Pension Reforms and Partial Retirement*

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Abstract

Most Western countries reformed their pension systems to foster employment at old age, but many people are unwilling to work full-time until the statutory retirement age. Partial retirement, i.e. the combination of part-time work with partial pension, has been proposed to increase employment among older individuals and improve their well-being. In this paper, we first study two reforms that (i) abolished a generous early retirement scheme and (ii) increased the statutory retirement age in the Netherlands. We find that they have opposite effects on the incidence of part-time work at old age and that those part-time workers often claim pension benefits at the same time. Second, we develop a structural model of retirement and combine it with the two reforms for estimation and validation. The model replicates well the effects of the reforms on work and pension claiming decisions. Third, the model shows that the effect of partial retirement schemes on labour supply is heterogeneous across pension regimes, but positive under the reformed Dutch one, and it increases total work hours by up to 2.5 percent at age 66. Workers with lower wealth, who cannot afford to work part-time otherwise, value partial retirement most.

Keywords: Life-Cycle Model, Labour Supply, Retirement, Pension, Social Security

JEL Codes: D15, H55, J22, J26, J32

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1 Introduction

Population ageing and declining fertility rates have led to major reforms of social security systems in most Western countries (OECD, 2021). Classical reforms abolish generous early retirement plans or increase the eligibility age to claim pension benefits. These reforms aim to stimulate employment among older workers for a longer period of tax and social security contributions, and a shorter period of pension claims. Both types of reforms have been found successful in increasing the average retirement age (Lindeboom and Montizaan, 2020; Lalive et al., 2023; Atav et al., 2023). However, many people are unable or unwilling to work (full-time) until the statutory retirement age. In this paper, we study whether partial retirement schemes, which allow to combine part-time work with partial pension income, can increase labour supply at old age and retirees' well-being.

While the most common retirement transition is from a full-time job into full retirement, many workers take a more gradual path reducing the number of work hours or taking 'bridge jobs' with less demanding tasks before they fully retire (around 30% in the US, Rogerson and Wallenius, 2013). The reasons for working part-time at old age may vary and be related to preferences over consumption and leisure, to the financial incentives embedded in the pension or tax system, or the external constraints due to deteriorating health and declining productivity and wage (Ameriks et al., 2020; Hudomiet et al., 2021; Maestas et al., 2023).

From a policy perspective, incentives for partial retirement have been proposed as a potential instrument to stimulate later retirement (Kantarcı and van Soest, 2013; van Soest and Vonkova, 2014; Berg et al., 2020). The rationale is that some people who otherwise would fully retire may be willing to work part-time if they are given the opportunity to top up part-time wages with partial pensions to finance their consumption. With this motivation, over half of EU member states introduced partial retirement schemes in the past decades, even though with different rules (Eurofound, 2016). Partial retirement schemes could be welfare-improving if they foster labour supply while increasing retirement flexibility at the same time. However, they could reduce labour supply if people use them to replace full-time work (Börsch-Supan et al., 2018; Elsayed et al., 2018). The net effect on labour supply is the sum of a negative effect at the intensive margin and a positive effect at the extensive margin, such that the result is theoretically ambiguous.

Despite its potential to increase labour supply and retirees' well-being, we know little about the effects of partial retirement. This is mainly because reforms that only introduce partial retirement are scarce. In this paper, we combine a structural model of retirement with two pension reforms that (also) changed financial incentives to partially retire in order to study the effect of partial retirement on labour supply, how it varies across pension regimes, and its effect on workers' welfare. We proceed in three steps.

First, we study two reforms of the Dutch pension system to investigate how different pension regimes affect retirement behaviour, with a focus on partial retirement. Similar reforms were conducted in many Western countries (such as the USA, UK, Sweden).[1] To this end, we combine administrative data from the pension fund of public sector employees, the largest in the country, and from Statistics Netherlands. The first reform, implemented in 2006, abolished the early retirement scheme offered by occupational pension funds (the 'early retirement reform' from now on). Pension benefits became less generous and the minimum claiming age was raised from 55 to 60. The new rules applied only to people born in and after 1950. The second reform, implemented in 2011, increased the eligibility age for the state pension (the 'state pension reform' from now on). Birth cohorts of years 1948 to 1960 are subjected to a progressively increasing retirement eligibility age, from 65 to 67, while the yearly benefit amount did not change. Partial retirement was possible before and after both reforms.

Both reforms made pension provisions less generous and as a result they stimulated labour participation. In fact, both reforms increased the average retirement age (Lindeboom and Montizaan, 2020; Atav et al., 2023). However, we find that the reforms had different effects on the incidence of part-time work. The early retirement reform decreased the share of people in part-time work in the ten years before the state pension age, which is the period when people can partially retire. This is because the old regime incentivized people to move from full-time to part-time work to be able to claim early retirement benefits, which would otherwise be lost. The state pension reform, on the other hand, increased the share of people working part-time after age 60. In particular, people retire later but work fewer hours each year, possibly to smooth leisure on their path to full retirement. We also find that, depending on the pension rules, up to 40 and 60% of part-time workers claim pension at the same time between age 60 and 65, i.e. they partially retire. Pension reforms, therefore, can have opposite effects on part-time work at old age, suggesting that partial retirement might have different implications depending on the considered pension regime.

Second, we develop a structural model of retirement to study the effects of partial retirement on labour supply and welfare. In order to capture the complexity of retirement decisions, our life-cycle model embeds several key features: Savings and pension rights accumulation, a continuous consumption/savings choice, a discrete choice for the number of work hours, a binary pension claiming choice, wage, health, and survival uncertainty. The combination of the work and claiming choices allows for two partial retirement options with different work hours. We use the state pension reform to estimate the model by targeting retirement behaviour across birth cohorts subjected to different state pension ages. We then use the early retirement reform, which induced very different life-cycle profiles, for out-of-sample validation. The model replicates the large and negative effect of the early retirement reform on the incidence of partial retirement, and the smaller

[1] See OECD (2021) for the most recent pension reforms in OECD countries.

and positive effect of the state pension reform. It also replicates the positive (negative) correlation of wages (wealth) with the use of partial retirement and retirement ages.

Third, using the validated model estimates, we conduct two main counterfactual policy experiments. First, we simulate the effect of increasing the state pension age by an additional year, similar to the planned increase by the Dutch law.[2] In line with the causal evidence on the impact of the state pension reform, we find that raising the state pension age increases labour participation, but it also leads to more part-time work already before the old state pension age. The marginal return – in terms of labour supply – from increasing the state pension age decreases, and gains from a further increase above age 68 might be limited. Second, we analyse the impact of partial retirement on labour supply. In our counterfactual analysis this means eliminating the partial retirement option. We find that labour participation is about 3 percentage points higher between age 62 and 66 when people are offered the partial retirement option. This positive effect at the extensive margin hides two different underlying effects: Some people that work part-time through partial retirement but would otherwise work full-time, and some who would otherwise not work at all. To quantify which effect is stronger we estimate the change in the total number of hours worked. We find that the net effect is heterogeneous across pension regimes, but positive after the abolishment of the early retirement scheme. In this case, partial retirement increases total work hours by up to 2.5 percent at age 66. Our welfare analysis shows that poorer workers, i.e. those that cannot finance gradual retirement with private savings, benefit most from the additional flexibility provided by the partial retirement option. For people in the bottom decile of the wealth distribution, partial retirement is as valuable as 9% of their wealth.

Our contribution to the existing literature on retirement and labour supply of older workers is three-fold. First, we contribute to the literature evaluating pension reforms. We show that classical reforms can have large effects on labour supply not only at the extensive but also at the intensive margin. In this respect, we expand on Lindeboom and Montizaan (2020) and Atav et al. (2023), who analyse the impact of the same two reforms discussed here but abstract form part-time work and partial retirement choices. In particular, while both reforms decreased life-time pension income, they had opposite effects on the incidence of part-time work at old age. The early retirement reform decreased part-time work before full retirement, while the state pension reform increased it. We also investigate the effect of a further planned, but not yet implemented, increase of the state pension age in the Netherlands.

Second, we contribute to the literature on structural modelling of retirement (Gustman and Steinmeier, 1986; Rust and Phelan, 1997; Heyma, 2004; French, 2005; van der

[2]The people in our estimation sample with the highest state pension age were born in 1953 and reached their state pension age of 66 years and 4 in 2019. People born after 30 September 1961 have a state pension age of around one year higher (67 years and 3 months), meaning that only in 2028 we will be able to judge the effect of such increase.

Klaauw and Wolpin, 2008; de Bresser, 2023). First, we introduce partial retirement in a life-cycle model, which we find to be important to understand both the increase of part-time work at old age and the timing of retirement. This means that we model labour supply and pension claiming as two separate decisions, as well as the dynamic implications of partial retirement decisions on current and future pension benefits. Second, unlike earlier studies, we draw on quasi-experimental variation for both estimation (by targeting the effects of a reform) and validation (with out-of-sample predictions) of the structural model. While combining policy reforms with a structural model is becoming a popular approach (Todd and Wolpin, 2006; Attanasio et al., 2011; Kaboski and Townsend, 2011; Voena, 2015; Blundell et al., 2016), its use in the retirement literature has been limited so far. Exceptions are French and Jones (2011), de Bresser (2023) and Iskhakov and Keane (2021), who exploit changes in pension rules only for validation (although the latter reform did not lead to any effect). In this study, we exploit two policy reforms which made pension provisions less generous, but which had opposite effects on the incidence of part-time work and partial retirement at old age. We show that our model is able to capture these different effects of pension rules on work and pension claiming decisions, and thus can be used for counterfactual policy analysis.

