
Dis.	Under AOW	-0.00328***	-0.722***	0.000258	-0.000533***	-0.000206***	0.727***	-0.00139***
		(-14.94)	(-1275.53)	(1.29)	(-4.48)	(-4.08)	(1133.86)	(-14.71)
	Nb obs.	2186960	2186960	2186960	2186960	2186960	2186960	2186960
Welf.	Under AOW	0.000126	-0.587***	0.000111	-0.00271***	0.587***	0.000460**	0.0000672
		(-0.42)	(-533.01)	(1.00)	(-12.56)	(456.85)	(2.79)	(0.12)
	Nb obs.	632709	632709	632709	632709	632709	632709	632709
Oth.	Under AOW	0.000268	-0.639***	0.000750	0.637***	-0.00217***	0.000849	0.00223**
		(0.25)	(-335.55)	(-1.01)	(260.80)	(-8.03)	(1.61)	(2.66)
	Nb obs.	477177	477177	477177	477177	477177	477177	477177
Noinc	Under AOW	0.00375***	-0.878***	0.000202	0.00205***	0.0000183	0.000281***	0.872***
		(8.24)	(-1461.95)	(1.24)	(9.94)	(-0.10)	(3.72)	(1069.45)
	Nb obs.	2841666	2841666	2841666	2841666	2841666	2841666	2841666

t statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

We can then compute the fiscal substitution effect of the reform as follows. By shifting the AOW-age up, the government saves 713 euro on AOW-benefits per person. Of these savings, 227 euro is lost on additional disability benefits, 64 euro on additional unemployment benefits, 18 euro on welfare benefits and 25 euro on other social benefits. In total, 334 euro or 47% of the initial savings is lost on additional social benefits per person. However, the government also gains additional taxes levied on additional employment generated by the reform. As we do not observe taxes but only income, we need an additional assumption to calculate the additional income tax revenues from the increased income from employment. We use a marginal tax rate of 45% on the additional employment income.[18] We

[18] In line with previous analysis by CPB, using information from the microsimulation model MIMOSI.

Table 8: Effect on average monthly income by source of income

	AOW pension	Employment earnings	Unemp.	Dis.	Welf.	Oth.
Under AOW	-713.4***	438.8***	63.79***	226.5***	18.44***	25.51***
	(0.162)	(8.835)	(0.676)	(0.899)	(0.265)	(2.125)
Observations	19975673	19975673	19975673	19975673	19975673	19975673
Pre-reform mean	.058	1401366	101931	239109	35864	68239

then get an average increase in taxes of $0.45 \cdot 439 = 197$ euro or 28% of initial savings. Hence, after accounting for the additional expenditures and the additional tax receipts, the government saves 576 euro per month per person. This amounts to about 81% of the initial savings. For a cohort size of 120 thousand individuals, this amount to budgetary savings of 210 million euro for a 3-month upward shift in the AOW-age.

5 Discussion and conclusion

In this paper we have analyzed the effects of the increase in the Dutch retirement age on employment and the use of social insurance of older workers, and also analyzed the effects on the government budget. We used differences-in-differences and Dutch administrative data. We find that the reform decreased the share of individuals retirement by some 50 percentage points. Close to one third (16 percentage points) of these individuals are employed between the old and new retirement age, whereas more than one third (20 percentage points) are in social insurance (disability insurance in particular). We do not find evidence of direct substitution: individuals merely persist in the state they were in before the old retirement age. Also, we find no upstream effects before the old retirement age in the dataperiod we consider.[19] Regarding the average retirement age, we find that increasing the statutory retirement age by 3 months results in an increase in the retirement age by 1.0 (DID) to 1.3 (RDD) months. Regarding the government budget, we find that both additional spending on social insurance and additional tax receipts are substantial, and that the net budgetary savings are in the order of 80% of direct

[19]Both the treatment effect after the old retirement age and the upstream effects before the old retirement age could be different in the long-run, as individuals have more time to anticipate and smooth the effects of the shift in the AOW-age. Note that the time between the announcement of the reform in 2011 and the implementation in 2013 was relatively short, when compared to reforms abroad.

savings on retirement (AOW) benefits.