Third, we contribute to the literature on partial retirement. Earlier studies provide mixed evidence on the effect of partial retirement on labour supply. Berg et al. (2020) find that incentives for partial retirement increase labour supply in Germany. However, Börsch-Supan et al. (2018) find a negative effect using aggregated data among various European countries. Another strand of the literature relies on stated preference (van Soest and Vonkova, 2014; Elsayed et al., 2018; Kantarcı et al., 2023), and also provides mixed results. The advantage of the stated preference approach is that it allows to study choice opportunities that are not available to workers. In particular, gradual retirement arrangements are often based on informal agreements negotiated between employees and employers (Hutchens, 2010). To address this challenge, our study focuses on retirement behaviour among Dutch public sector workers who face fewer restrictions if they want to partially retire. The pension fund of public sector employees has been offering a partial retirement plan for decades, and part-time work is much more common in the Netherlands compared to many other European countries. Our results suggest that the effect of partial retirement on labour supply strongly depends on the other features of the pension system, such as penalties in case of early claiming, which can help reconcile the existing mixed evidence.

The rest of the paper is organized as follows. Section 2 describes the Dutch pension system and its reforms. Section 3 presents the data and sample selection. Section 4 presents empirical evidence on the effects of the two reforms. Section 5 presents the model, the solution and the estimation approach. Section 6 discusses the model estimates and model fit. Section 7 presents counterfactual policy experiments. Section 8 concludes.

2 Institutional setting

The pension system Retirement income in the Netherlands mainly stands on two pillars: The state pension and the occupational pension.[3] The General Old-Age Pensions Act (AOW) is the state pension scheme, paying a flat-rate benefit when people reach the state pension age, independent of the individual work history. It provides a subsistence-level income to individuals older than the state pension age. The scheme is unfunded and based on the pay-as-you-go principle: Current state pensions are financed from the current premiums paid by workers through income taxes. The state pension age, originally set at 65 years, is gradually increasing since it was reformed in 2011. Employment contracts are terminated at the state pension age and, as a result, few people work beyond it (Atav et al., 2023). Social security benefits (e.g. disability insurance) expire at the same age.

Participation in the occupational pension scheme is mandatory for all employees. Participants accrue pension rights which are paid from the age of claiming. Accrual is based on the number of contribution years, the full-time wage, and the number of work hours expressed as full-time equivalent.[4] The minimum claiming age was set at 55 until 2006, when it was increased to 60 and benefits became less generous. Employees can choose, but are actuarially penalized for claiming early and rewarded for claiming later. They can also partially retire: They can claim part of their pension rights while working part-time and delay claiming of the remaining part. The scheme is fully funded, meaning that pensions are financed from the premiums paid by participants (and their employers) and from the returns on the invested premiums.

The early retirement reform The early retirement scheme of public sector workers (FPU) was introduced on 1 April 1997 by ABP, the pension fund of public sector employees. It allowed workers to retire before the state pension age, as early as of 55, with a generous pension benefit. Therefore, early retirement was the norm. Effectively, these employees were subject to two different schemes: The early retirement scheme, paying benefits before the state pension age, and the normal occupational pension scheme, paying benefits after the state pension age.

The early retirement pension benefit incorporated a flat-rate component, independent of the work history, and an accrued component, which depended on the individual work history. The final amount was equal to the sum of the two components multiplied by a retirement age specific factor to penalize retirement before the pivotal age of 62 or to reward working beyond the pivotal age. The early retirement benefit could be claimed between ages 55 and 65, until the state pension age, and would be lost otherwise. As of the state pension age, employees became eligible for the normal occupational pension

[3] A third pillar is private pension savings and its share in retirement income is limited.

[4] Until 2004, only the last wage applied for the final calculation. As of 2004, instead, the period-specific wage applied for the amount accrued in that year.

and the state pension. In case of early retirement, only the benefits received before the state pension age were actuarially adjusted. Under this scheme, people could retire at age 62 and receive an early pension equal to around 70% of their gross wages until age 65. As of 65, the total pension (including the state pension) would decrease to around 65% of the gross wage.[5]

After an initial announcement on 5 July 2005, the early retirement scheme was abolished on 1 January 2006 for workers born in and after 1950.[6] While the reform was not unexpected due to the ongoing public discussion at that time, the speed at which it was implemented and the differential treatment of workers born before and after 1 January 1950 came as a surprise when the reform was first announced.[7]

For the reform cohort, the early retirement scheme was abolished and they were eligible to participate only in the normal occupational pension scheme. In this scheme, the minimum age individuals can claim pension rights is 60, such that the reform implied an increase of the minimum claiming age from 55 to 60. Upon claiming, the pension benefit is equal to the sum of accrued rights and the state pension multiplied by an actuarial factor. This factor implies an actuarial reduction for claiming before the state pension age. In this case, early claiming impacts future benefits at all ages via the actuarial penalties. The 1950 cohort could retire at age 62 and receive a pension equal to around 64% of their gross wages for all subsequent years.

The state pension reform In 2011, the Dutch government introduced a reform to gradually increase the state pension age from age 65 to above age 67.[8] Figure 1 shows the increase in the state pension age for different birth cohorts.[9] Here we focus on the individuals born between November 1949 and July 1953 (the shaded area in Figure 1). For the former cohort, the state pension age was increased form 65 to 65 and 3 months, and for the latter group it was increased from 65 to 66 and 4 months.

The major reforms of the early retirement scheme and the state pension age implied very different pension rules across birth cohorts. People born in November and December 1949 could retire with generous early retirement benefits as of age 55 and receive the state pension as of age 65 and 3 months (group 1 in Table 1). People born shortly after,

[5]Calculations based on the examples in Lindeboom and Montizaan (2020).

[6]The scheme was also abolished for those born before 1950 but who had not worked continuously in the public sector since 1 April 1997.

[7]After the announcement of the reform, the pension fund ABP launched a campaign to inform its clients about the new system. In a special newsletter, unions, employers, and ABP explained the new pension scheme. Furthermore, ABP clients and their employers received a personalized letter about the core characteristics of the new scheme, along with a complete electronic service package.

[8]The social partners approved the final draft of the pension agreement on 9 June 2011.

[9]As of 1 January 2023, the state pension age is 67 years and 3 months for individuals born between 1 January 1960 and 30 September 1961. As the retirement age is now linked to life expectancy, for individuals born after 30 September 1961, the exact retirement age is not yet known (at least 67 years and 3 months). The final retirement age will be fixed 5 years in advance.

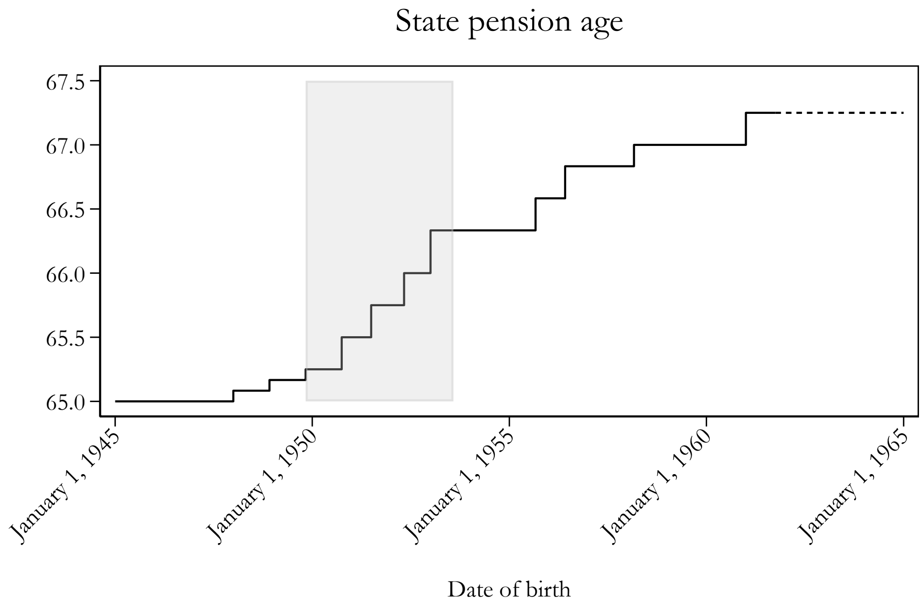

Figure 1: Reform of the state pension.

Note: The shaded area refers to the cohorts used in our analysis, born between November 1949 and July 1953. Information about the state pension age can be found at svb.nl.

however, face the same state pension age but could only claim occupational pension rights as of age 60 and with less generous provisions (group 2). Furthermore, people born 3 years later (group 6) face a significantly higher state pension age (1 year and 1 month higher). The pension system therefore became progressively less generous, with the aim of stimulating employment during the otherwise retirement years. No other reform differentially affected these birth cohorts.[10]

Group	Birth cohort	Early retirement	State pension age
1	Nov/1949 - Dec/1949	from 55 with minor penalties	65+3 months
2	Jan/1950 - Sept/1950	from 60 with large penalties	65+3 months
3	Oct/1950 - Jun/1951	"	65+6 months
4	Jul/1951 - Mar/1952	"	65+9 months
5	May/1952 - Dec/1952	"	66
6	Jan/1953 - Jul/1953	"	66+4 months

Table 1: Pension rules by date of birth.

[10] A new disability insurance (DI) scheme, which potentially affects labour supply at old age, came into effect in January 2006 and applied to all sickness cases reported as of January 2004 (admission to the DI scheme comes after 2 years of sickness leave). This means that, at the time when the early retirement reform was implemented, all sickness case were insured based on the same DI rules (regardless of the date of birth). Hence, during our study period, the rules of the current DI scheme apply.

3 Data and sample

Data We use unique administrative data from ABP, the occupational pension fund of workers in the government and education sectors.[11] ABP is the largest pension fund in the Netherlands (among the largest in the world) and insures about 15% of the Dutch population. Our initial sample includes all people who are participants of ABP as of December 2019 and were born before 1957. We observe, between January 2005 and December 2019, their wage, full-time equivalent (FTE, the number of work hours divided by the number of hours in a full-time schedule), accrued and paid pension rights, as well as background characteristics including date of birth, gender and marital status. Exact dates are observed when the value of a variable changes. Based on this information, we construct a panel dataset of individuals with monthly observations.