Our results line up well with the findings of studies on related reforms abroad, see Table C.2 in the Appendix. We compare the results with the findings of studies on the early retirement age (ERA) and the normal retirement age (NRA), as the AOW-reform contains elements of both types of reforms. In line with ERA reforms, individuals can not claim AOW benefits before they reach the AOW age, so liquidity constraints might be relevant. However, in line with NRA reforms, the AOW reform is a reform of the statutory retirement age, where norms and employment protection legislation might also be relevant. The treatment effect we find is on the upper end of the NRA studies and more in the middle of the ERA studies, where ERA studies typically find larger effects than NRA studies.

Several policy implications can be derived from these results. So far, it seems that the increases in the AOW age have been beneficial for problems in terms of age dependency as described in the Introduction. On the other hand, these results may only hold true up until a certain age. Even though life expectancy of individuals is increasing, after a certain point individuals may simply not be able to work due to, for example, health related reasons. Moreover, although individuals that first worked remain employed, individuals that were initially unemployed, disabled, had no income or made use of financial aid or other social security programs remain in these states longer too. Given the limited period for which some of these social security benefits can be taken up this may yield financial complications for certain households, in particular among the most disadvantaged. On the other hand, increasing the AOW could also have longer term upstream effect on employment rate before 65, which would in turn have positive budgetary effect in the future.

The effect of further increase in the AOW age will also depend on the role of this age in shaping retirement behavior in the future. The different potential determinants of the bunching at the AOW – liquidity constraints, norms, employers effects, financial incentives – may not stay constant over time. Understanding the relative importance of these channels is an interesting direction for future research. Also, studying the effects of the reform on a broader set of outcomes, like health expenditures, would be another interesting direction for future research.

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Appendices

A. Computation of the effect on the average retirement age

This appendix describes the computation of the effect of the reform on the average claiming age and retirement age. We use the coefficients estimated in the fully interacted differences-in-differences specification:

$$y_{iact} = \alpha_0 + \delta_c + \theta_{at} + \alpha_1(\delta_c \times \theta_{at}) + \alpha_2 X_{iat} + \epsilon_{iact} \tag{A.1}$$

The DID coefficients we are interested in are the $\beta_3^{c,a}$ coefficients. They give, a given outcome y, the effect of the increase in the AOW for a given monthly age a and for a given cohort c, relative to the reference cohort c_{ref} with AOW-age equal to 65 years and 3 months.

Effect on the average claiming age We first compute the effect of the reform on the average claiming age using as an outcome y our definition of retirement (pension benefits as the main source of income).

$\beta_3^{c,a}$ coefficients measure the effect of the reform on the probability to have claimed a pension, and can be interpreted as follows: absent the reform, the probability of being retired at age a for individual of cohort c would have been -$\beta_3^{c,a}$ bigger. Formally, if we note X_C the random variable of the observed claiming age for cohort c and X_C^{cf} the counterfactual one absent the reform:

$$P[X_C^{cf} \leq a] = P[X_C \leq a] - \beta_3^{c,a}$$

The effect of the reform on the average retirement age can be defined as the difference between the observed average retirement age and the counterfactual one, absent the reform [20], using monthly age in the sum.

[20] The following calculation are inspired by Mastrobuoni (2009) (eq (4) in p. 1229)).

$$
\begin{aligned}
\Delta_c &= \sum_{a=720}^{792} aP[X_C = a] - \sum_{a=720}^{792} aP[X_C^{cf} = a] \\
&= \sum_{a=720}^{792} a(P[X_C = a] - P[X_C^{cf} = a]) \\
&= \sum_{a=720}^{792} a(P[X_C \leq a] - P[X_C^{cf} \leq a] - P[X_C \leq a-1] + P[X_C^{cf} \leq a-1]) \\
&= \sum_{a=720}^{792} a(\beta_{a,c} - \beta_{a-1,c})
\end{aligned}
$$

We simply use the following property of the CDF : $P[X = a] = P[X \leq a] - P[X \leq a-1]$.

This expression we obtain can be simplified if there is an age a_{min} (resp. a_{max}) below (resp. above) which there is no effect of the reform (i.e $\beta_{a,c} = 0$ for $a \leq a_{min}$ or $a \geq a_{max}$)

$$
\begin{aligned}
\Delta_c &= \sum_{a=720}^{792} a(\beta_{a,c} - \beta_{a-1,c}) = \sum_{a=a_{min}}^{a_{max}} a(\beta_{a,c} - \beta_{a-1,c}) \\
&= a_{min}(\beta_{a_{min},c} - 0) + (a_{min}+1)(\beta_{a_{min}+1,c} - \beta_{a_{min},c}) + \ldots + \\
&\quad (a_{max}-1)(\beta_{a_{max}-1,c} - \beta_{a_{max}-2,c}) + a_{max}(0 - \beta_{a_{max}-1,c}) \\
&= \sum_{a=a_{min}}^{a_{max}} -\beta_{a,c}
\end{aligned}
$$

Effect on the average retirement age Similarly, we can compute the effect of the reform on retirement, that is withdrawal from employment, using the coefficients obtained by estimating equation A.1 using employment as the y variable.

$\beta_3^{c,a}$ coefficients measure the effect of the reform on the probability to be employed, and can be interpreted as follows: with the reform, the probability be employed at age a, i.e to retire later than age a, is $\beta_3^{c,a}$ bigger. Formally, if we note X_R the random variable of the observed retirement age for cohort c and X_R^{cf} the counterfactual one absent the reform:

$$P[X_R > a] = P[X_R^{cf} > a] + \beta_3^{c,a}$$

Using the same approach as before, and using a symmetric mathematical relation ($P[X = x] = P[X > a - 1] - P[X > a]$), we can express the change in the average retirement age as the sum of the estimated coefficients:

$$
\begin{aligned}
\Delta_c &= \sum_{a=720}^{792} a(P[X_R = a] - P[X_R^{cf} = a]) \\
&= \sum_{a=720}^{792} a(P[X_R > a-1] - P[X_R^{cf} > a-1] - P[X_R > a] + P[X_R^{cf} > a]) \\
&= \sum_{a=720}^{792} a(\beta_{a-1,c} - \beta_{a,c}) \\
&= \sum_{a=a_{min}}^{a_{max}} a(\beta_{a,c} - \beta_{a-1,c}) \\
&= a_{min}(0 - \beta_{a_{min},c}) + (a_{min}+1)(\beta_{a_{min},c} - \beta_{a_{min}+1,c}) + ... + a_{max}(\beta_{a_{max}-1,c} - 0) \\
&= \sum_{a=a_{min}}^{a_{max}-1} \beta_{a,c}
\end{aligned}
$$

Implementation of the computation The following figures present the effect of the increase in the AOW-age on the average claiming and retirement age using the method described above.

Figure A.1 presents the results for the same sample we use in the major parts of the paper, namely cohorts with AOW increasing from 65 years and 3 months to 65 years and 9 months. We present the coefficients estimated with the fully-interacted DID specification of equation (A.1), and the average effect obtained by summing those coefficients. We compute the average effect as the sum of the coefficients between the former and the new AOW age. It amounts to making the following restrictions, using the same notations as above : $a_{min} = 65.25$ and $a_{max} = 65.5$ or $a_{max} = 65.75$ depending on the cohort considered. The first one is testable and seem verified, as all coefficients are insignificant before 65. The second one is not testable as we do not observe employment or claiming trajectories beyond age 66.

Figure A.2 presents the same results for the subsample of indivduals used for the regression discontinuity analysis (see Appendix B for details.)

Figure A.1: Effect on average claiming age and average retirement age: full sample