Sample selection We impose several restrictions on the data. First, we select individuals based on their date of birth such that we cover different pension rules, but also such that we observe everyone over a relevant period of life regarding retirement choices. That is, we select people born between November 1949 and July 1953 who have been subjected to different pension rules in the occupational and state pension schemes (as summarized in Table 1). We do not select cohorts born before November 1949 because they are subjected to a different state pension age (see Figure 1), and because for the older cohorts we have fewer observations at younger ages. Similarly, we limit our sample to people born in July 1953 (or before) because we last observe their employment status at age 66 and 5 months in December 2019, right after reaching the state pension age of 66 and 4 months, while for younger cohorts we would progressively miss observations before their state pension age. We observe everyone in our final sample between age 55 years and 2 months and 66 years and 5 months.

Second, we limit our analysis to men because the majority of women work part-time throughout their career in the Netherlands, and thus gradually retire rarely.

Third, our data includes all individuals who worked for the government and in the education sector at any point in time in their career. This includes people who have been long retired or those who worked in the public sector for short periods of time at young ages. Therefore, some individuals might not have been affected by the pension reforms. We thus keep individuals who are observed working at the age of 55 and two months, which is the first available age for our oldest cohort (people born in November 1949 are first observed on January 2005). Finally, we drop individuals who moved to a sector not covered by ABP after age 55 and hence accrued pension rights in a different fund. This implies excluding only a small number of individuals and our empirical results remain

[11] The government sector includes the sectors of central government, provinces, municipalities, water boards, army, police, judiciaries, and all civil servants. The education sector includes all school levels as well as universities, public research institutes and university medical centres.

virtually identical if we do not impose this last restriction.

These restrictions lead to a sample of 62,402 individuals born in a period of four years and working in the public sectors. We classify them into 6 groups. Table 2 shows, for each group, the average age at which individuals stop working ('Retirement age'), the average age at which they start claiming occupational pension rights ('Claiming age'), and the sample size. The claiming age can be lower than the retirement age if a person works part-time while claiming partial pension, i.e. partial retirement, but it can also be higher. Both ages gradually increase across birth cohorts (the differences in averages between two subsequent groups is always significant at the 0.1% level). Overall, the average retirement and pension claiming ages increase by about two years across the selected birth cohorts.

Group	Birth cohort	Retirement age	Claiming age	Individuals
1	Nov/1949 - Dec/1949	62.71	62.54	2,456
2	Jan/1950 - Sept/1950	63.72	64.37	11,554
3	Oct/1950 - Jun/1951	63.88	64.42	12,358
4	Jul/1951 - Mar/1952	64.03	64.53	12,562
5	May/1952 - Dec/1952	64.27	64.76	13,566
6	Jan/1953 - Jul/1953	64.34	64.82	9,906
Total	Nov/1949 - Jul/1953	63.99	64.49	62,402

Table 2: Main sample.

Note: Groups are defined in Table 1. The retirement age is defined as the last age (in months) at which a person is observed working. The claiming age is defined as the first age (in months) at which a person is observed claiming pension benefits.

4 Empirical evidence of the effect of the reforms

Trends in employment and pension claiming We analyse the work and pension claiming decisions across the different pension regimes presented above. We observe labour supply in terms of FTE and define part-time work as working less than 0.875 FTE (e.g. less than 35 hours compared to a weekly full-time schedule of 40 hours).

In Figure 2, panel a) presents the share of individuals working at different ages for the 6 groups. First, the figure shows that retirement is an active choice: The majority of the sample retires before reaching their state pension age. Also, people rarely work beyond the state pension age, because work contracts are terminated (Atav et al., 2023). Second, the average retirement age increases as the pension system becomes less generous. Comparing group 1 with the other groups suggests that the early retirement reform had a large effect on the employment rate, especially from age 62. Comparing groups 2 to 6 suggests that the gradual increase of the state pension age made people work longer.

Panel b) presents the share of individuals who claim pension. While the work and pension claiming choices are strictly related to each other, the figure shows that they are two different choices. For group 1, the increase of the pension claiming rate at age 56 is larger than the corresponding drop in employment, meaning that some people claim their pensions while still working. Instead, for groups 2 to 6, the claiming rate is zero until age 60 (the early claiming age), but the employment rate decreases from age 55 to 60. That is, some people stop working even though they cannot claim their pensions yet, and possibly rely on savings. Therefore, we will model the work and pension claiming choices separately as well as (dis-)saving decisions.

Panel c) reports the share of people in part-time work. At age 55, the part-time rate is close to 10% in all groups. For group 1, the share of part-time workers increases at age 56, when people start claiming pension benefits, and remains stable until age 62. The increase could then be driven by individuals who partially retire to claim pension benefits while still working. For the other groups, the share of part-time workers increases from age 62 and decreases after 64. This hump-shaped pattern is more pronounced for individuals who face a higher state pension age. Setting aside differences by group, the increasing incidence of part-time work with age could be driven by deteriorating health. Appendix C.1 shows that, even after taking into account objective health limitations, the part-time rate among healthy people increases notably for groups 2 to 6 as of age 60.

Because differences in the part-time rate could be mechanically driven by differences in employment across groups, in panel d) we condition the outcome variable on being employed. The conditional rate is notably larger for group 1, which shows that individuals in this group are not only less likely to work at every age, but those employed are also more likely to work fewer hours. For groups 2 to 6, instead, the share of part-timers among workers remains stable until about age 60 and increases afterwards, when they become eligible to claim pension.

These trends suggest that the early retirement reform increased labour supply along both the extensive and intensive margins: Individuals work for more years but also more hours in every year (group 1 vs 2). On the other hand, the state pension reform increased the employment rate, but also the part-time rate already before the state pension age, as suggested by the comparison of groups 2 to 6. While the net effect of the reform on labour supply seems positive, it is worth noting that the effect at the intensive margin is negative: People work for more years but also fewer hours in every year.

Panels e) and f) of Figure 2 present the share of people in partial retirement (that is working part-time and claiming pension at the same time).[12] The figure shows that partial retirement is a fairly popular choice in the early retirement scheme. In group 1, 7% of the individuals participate in partial retirement at age 63, which corresponds to about 14% of the employed people and 70% of the people working part-time. In the reformed pension scheme, however, partial retirement is less attractive. The share of

[12]We only have data on pension benefits paid under the early retirement scheme from 2006 onwards. Therefore, for group 1, we can compute the share of people in partial retirement only as of age 56. For the other groups the share is zero until age 60, the earliest age at which occupational pension rights can be claimed after the early retirement reform.

people participating in partial retirement shows a steep increase from age 60 to 65 in groups 2 to 6, with around 30-40% of the individuals working part-time at ages 64 and 65 being in partial retirement. Across all groups, the take up of partial retirement seems important to explain part-time work trends at old ages.

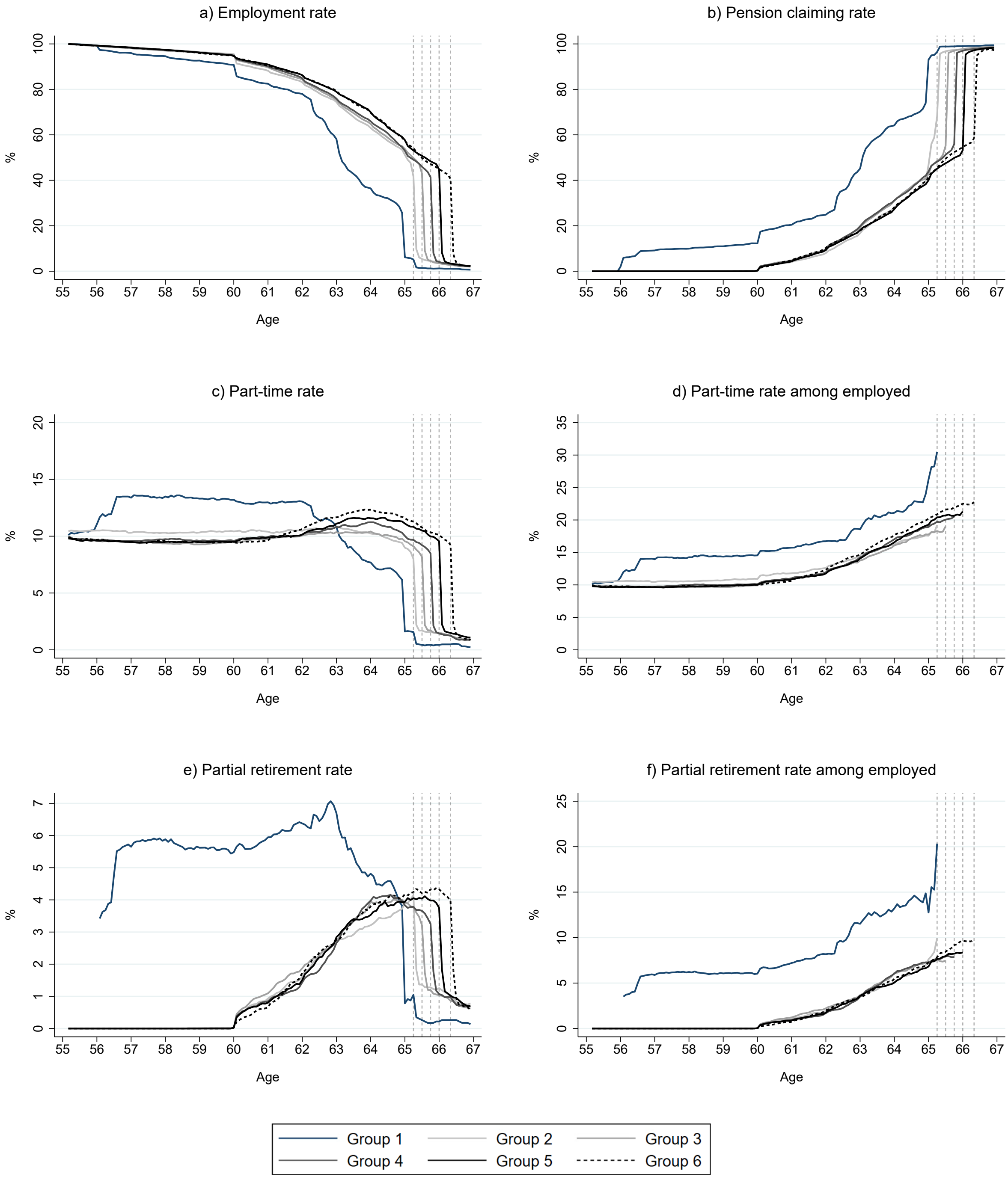

Figure 2: Labour supply and pension claiming over age.

Note: Panel a): Share of people working. Panel b): Share of people claiming pension benefits. Panel c): Share of people working part-time (i.e. less than 0.875 FTE). Panel d): Share of people working part-time among those that work. Panel e): Share of people in partial retirement (i.e. working part-time and claiming pension). Panel f): Share of people in partial retirement among those that work. Vertical lines refer to the different state pension ages.

Difference-in-Differences estimates Before using the two reforms presented above to estimate and validate our structural model, we check whether they had economically meaningful and statistically significant effects on retirement behaviour.[13] To estimate causal effects of the reforms, we could rely on a Regression Discontinuity approach as in Lindeboom and Montizaan (2020) and Atav et al. (2023). However, for the state pension reform, this allows to measure treatment effects of increases in the state pension age by three to four months. Since we model *annual* decisions in our structural analysis, an increase by few months would not be captured.[14] We therefore rely on a Difference-in-Differences (DiD) approach and compare individuals from group 1, 2 and 6 over time.

We compare people born in November and December 1949 (group 1) to people born in January and February 1950 (part of group 2) to study the effect of the early retirement reform. The reform was announced on 5 July 2005. The January-February 1950 cohort learns at age 55 and a half that they cannot use the early retirement scheme to retire, while nothing changes for the November-December 1949 cohort. Before age 55 and a half, both groups know that a reform will likely be implemented due to ongoing public discussion, but the differential treatment of workers born around January 1, 1950 came as a surprise. We consider the two birth cohorts as treatment and control groups, respectively, and compare their decisions before and after age 55 and a half in a DiD framework. The two groups are affected in the same way by the state pension reform, which implies a small change in rules for these workers: At age 61 and a half they learn that the state pension age is increased from 65 to 65 and 3 months. In fact, the reason why we do not consider people born earlier (e.g. in October 1949) is that they face a different state pension age. We select the treatment group to consist of people born in January and February 1950, and exclude those born in March or later, to keep individuals with approximately the same age of the control group when they are informed about the reforms.

To analyse the impact of the state pension reform, we compare people born in June and July 1953 (part of group 6) to people born in January and February 1950 (part of group 2).[15] In this setting, the former cohort represents the treatment group and the latter the control group. This reform was signed on 9 June 2011 and the June-July 1953 cohort learns at age 58 that their state pension age is notably increased from 65 to 66 and 4 months. For the January-February 1950 cohort the state pension age was almost unchanged, as it is increased from 65 to 65 and 3 months when they were 61. The fact that the control group received the announcement of the reform at a different age

[13] The existence of a non-zero effect is not strictly necessary, because changes in rules that do not lead to changes in behaviour are still informative for the model estimates, as in Iskhakov and Keane (2021).

[14] We still provide evidence in the spirit of a Regression Discontinuity approach in Appendix C.3

[15] Results are similar if we use a larger or different sample. Our preferred specification is to select a small sample based on the month of birth such that individuals have approximately the same age when they are informed about the reform. In particular, the June and July 1953 cohort learn about the reform around their 58th birthday on 9 June 2011. Age after 58 would then be the 'post-period' in our DiD estimates.

complicates the interpretation of the results, but given the minor increase of the state pension age of just three months the reform is likely to have a limited effect on their behaviour anyway. If anything, our estimates would provide a lower bound for the effect of increasing the state pension age from 65 to 66 and 4 months, because the control group is also partially treated. The treatment and control groups were also affected similarly by the 2006 reform as both groups do not have access to the early retirement scheme, but they learn this at different ages, i.e. 52 and 55 and six months. This means that one group had more time to prepare by, for example, saving more. Any difference in retirement behaviour between the two groups could therefore reflect such differences, on top of the effect of the 2011 reform. While the DiD estimates do not control for this, our structural model does since it explicitly models existing differences in savings and work histories via accumulated assets and pension rights. Therefore, while the DiD estimates could reflect (minor) differences in exposure time to the first reform to some extent, the second reform still provides differential treatment over cohorts that can be used to estimate the structural model, to which we return later.

We estimate the following linear probability model using monthly age observations

$$y_{it} = \alpha_i + \gamma_{s(t)} + \sum_k \beta_k (I\{s(t) = k\} \times T_i) + \varepsilon_{it}$$

where t is age in months $(55+2, 55+3, 55+4, \ldots, 66+11)$, s is age in semesters ($s = 1$ for $t \in [55; 55.5)$, 2 for $t \in [55.5; 56)$, etc.), α_i and $\gamma_{s(t)}$ are individual and age fixed effects, I is the indicator function and T_i is a dummy equal to one for the treatment group. We group observations in semesters to increase the precision of our estimates. β_k represents the DiD effect at semester k with respect to the baseline semester (age between 55 and 55.5). y_{it} is alternatively a dummy for work, for part-time work or for partial retirement. Standard errors are clustered at the individual level. Figures 3 and 4 presents the estimated effects of the reforms: The left panels refer to the early retirement reform, while the right panels refer to the state pension reform.

Panel a) of Figure 3 shows a clear effect of the early retirement reform on the employment rate. In particular, it shows a large effect between age 62 and 65, when most people retire under the generous early retirement scheme. The effect disappears when everyone stops working after age 66. On the other hand, panel c) shows that the effect on the probability of working part-time is negative between ages 56 and 62. That is, people are more likely to work full-time due to the reform. The effect turns positive between 62 and 65, when most people in the control group retire. Panel e) shows the effect on the probability of working part-time conditional on working. It shows how the reform affected the composition of the workforce in terms of full-time versus part-time employment. Among the employed people, the reform increased the probability of working full-time rather than part-time by 3 to 6 percentage points at ages 56 to 64. The reason is that under the early retirement scheme many people switch from full-time work to part-time work to be able to claim partial pension benefits, which would otherwise be lost. As a result, the reform made partial retirement less popular. This interpretation is confirmed by the results for partial retirement presented in panels a) and c) of Figure 4.

Panel b) of Figure 3 shows no effect of the state pension reform on employment until age 60, the minimum pension claiming age. A significant difference between the two groups opens after age 60 and is largest in the period between the old and the new state pension ages and falls again afterwards as everyone retires. Similarly, panel d) shows that the effect on the probability of working part-time is zero until 60 and positive afterwards. Part of this effect is mechanically driven by the higher propensity to work of the treated group. However, panel f) shows that even after conditioning on working, the part-time rate among employed people is significantly higher for the treated group. In fact, employees are significantly more likely to work part-time already at 62, well before the new state pension age. Panels b) and d) of Figure 4 suggest, again, that part of this increase in part-time work is driven by a higher propensity of taking partial retirement.

Overall, our estimates suggest that, while both reforms made the pension system less generous, they had opposite effects on the incidence of part-time work among older workers. They also suggest that, to some extent, these effects on part-time work are driven by a different propensity to retire partially under different pension schemes. However, they have little to say about the effect of offering a partial retirement scheme on labour supply and how much workers value it, for which we turn to the structural analysis.