(a) Claiming age (b) Retirement age

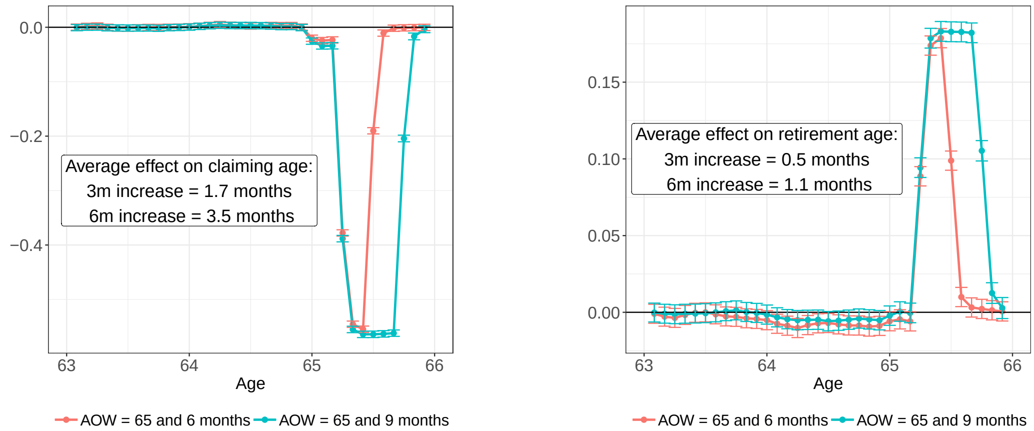
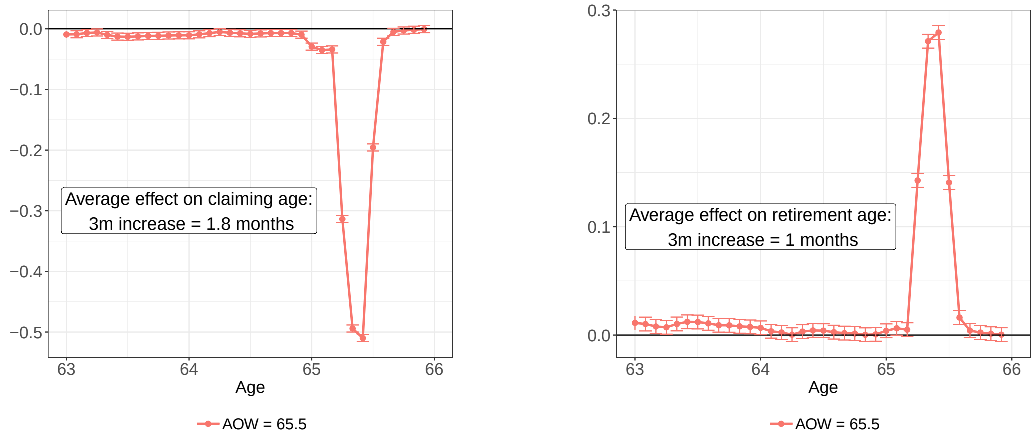


Figure A.2: Effect on average claiming age and average retirement age: sub-sample for comparison with RD estimation

(a) Claiming age (b) Retirement age



B. Regression discontinuity estimation

In this appendix we describe the regression discontinuity design (RDD) approach used as a complementary approach of the main one used in the empirical analyses: differences-in-differences (DID)

In our RDD setting, the treatment is still defined as an increase in the AOW-age within this context. Cutoffs are defined by the discontinuous changed in the AOW-age, and the running variable is the date of birth of the individuals. More precisely, the cutoff is the first month of birth from which onward the new AOW age applies. As all individuals receive the AOW-benefits they have accumulated once they surpass this cutoff, the set up calls for a sharp RDD. The identifying assumption of this approach is that the month in which individuals are born is random and, therefore, individuals around the cutoff are similar to the extent that their retirement decisions should be comparable. In essence, the only thing that is expected to differ between these individuals is the AOW age that they are subjected to. As a result, any discontinuity in the outcome variable at the cutoff is attributed to being treated.

We estimate two types of RDD models. In the first set of estimations, the outcome variable is the probability of being employed or retired and different age. We expect a discontinuous change at the AOW cutoff, only at the ages concerned by the increase in the AOW-age. In the second set of results we estimate the effect of discontinuity in the AOW-age on the average retirement and claiming age.

Formally, we estimate the following models:

$$\begin{aligned} Y_i &= \alpha_0 + \alpha_1 \times Z_i + \tau \times D_i + \epsilon_i \\ &\quad + \sum_{d=1}^{d_{max}} \beta_{d,bef}(x_i - T_0)^d + \beta_{d,aft} \times D_i \times (x_i - T_0)^d \end{aligned}$$

Y_i is either employment rate at different age or individual retirement age. Z_i are control variables, D_i a dummy for being born after the threshold, T_0 the birth-date based threshold, x_i the birth-date (in month), and d_{max} the highest degree of the polynomial included in the estimation. The bandwidth of each RD is determined by the size of the birth cohorts that belong to the control and the treatment group

RDD estimation on the effect on employment rate

We first analyze the effect of the increase in the AOW-age on the employment at different ages. We estimate our RDD models separately for each monthly age and for the two jumps in the AOW-age we consider. Table B.1 below summarizes the