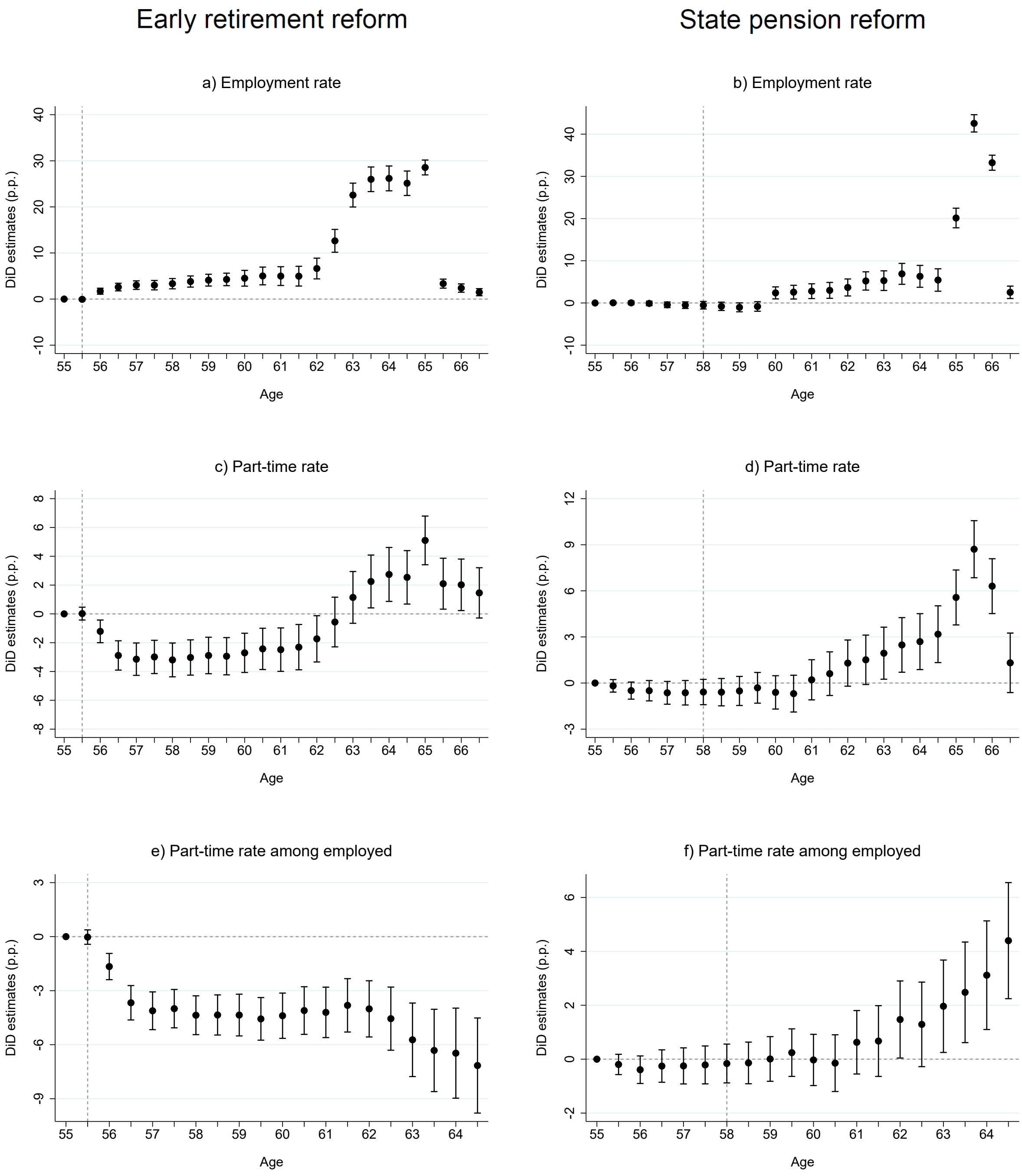

Figure 3: DiD estimates of the effects of the reforms on the probability of working, of working part-time, and of working part-time conditional on working.

Note: To study the occupational pension reform (left panels) we use cohort January-February 1950 as the treated group and cohort November-December 1949 as the control group. To study the state pension reform (right panels) we use cohort June-July 1953 as the treated group and cohort January-February 1950 as the control group. The semester from age 55 to 55.5 is used as baseline in all regressions. The vertical lines indicate the age at which the treatment groups receive information about the reforms. Standard errors are clustered at the individual level.

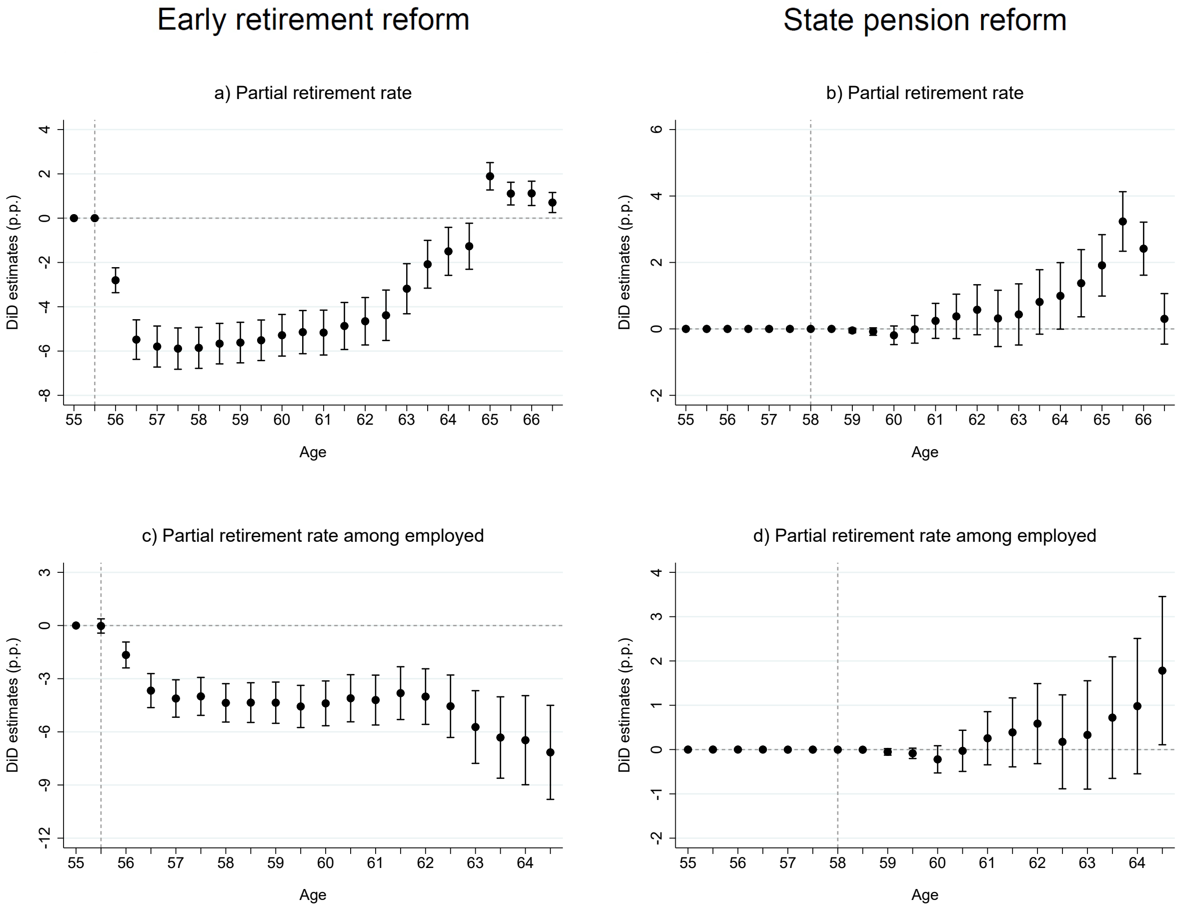

Figure 4: DiD estimates of the effects of the reforms on the probability of being in partial retirement, unconditionally and conditional on working.

Note: To study the occupational pension reform (left panels) we use cohort January-February 1950 as the treated group and cohort November-December 1949 as the control group. To study the state pension reform (right panels) we use cohort June-July 1953 as the treated group and cohort January-February 1950 as the control group. The semester from age 55 to 55.5 is used as baseline in all regressions. The vertical lines indicate the age at which the treatment groups receive information about the reforms. Standard errors are clustered at the individual level.

5 Model

The empirical analysis presented above establishes the responsiveness of part-time work decision, and in particular partial retirement choices, to changes in pension rules. However, it has little to say about the mechanisms underlying those choices. The model we develop below allows us to understand the effects of pension rules on behaviour and on welfare, carry out counterfactual analysis, and ultimately address policy questions regarding the effects of partial retirement and increasing state pension ages.

5.1 Outline of the model

We model individuals' annual consumption, labour supply and pension claiming choices as of age 56.[16] The labour supply choice set includes (voluntary) non-employment, full-time employment, and two different part-time work levels (0.5 and 0.8 FTE) which cover the two most popular choices of part-time contracts in the sample (see Figure C.2).[17] Retirement arises endogenously from the labour supply decision. The combination of the labour supply and the (binary) pension claiming choices allows two different partial retirement options: 0.5 FTE work and half pension, and 0.8 FTE work and one fifth of the pension benefit.[18] Full-time work while claiming pension is not allowed. Individuals cannot work beyond the state pension age, which is cohort-specific, because employment contracts are terminated. They can claim pension benefits only as of the early retirement age (also cohort-specific) and have to claim as of the state pension age. In the model, we restrict labour supply choices such that the number of hours worked cannot increase with age. Since it rarely happens in our sample, we make this simplifying assumption to ease the computation. Wages, which affect future pension income, evolve exogenously according to a stochastic autoregressive model. This also reflects the role of human capital accumulation in this institutional context, with starting wages affecting future wages and past work histories affecting future pension benefits.

In every period an individual may die with probability that increases with age. People die with certainty if they reach the age of 100. Differences in labour supply and claiming decisions can also arise due to differences in health status, which can change in every period. Future sickness status depends on age and current status. For computational and data reasons, we assume that health status can only be good or bad. Having only two possible values for health reduces the state space, but it still allows to account

[16] The model starts at 56 because this is the first age at which we observe wealth for the older cohorts, and because policy uncertainty largely resolves at 56.

[17] We also express the labour decision in terms of annual hours of work: 0 for not working, 1,000 hours for 0.5 FTE work, 1,600 for 0.8 FTE work and 2,000 for full-time work.

[18] ABP regulation states that at most a share equal to $(1 - FTE)\%$ of pension rights can be claimed while working. In the model, we assume that people claim the maximum amount possible if they decide to claim.

for severe and objective sickness cases that lead to very different behaviour, as shown in Figure C.1. We model sick people as qualifying as disabled and receiving disability insurance (DI) benefits. That is, we do not model disability insurance claiming choices or implicitly assume that eligible people would always claim. This is because we use administrative data on DI recipiency to infer health status – alternative data, such as health care expenditure, is only available from 2009. While receiving DI benefits, sick people can either work part-time or claim pension benefits, but not both.[19] The model does not feature involuntary unemployment and thus no unemployment insurance as only 1% of the people in our sample make use of it.

In the model, observed ex-ante heterogeneity is further driven by accumulated savings and pension rights as of age 56, both of which reflect individual specific work histories. As described in Section 2, people build pension rights proportionally to their wages and labour supply, which determine pension income in retirement. While the model does not include any uncertainty with respect to pension rules, initial conditions in assets and pension rights also reflect past uncertainty. Consistently, we estimate the model with data on people for whom pension rules uncertainty is largely resolved before entering the model. For cohorts 1949 and 1950 uncertainty essentially resolves with the early retirement reform at age 56. The state pension reform, announced when they were 61, implies an increase of just three months in the state pension age which we abstract from since (i) it is a minor change and (ii) its effect would not be relevant for this exercise as we model *annual* choices. The 1953 cohort is 53 years old at the time of the early retirement reform and 58 at the time of the state pension reform, when uncertainty resolves. We assume they already know their final state pension age as of 56 and avoid modelling uncertainty for the first two years.

All choices are affected by the tax and welfare system, which define disposable income under each employment and retirement option. We model taxes, pension rights accumulation and benefits, pension and other types of contributions according to the cohort-specific regulations.

Table 3 summarizes the main features of the model. We treat retirement as an absorbing state, meaning that people cannot move from retirement to employment, as it rarely happens in our data. Similarly, they cannot stop claiming pension, as required by the pension regulation. Therefore, the model includes an endogenous state variable 'Retirement status' which affects the future choice sets for the work and claiming decisions, and it is affected by current choices. The exogenous state variable 'Birth cohort' is time-invariant and determines the pension regime which each individual is subject to based on their date of birth. It thus affects the way pension rights and benefits are computed, but also the choice sets because different birth cohorts can early retire at different ages.

[19] We assume that all people in bad health have the capacity to work part-time, because most of the people on DI in our sample work before age 60 (see Appendix C.1).

Table A.1 in the Appendix summarizes the timeline of the model and provides additional details.

Choice variables	1. Consumption/savings (continuous)	c/a
	2. Hours of work per year (0, 1000, 1600, 2000)	h
	3. Occupational pension claiming (0,1)	op
State variables	1. Age	t
	2. Assets	a
	3. Full-time wage	W
	4. Pension rights	PR
	5. Health status (good or bad)	$health$
	6. Retirement status	ret
	7. Birth cohort/pension regime	$cohort$
Uncertainty	1. Survival	
	2. Wage	
	3. Health	

Table 3: Model overview

5.2 Parametrization

Preferences We assume people derive utility from consumption and leisure according to the following specification[20]

$$u(c_t, l_t) = \frac{1}{\lambda} c_t^{\lambda} + \psi \frac{1}{\gamma} l_t^{\gamma} \tag{1}$$

where leisure $l_t \in [0, 1]$ is given by

$$l_t = (4,000 - h_t - \delta I\{health_t = bad\})/4,000 \tag{2}$$

h_t being the annual number of hours worked, and δ is the (time) cost of bad health.[21] We assume δ to be positive, that is sick people have higher marginal utility of leisure compared to healthy people. Following De Nardi (2004), people derive utility from leaving a bequest as specified by (3), where b_1 captures the relative weight of the bequest motive and b_2 determines its curvature

$$B(a_{t+1}) = \frac{b_1}{\lambda}(b_2 + a_{t+1})^{\lambda}. \tag{3}$$

Wage and health The logarithm of gross full-time wage evolves exogenously according to an AR(1) process. While the initial conditions allow for cross-sectional dependence

[20]This is similar to Gustman and Steinmeier (2005) and Keane and Wasi (2016).

[21]The time endowment is based on de Bresser (2023): $(24-7)\times 5\times 47 = 3995$ hours per year (minimum of 7 hours per day for sleep and does not count weekends and 5 weeks of vacation). It's also in line with estimates from French (2005).

between individual tenure and wage, the dynamics of wages do not depend on individual work experience. This is in line with the institutional context of the Netherlands, where the relationship between tenure and salary is fixed according to collective labour agreements (de Bresser, 2023). Furthermore, most workers have reached the end of their wage scale when entering the model. All these considerations are particularly true for the public employees covered by our data. Earnings depend on the number of hours worked and on a wage penalty for part-time work $(1-\eta)$, as documented by Russo and Hassink (2008) for the Netherlands:

$$\ln(W_t) = (1-\rho)\mu + \rho\ln(W_{t-1}) + \xi_t \tag{4}$$

$$Earnings_t = FTE_t \times W_t \times \exp[\log(\eta) I\{FTE_t < 1\}] \tag{5}$$

$$FTE_t = \begin{cases} 0.0 & \text{if } h_t = 0 \\ 0.5 & \text{if } h_t = 1,000 \\ 0.8 & \text{if } h_t = 1,600 \\ 1.0 & \text{if } h_t = 2,000. \end{cases}$$

We assume that the idiosyncratic errors term are normally distributed and *iid*, $\xi_t \sim N(0, \sigma_\xi^2)$.

Health status can only take two values (good or bad). The probability of being healthy or unhealthy next year depends on age and this year's status

$$\Pr(health_{t+1} = bad | health_t, t) = \frac{\exp[\pi_0 + \pi_1 t + \pi_2 I\{health_t = bad\}]}{1 + \exp[\pi_0 + \pi_1 t + \pi_2 I\{health_t = bad\}]}. \tag{6}$$

We assume that people in bad health are eligible for DI, which in the Dutch context implies having at most 65% of the work capacity left. We assume that everyone who is eligible for DI claims it but can also work part-time (0.5 FTE) at the same time. The assumption that people in bad health have some remaining work capacity is based on the fact the most people on DI in our sample are observed to be working, although they tend to retire early (see Appendix C.1).

Budget constraint In every period, the agent receives income and pays an income tax, the pension premium for occupational pension, and other social contributions. Pension contributions allow workers to build up pension rights. Pension rights (PR) when entering the model accumulated differently for the different cohorts.[22] Taking PR as given at 56, they then accumulate according to (7). The increase in PR is proportional to the number of work hours (FTE) and the full-time wage (W), and also a function of the accrual rate

[22] That is mainly because cohorts 1950 and 1953 only accumulate rights for the old age pension as of 2006, but also receive a compensation for not being able to retire via the old early retirement scheme (see Appendix A.3).

(AR) and the state pension offset (SPO), which takes into account that people will receive a state pension and do not need to accrue pension rights on the entire wage. A factor $f(\cdot)$ takes into account the age- and cohort-specific actuarial adjustments in case of early claiming. The pension rights translate into benefits b_t as in (8), which can be claimed as of 61 (56) for cohorts 1950 and 1953 (1949). Those benefits can be claimed fully if not working or partially if working part-time. We assume that the share claimed is always equal to one minus the full-time equivalent implied by the work choice. The benefit is then constant afterwards, unless the number of hours worked changes. If the number of work hours changes, the share of pension claimed changes but also an actuarial adjustment is applied to the additional share claimed. The benefit also changes at age 66 for the 1949 cohort as they move from the early retirement scheme to the normal pension scheme. Therefore, differences across birth cohorts, given by the two reforms, enter the model via the budget constraint and in particular through the different actuarial adjustment factors, accrual rate, state pension offset, minimum claiming age and early pension rights calculation. More details are presented in Appendix A.3.

$$PR_{t+1} = [PR_t + FTE_t \times AR_{cohort} \times (W_t - SPO_{cohort})] \times f(op_t, h_t, ret_t, cohort) \tag{7}$$

$$AR = \begin{cases} 1.75\% \\ 2.05\% \end{cases}, \; SPO = \begin{cases} 15,500 & \text{if cohort } = 1949 \\ 9,600 & \text{if cohort } = 1950, 1953 \end{cases}$$

$$b_t = \begin{cases} [\mathit{early\ retirement\ rights}_t] \times (1 - FTE_t) \times f(\cdot) & \text{if cohort } = 1949 \;\&\; t < 66 \\ [PR_t + \mathit{state\ pension}] \times (1 - FTE_t) \times f(\cdot) & \text{otherwise} \end{cases} \tag{8}$$

In the model, apart from wages an pensions, the other source of income is the DI benefit. If health status is 'bad', the agent receives a DI benefit and cannot work full-time. The yearly DI benefit (DI_t) is equal to 70% of the current full-time wage realization W_t times the disability grade.[23] We assume that the disability grade is always 50%.[24] The agent continues to accrue pension rights in proportion to the DI benefit.

$$DI_t = I\{health = bad\} \times W_t \times 0.5 \times 0.7 \tag{9}$$

[23] In reality, the benefit amount depends on the last wage before sickness. We make this simplifying assumption because we do not keep track of the wage history and because wages follow a very persistent AR(1) process.

[24] To ease computation the model does not feature heterogeneity in the disability grade. People qualifying as disabled, in the Netherlands, have at most 65% of the working capacity left. Since we want to allow sick people to work part-time in the model, as observed in the data, the only available work option corresponds to 0.5 FTE making it a natural choice to assume 50% disability.

To a given set of choices (c_t, l_t, op_t) and state realization (X_t) corresponds a net income as computed by τ, which takes into account the different income sources as well as the tax paid on income and the contributions to social security schemes (details in Appendix A.2).[25] Assets, which include all types of savings, pay a constant return r and accumulate according to equation (10).

$$a_{t+1} = (a_t + \tau(c_t, l_t, op_t, X_t) - c_t)(1 + r) \tag{10}$$

Recursive formulation Equation (11) shows the recursive value function representing the agent's problem. The state variables are jointly denoted as X_t. p_t is the probability to survive period t conditional on surviving period $t-1$, but eventually no one survives age 100. Expectation is taken with respect to future wage and health, conditional on current state and choices. As uncertainty is essentially resolved for people in our sample before entering the model, there is no uncertainty with respect to future pension rules. The maximum is taken with respect to current consumption (c_t), leisure time (l_t), and the occupational pension claiming choice (op_t). The choice set for consumption depends on the realized state variables but also on the discrete choices because both affect disposable income and savings. Similarly, the choice sets for the discrete decisions depend on the realized state variables, for example because claiming is only possible from certain ages and retirement is an absorbing state, and it's also not possible to work full-time while claiming pension. The model has no closed form solution and therefore we rely on a numerical solution via value function iteration. More details on the model solution are presented in Appendix B.1.

$$\begin{aligned} V_t(X_t) = \max_{c_t, l_t, op_t} & \{u(c_t, l_t) + p_t \beta \mathbb{E}_t[V_{t+1}(X_{t+1}) | X_t, c_t, l_t, op_t] + (1 - p_t) B(a_{t+1})\} \\ & \text{s.t. (1) to (10)} \end{aligned} \tag{11}$$

5.3 Model estimation

As in French (2005), we follow a three-step procedure to estimate the model. In the first step, we externally set some parameters to values from the literature. In particular, we set the interest rate r to 1%. Our wealth data covers the period from 2006 to 2021, during which interests rates were particularly low, if not negative, and the average Euro Interbank Offered Rate (Euribor) was 0.9%. We set the time discount factor β to 0.99, similar to estimates from de Bresser (2023) and close to $1/1 + r$. We set the part-time

[25] French and Jones (2011) argue that it's relevant to include spousal income in their model as it can insurance against uncertain medical expenses. Our model does not feature medical expenditure because they were of limited importance in the Netherlands during the period studied in this paper and consisted mostly of monthly premiums for mandatory health insurance. We thus abstract from spousal income and also from medical expenses.

penalty to 13% $(1-\eta)$, similarly to Keane and Wasi (2016). We finally take survival probabilities from the life tables published by the Dutch Royal Actuarial Society. In the second step, we estimate the parameters that govern the exogenous evolution of wage and health using a regression approach (results and details are presented in Appendix B.2). Finally, we estimate preferences using the Method of Simulated Moments (MSM).