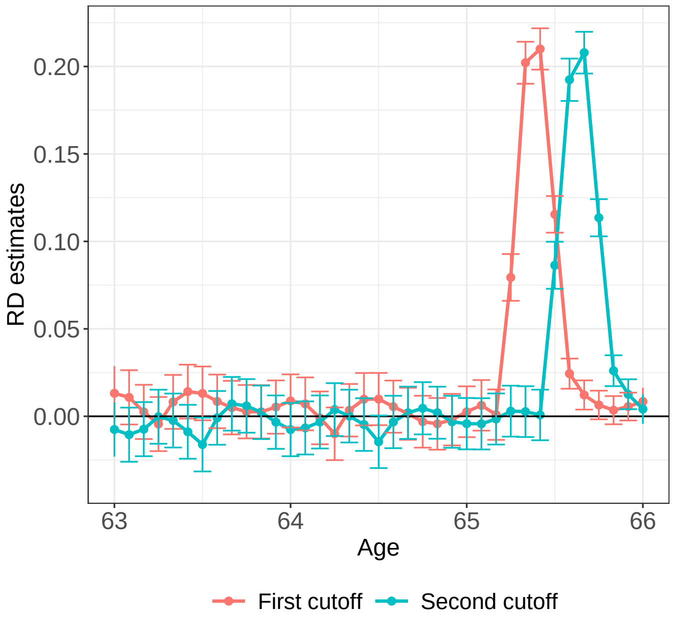
Table B.1: Treated and untreated cohorts by RDD

	Control	AOW-age	Treated	AOW-age
RD1	After 31-10-1949 and before 01-10-1950	65 + 3 months	After 30-09-1950 and before 01-07-1951	65 + 6 months
RD2	After 30-09-1950 and before 01-07-1951	65 + 6 months	After 30-06-1951 and before 01-04-1952	65 + 9 months

cohorts that are on the left and right sides of the cutoff for the estimation. Note that the cohort on the right on the cutoff for the first discontinuity is the one on the left for the second one.

Estimation results are presented in figure B.1, which shows the estimated τ coefficient of the RDD equation, for all ages and for the two AOW jumps we consider. As expected, we find insignificant effects for the ages that are not impacted by the change in the AOW-age. The employment rate is estimated to increase by around 20 percentage points with the increase in the AOW-age. It is roughly similar for the two discontinuities we consider.