The goal of the MSM estimator is to find the preference vector that yields simulated life-cycle decision profiles that 'best match' (as measured by a GMM criterion function) the profiles from the data. Due to the poor small–sample properties of the optimal weighting matrix, we use a diagonal weighting matrix that contains only inverses of the estimated variances of sample moments on the diagonal (Altonji and Segal, 1996). Further details on the MSM estimator are presented in Appendix B.3, and targeted moments are discussed below. We use initial conditions from cohorts born in January 1950 and June 1953 to construct the simulated profiles (summary statistics in Table 4), as well as random realizations for wages, survival and disability status according to the externally estimated process in the second step.

The minimization of the MSM objective function is complicated because the objective function is not uniformly differentiable and has multiple local minima. Similarly to Theloudis (2018), we combine a global with a local optimizer. We start with a simulated annealing algorithm as in Goffe et al. (1994). We then use the best guesses of the global optimizer as starting values for the subplex algorithm Rowan (1990).

We only use the birth cohorts 1950 and 1953 to construct the initial conditions, from which we simulate decisions, and the targeted moments. Our estimation, therefore, exploits only the exogenous variation in pension rules generated by the state pension reform. This means that our estimates are designed to match the retirement decisions of these two cohorts, and therefore also the difference between them. Still, it does not mean that we would necessarily achieve a good fit if the model is miss-specified. Instead, we do not target moments from the 1949 cohort, which have access to generous early retirement benefits. This means that we can use the 1949 cohort to validate the model estimates. The reason to exploit the early retirement reform for validation and the state pension reform for estimation, and not the other way around, is that the former reform had stronger effects on retirement choices as the changes in pension rules were more drastic. Therefore, it provides a more demanding test to check whether our model can replicate well out-of-sample behaviour. We present results when using the early retirement reform for estimation in Appendix C.5, i.e. when we switch the role of the reforms used for estimation and validation, and show that results are very similar.

Targeted moments For each pension regime (i.e. for the 1950 and 1953 cohorts) and each age at which choices are active, we target average wealth, the pension claiming rate, the full-time and the part-time rate for healthy people, the employment rate for sick

Variables	1949	1950	1953
Savings (2006 euros)	145,865	144,003	136,062
	(101,621)	(110,195)	(108,582)
Full-time wage (2006 euros)	47,535	47,871	49,831
	(16,498)	(16,529)	(17,171)
Accrued years of pension	29.73	29.77	29.81
	(7.63)	(7.09)	(6.88)
Part-time work (%)	0.09	0.08	0.06
	(0.29)	(0.27)	(0.23)
Disability (%)	0.03	0.04	0.02
	(0.17)	(0.21)	(0.15)
Individuals	838	893	880

Table 4: Average initial conditions by cohort.

Note: Standard deviations in parentheses. In the model, the state variable is accrued pension rights and not accrued years. We report accrued years for ease of comparison across cohorts because differences in accrued rights do not necessarily reflect differences in final benefits due to different pension regimes. Savings are adjusted as discussed in Appendix B.4.

people, and the partial retirement rate. In total, we target 112 moments, of which 55 for cohort 1950 and 57 for cohort 1953. We access sickness and wealth data by linking our sample to administrative information from Statistics Netherlands. As we model annual decisions, we match annual life-cycle profiles. Labour supply and claiming profiles are measured annually on the birthday. Wealth, however, is only measured on January 1st and therefore, for each individual, we use the closest measure to their birthday to compute average savings at the respective ages.

For labour participation and benefit claiming, we simply target the average level over age for the estimation sample. For wealth, however, we are concerned that inflation and business cycle fluctuations might bias our model estimates because we do not model macroeconomic trends. Therefore, we first deflate wealth using a Consumer Price Index. Second, we use a regression approach to net out year effects. In practice, we use for this task a larger sample (cohorts from 1919 to 1956) and regress wealth on age and calendar year dummies. We then subtract the estimated coefficients for calendar years from observed wealth in the corresponding years, and subsequently compute the average at each age for our estimation sample. For both adjustments we use 2006 as the baseline year (when cohorts 1949 and 1950 enter the model). Details in Appendix B.4.

Identification and simulation exercise Since all parameters are affected by all moments in complex non-linear models, it is difficult to judge how the identification of each parameter relates to a specific profile. Heuristically, the leisure cost of poor health is driven by the difference in labour supply between people with good and bad health conditions, and the weight of leisure is driven by the combination of the employment and the part-time rate. It is more difficult to relate the remaining parameters to specific groups of moments since they all have profound effects on labour supply, benefit claiming and assets accumulation. We verified that the moments identify these parameters by fixing key parameters at different levels and estimating the remaining parameters or by checking how the value of the MSM objective function changes.

We also conduct a simulation exercise to confirm that our model is estimable. In particular, we want to check if we are able to recover the underlying parameters when we know the true data generating process. Given the model solution corresponding to an arbitrary preference vector, we simulate the life-cycle profiles starting from the initial conditions. The goal of this exercise is to estimate preferences using these simulated profiles as if they were the 'real' data. This exercise confirms that the model is estimable (results not presented).

6 Results

This section presents the results of the model estimation and fit when using cohorts 1950 and 1953, that is exploiting the exogenous variation induced by the state pension reform. Estimates for the preference parameters are shown in Table 5 (computation of the standard errors is discussed in Appendix B.3). While context-specific, our estimates are largely in line with those in earlier studies. We estimate λ, which determines the marginal utility of consumption, to be around -0.36, is line with Gustman and Steinmeier (2005) who estimate it as -0.26. The time cost of bad health, δ, is estimated to be about 643 hours per year, which is somewhat larger but comparable to estimates from French (2005), de Bresser (2023) and French and Jones (2011) – between 130 and 500. However, our definition of bad health only includes severe cases, explaining the higher estimate. The estimate suggests that the marginal utility of leisure is significantly higher for sick people, and that sickness implies a reduction of around 16% in disposable time. The relative weight of the bequest motive and its curvature, b_1 and b_2, are estimated to be around 49 and 270 thousand euros and fall within the (large) interval provided by past studies (French and Jones, 2011; de Bresser, 2023). It is more difficult to compare estimates of preferences over leisure, γ and ψ, due to differences in functional form assumptions. We estimate γ to be close to and not significantly different from zero, implying that utility over leisure can be approximated by a logarithmic function.

The first and second columns of Figures 5 and 6 show that the model performs well in replicating the targeted moments of labour supply, pension claiming, and saving decisions. In particular, the model replicates well the share of people in partial retirement for both cohorts. Notably, the increase in partial retirement at age 62 corresponds to a similar increase in the part-time work rate, suggesting that it reflects mainly people moving from a full-time work position into partial retirement. Figure C.4 in the Appendix further reports the average full-time equivalent and simulated consumption levels (not targeted).

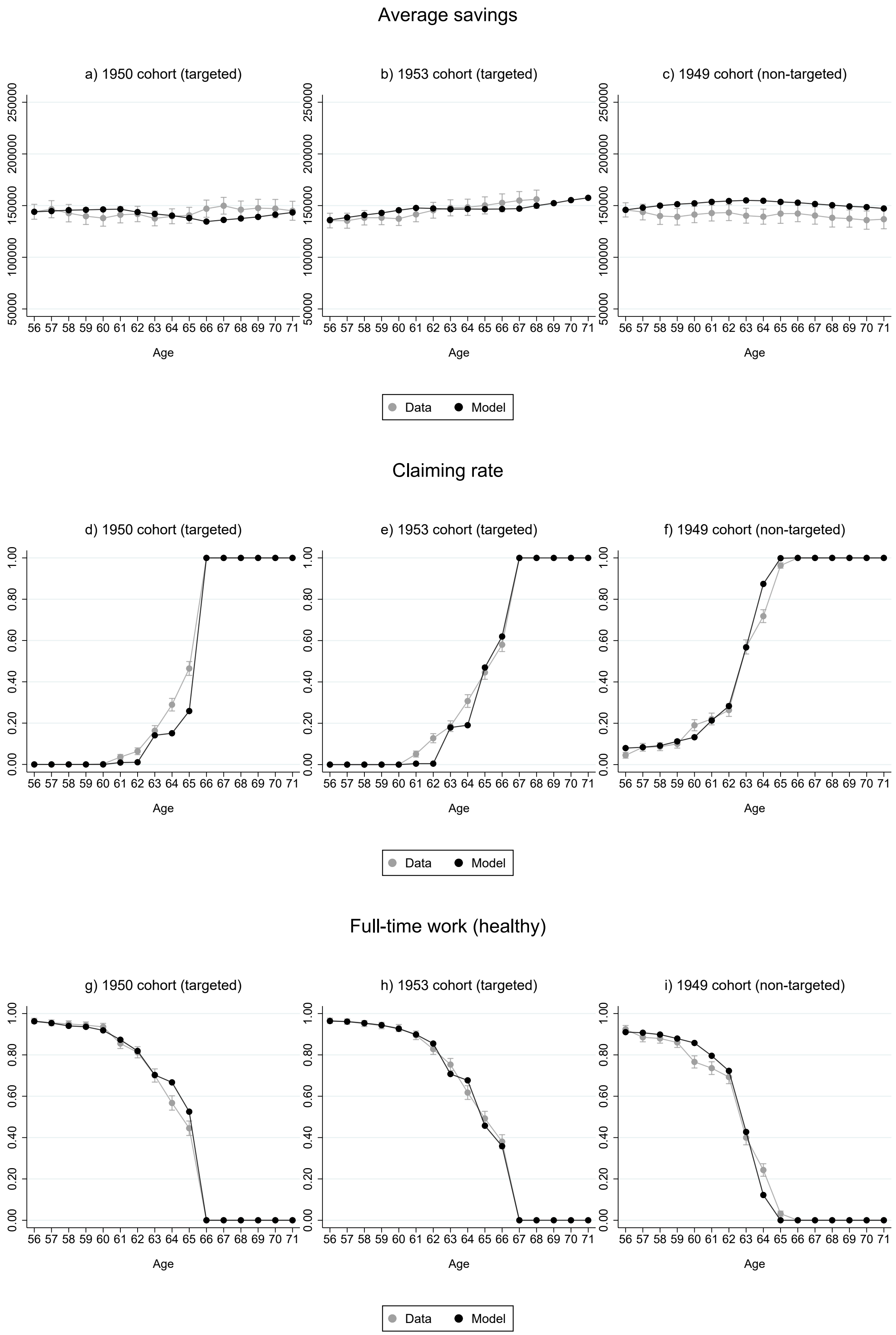

Figure 5: Model fit for targeted and non-targeted cohorts.