Figure B.1: RD estimation: effect on employment rate

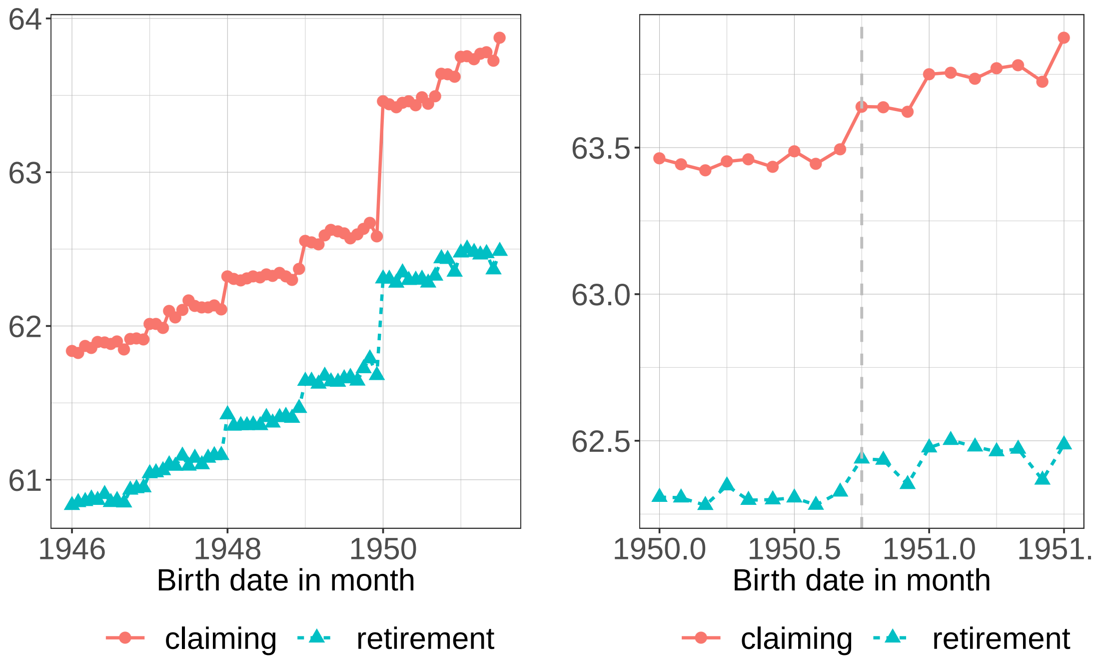


RD estimation on the effect on average retirement age

We then estimate the effect of the change in the AOW age on the individual average retirement age. We use two definitions of retirement: claiming age - when pension is your main source of income and actual retirement - age of withdrawal from the labor force (see section 4.2 for details). Estimating the effect of the reform on the average claiming and retirement age requires to be able to observe those processes

Figure B.2: Average retirement age by date of birth

(a) All cohorts (b) Treated cohorts only



for every individual of our sample. We then face two types of censoring: from the left, with individuals who have already retired or claiming at 56, and to the right for individuals we do not observe retiring before the last date of observation (2016 and 6 months with our definition of retirement). In the following we then restrict our sample for which we observe retirement and claiming for the age (56 to 66) and years (2001-2016) we consider.

Figure B.2 present the evolution of the claiming and retirement by month of birth. We observe the following pattern. First, the average retirement age is lower than the average claiming age. Second, we observe seasonality in both process with an discontinuity in January even absent any reform, which is related to a bunching in retirement observed in the month of January. Lastly, we can observe the effect of the AOW reform on the right panel. On the left panel, we can compare this effect to the effect of the second pillar reform in 2006 (from January 1950), which appears to have a much stronger effect.

Figure B.3 presents the average by month of birth for claiming and retirement respectively. We observe a jump for both definitions. As the change occurs for individuals born in October, the estimation of the cohort effect on the right hand side of the discontinuity is complicated by the interaction with the January effects.

Table B.2 presents the estimated coefficient of the τ parameter of the RDD equation, for a 3 months increase in the AOW-age at the threshold. The model is estimated for two different outcomes: individual claiming age (columns 1 to 4) and retirement age (columns 5 to 8). For each set of models we estimate different specifications: with and without controls, and for polynomials of degree 1, 2 or 3.

The estimated effect of on the average claiming age is rather robust across the different specification: a 3 months increase in the AOW leads to a 1.8 to 2.1 months increase in the average claiming age. Results for average retirement are on the other hand less robust: they are much more sensitive to the specifications used (inclusion of controls and degree of the polynomial function), and less precisely estimated (not significant at conventional levels for the last model). This may be related to the somehow noisy measure of retirement we use.

Interestingly, the estimated effect of the reform is of similar magnitude as the ones obtained with the differences-in-differences approach (Figure A.2).

Figure B.3: RDD graphs for average claiming and retirement age

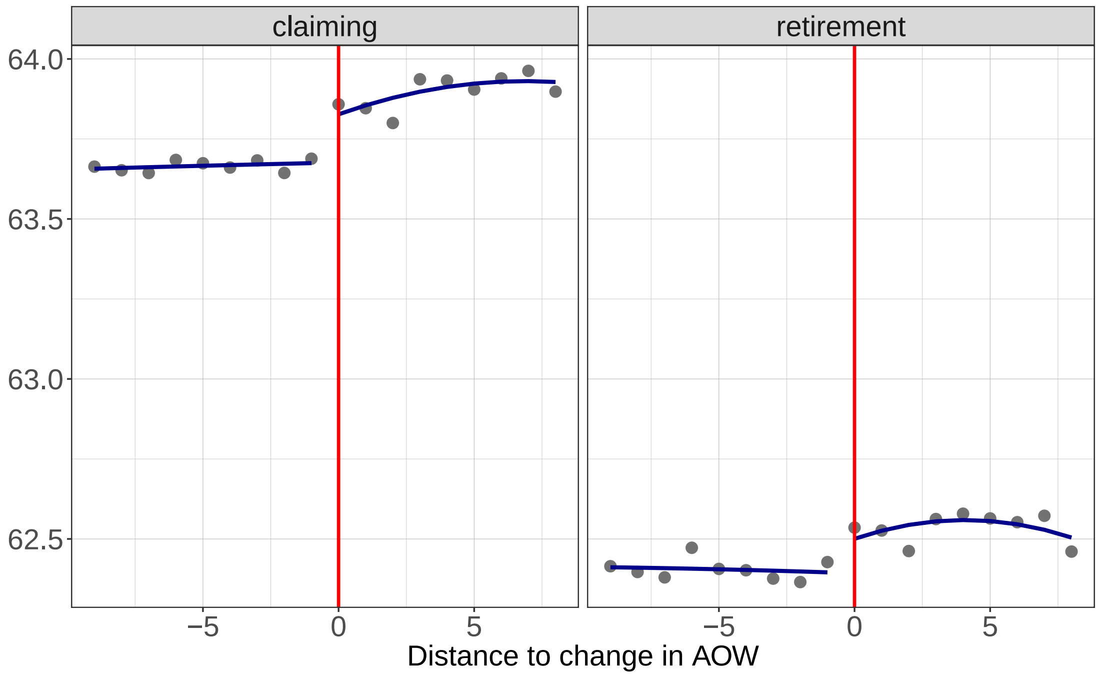


Table B.2: Estimation of the effect of the reform by RDD

	Y = claiming age				Y = retirement age			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment effect τ	2.050***	2.050***	1.813***	1.836**	1.671***	1.671***	1.283*	1.075
	(7.63)	(7.63)	(4.28)	(2.78)	(4.74)	(4.74)	(2.30)	(1.24)
N	157235	157235	157233	157233	157235	157235	157233	157233
Controls	No	No	Yes	Yes	No	No	Yes	Yes
Degree polynomial	1	2	2	3	1	2	2	3

t statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

NOTE: Columns (1) to (4) correspond to the RDD estimation with claiming age as an outcome variables, for different control variables and specification for the polynomial functions. Columns (5) to (8) present the same results for retirement age.

C. Additional plots and tables

Table C.1: Heterogeneity analysis

		Emp.	Ret.	Unemp.	Dis.	Welf.	Oth.	Noinc
Gender								
Men	Under AOW	18.94***	-42.18***	3.157***	12.81***	2.313***	2.733***	2.239***
(N=9930268)		(60.37)	(-75.25)	(23.65)	(53.39)	(6.94)	(29.53)	(28.14)
	Pre-reform mean	49.4	22.3	5.4	13.5	2.7	3.3	3.4
Women								
(N=10045405)	Under AOW	13.62***	-60.36***	2.016***	10.36***	4.034***	2.038***	28.29***
		(43.27)	(-104.73)	(22.46)	(88.86)	(9.48)	(35.14)	(73.20)
	Pre-reform mean	31.2	17.9	3.3	11.5	4.4	2.1	29.6
Sector								
Public	Under AOW	29.14***	-36.83***	2.351***	3.049***	0.00880	0.634***	1.641***
(N=1257765)		(68.55)	(-73.62)	(9.59)	(20.09)	(0.57)	(5.91)	(11.78)
	Pre-reform mean	67.1	24.3	3.3	3.0	0.0	1.0	1.3
Private								
(N=9507995)	Under AOW	27.13***	-43.26***	4.874***	4.731***	0.325***	2.064***	4.139***
		(110.58)	(-88.63)	(28.71)	(40.03)	(11.54)	(33.24)	(28.86)
	Pre-reform mean	60.4	22.0	7.1	4.5	0.5	1.7	4.0
Origin								
Autochtone	Under AOW	16.49***	-50.24***	2.576***	11.15***	1.958***	2.291***	15.78***
(N=17981165)		(76.45)	(-115.72)	(24.65)	(64.37)	(44.04)	(64.86)	(85.71)
	Pre-reform mean	40.1	20.8	4.4	12.0	2.4	2.7	16.8
Foreign								
(N=1994508)	Under AOW	14.45***	-60.61***	2.629***	14.97***	13.23***	3.236***	12.06***
		(11.34)	(-33.74)	(16.65)	(17.35)	(5.75)	(10.39)	(11.26)
	Pre-reform mean	33.4	12.2	4.1	16.7	15.0	3.0	15.5
Marital status								
Single	Under AOW	16.03***	-50.37***	2.533***	10.63***	1.957***	1.723***	17.49***
(N=1733936)		(57.38)	(-85.16)	(21.29)	(75.91)	(5.66)	(20.16)	(62.88)
	Pre-reform mean	41.1	20.6	4.3	11.4	2.1	1.9	18.6
Couple								
(N=16665765)	Under AOW	16.90***	-54.42***	2.862***	17.25***	8.879***	4.762***	3.763***
		(44.44)	(-99.57)	(11.37)	(43.30)	(14.23)	(36.06)	(18.16)
	Pre-reform mean	37.4	17.9	4.9	18.9	9.9	5.2	5.8

t statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure C.1: Estimated effect of the increase in the AOW-age for younger cohorts

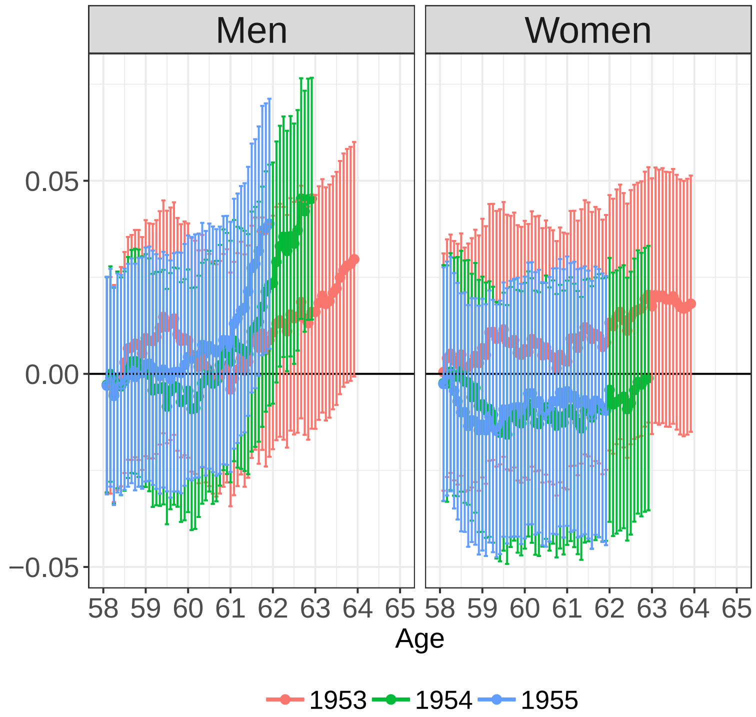


Figure C.2: Estimated effect of the increase in the AOW-age for cohort 1954, for different specifications of time effects.

Table C.2: Overview of results of selected studies

Study	Type	Reform	Country	Method	Treated	Outcome	Before	TE
Staubli & Zweimüller (2013)	ERA	60 → 62 for men and 55 to 58.25 for women between 2001 and 2010	AUT	DID	Women born after Sept. 1945 and men born after Sept. 1940	Employment rate	♀: 67% ♂: 36%	♀: +11 ppt ♂: +9.8 ppt
Rabaté & Rochut (2019)	ERA	60 → 62 between 2010 and 2015	FRA	DID	Birth cohorts 1951 to 1955	Employment rate	51%	+21 ppt
Geyer & Welteke (2019)	ERA	60 → 63 in 1999	GER	RDD	Women born 1952 onwards	Employment rate	44%	14 ppt
Behaghel & Blau (2012)	NRA	65 → 66 between 2004 and 2009	US	DID	Birth cohorts 1938 to 1942	Exit from employment hazard at NRA	-	+1 ppt
Atalay & Barrett (2015)	NRA	60 → 65 between 1995 and 2017 (♀)	AUS	DID	Women born June 1935 to 1952	Labor force participation dummy	42%	+12 ppt
Cribb et al. (2016)	NRA	60 → 61 between 2010 and 2011 (♀)	UK	DID	Women born April 1950 to 1953	Employment rate	58%	+ 7.3 ppt
De Vos et al. (2018)	NRA	65 → 65 between 2013 and 2016	NL	DID	Birth cohorts 1948 to June 1951	Employment rate	37%	+10 ppt
This paper	NRA	65 → 67 between 2013 and 2017	NL	DID	Birth cohorts 1948 to June 1951	Employment rate	40%	+16 ppt

Notes: DID and RDD denote differences-in-differences and regression discontinuity design, respectively, and ppt denotes percentage points. Column 'Before' contains the average outcome value before the reform age, and column 'TE' contains the treatment effect.