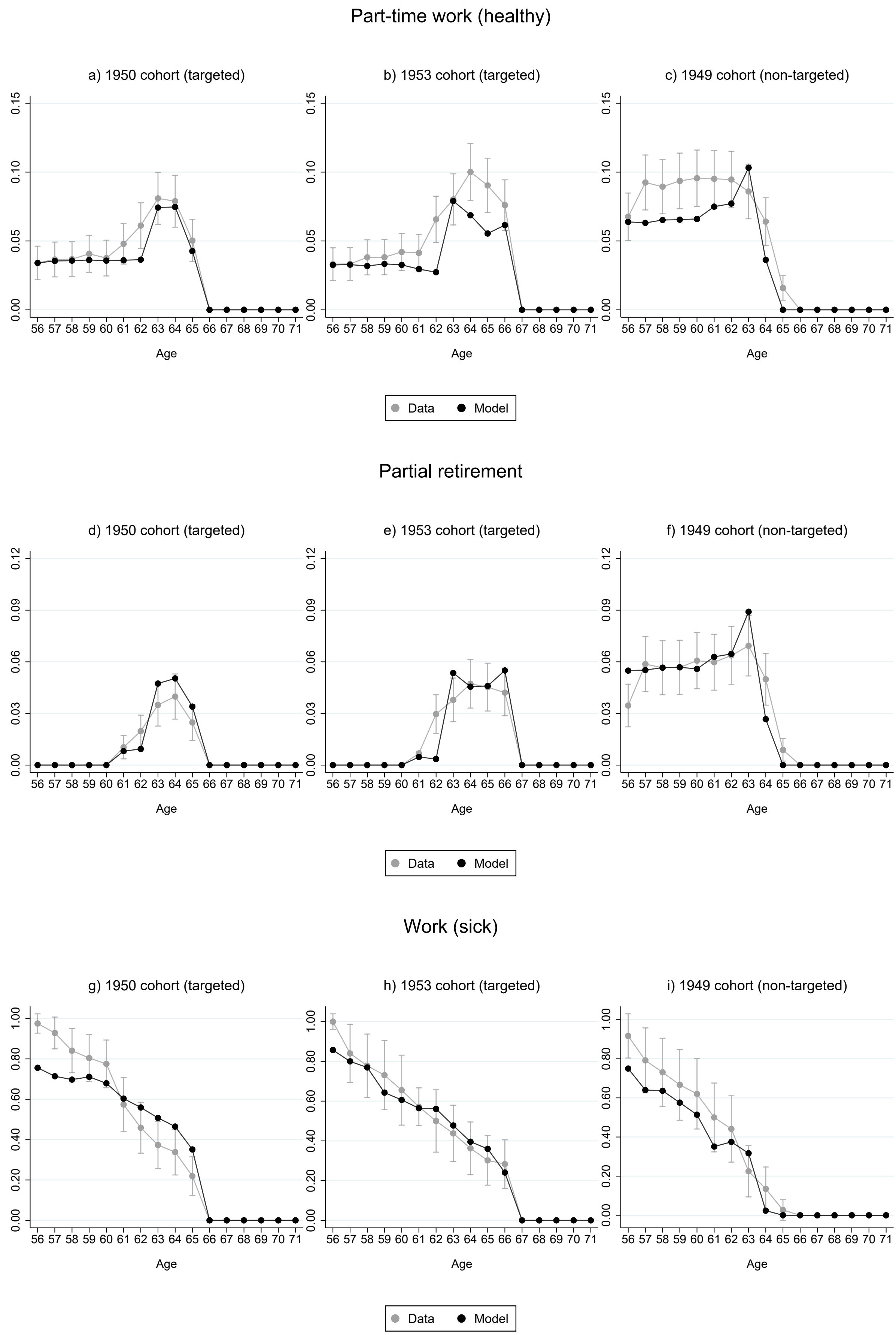

Figure 6: Model fit for targeted and non-targeted cohorts.

Parameter	Estimate	Std.Err.
γ	-0.149	0.680
λ	-0.359	0.016
ψ	0.040	0.008
δ	643.974	126.338
b_1	49.617	21.067
b_2	272,556.868	9,352.560

$u(c_t, l_t) = \frac{1}{\lambda} c_t^{\lambda} + \psi \frac{1}{\gamma} l_t^{\gamma}$

$l_t = (4,000 - h_t - \delta I\{health_t = bad\})/4{,}000$

$B(a_{t+1}) = b_1 \frac{1}{\lambda}(b_2 + a_{t+1})^{\lambda}$

Table 5: MSM estimates and asymptotic standard errors.

Retirement decisions by wage and wealth Before turning to the model validation using the early retirement reform, we investigate heterogeneity in retirement decisions and whether the model is able to replicate them. We define two outcome variables: A dummy which equals one if an individual ever participates in partial retirement and a variable representing the individuals' retirement age. We do this separately using the administrative data and our model simulations, for a total of four outcomes. We then regress them on full-time wage and wealth measured when entering the model. Table 6 presents the results.

First, the data suggest that wage is positively (and significantly) correlated with both the probability of retiring partially and the average retirement age. Our model replicates both the sign and the magnitude of these correlations. These correlations suggest that a higher cost of leisure leads people with a higher wage to retire later, but also that only people with higher wages might afford to retire partially, potentially because they do not have to reduce their consumption when moving from full-time to part-time work. On the other hand, wealth is negatively correlated with both outcomes: People with higher wealth can afford to retire earlier and partially retire less often, which means that if they reduce work hours as they age they do not need to rely on partial pension income. The model replicates well that the correlation with partial retirement is negative but close to zero, but it overstates the magnitude of the negative correlation with the retirement age. Overall, the results suggest that the model captures fairly well retirement heterogeneity driven by wage and wealth, even though these margins are not targeted by the estimation.

		Data		Model
		Estimate	95% CI	Estimate
Partial retirement	Wage (10,000)	0.0086**	[0.0007;0.0164]	0.0186
	Wealth (10,000)	-0.0012*	[-0.0024;0.0000]	-0.0002
Retirement age	Wage (10,000)	0.1921***	[0.1383;0.2459]	0.1441
	Wealth (10,000)	-0.0213***	[-0.0311;-0.0116]	-0.1096

Table 6: Correlations between wage and wealth and retirement decisions.

Validation We further validate our model estimates by simulating the life-cycle profiles of the 1949 cohort and comparing them to the data. This implies adjusting the model to incorporate the rules of the pension regime that applies to the 1949 cohort, which are different from the ones used for estimation. It also implies simulating the model starting from the initial conditions (assets, wage, health, etc.) observed in the data for this cohort.[26]

The results are presented in the third column of Figures 5 and 6. The figures show that the model replicates pension claiming and full-time work decisions very well. In particular, the model is able to capture the differences across the pension regimes. At age 63, 60% of people claim pension benefits in the 1949 cohort while this is only 20% for the 1950 and 1953 cohorts. Similarly, among healthy people aged 63, the full-time work rate is 40% for the 1949 cohort and around 70% for the other two cohorts. The model also performs well with respect to the labour supply choices of sick people (who can only work part-time). The fit is somewhat less good for the part-time work choices of healthy people: The model slightly under-predicts the part-time rate between age 57 and 60. However, the model fit is still good for partial retirement decisions, which is the main object of interest. In particular, the three cohorts markedly differ with respect to the evolution of the partial retirement rate over ages and the model is able to mimic these differences. To highlight these differences, Figure 7 reports the difference in the partial retirement rate between birth cohorts 1950 and 1949 in panel a), and between birth cohorts 1953 and 1950 in panel b). It shows that the model is able to capture well the direction and the magnitude of the effect of both reforms. This suggests that our estimates reflect policy-invariant preference parameters which can be used for counterfactual analysis.

7 Policy simulations

In this section, we present the results of two counterfactual policy simulations. First, we consider the effect of increasing the state pension age by one additional year, as planned by the Dutch law. Second, we investigate the effect of introducing a partial retirement plan on the number of work hours. Our simulations are conditional on the observed state variables when entering the model and we estimate the effects of permanent policy changes implemented when individuals are 55 years old.

[26]Because the 1949 cohort can make use of effectively two different pension schemes, the early retirement and the old age pension scheme, we need to add a state variable in the model with respect to the one used for cohorts 1950 and 1953. This additional state variable allows to model the evolution of pension rights and benefits under both schemes. In practice, this simply means that the way how pension income is computed is more complicated. This additional state variable does not bring in any additional parameter, meaning that it is essentially switched off for cohorts 1950/1953. Appendix C.5 also verifies that this change is innocuous, because using (also) the 1949 cohort and model for estimation does not change the results.

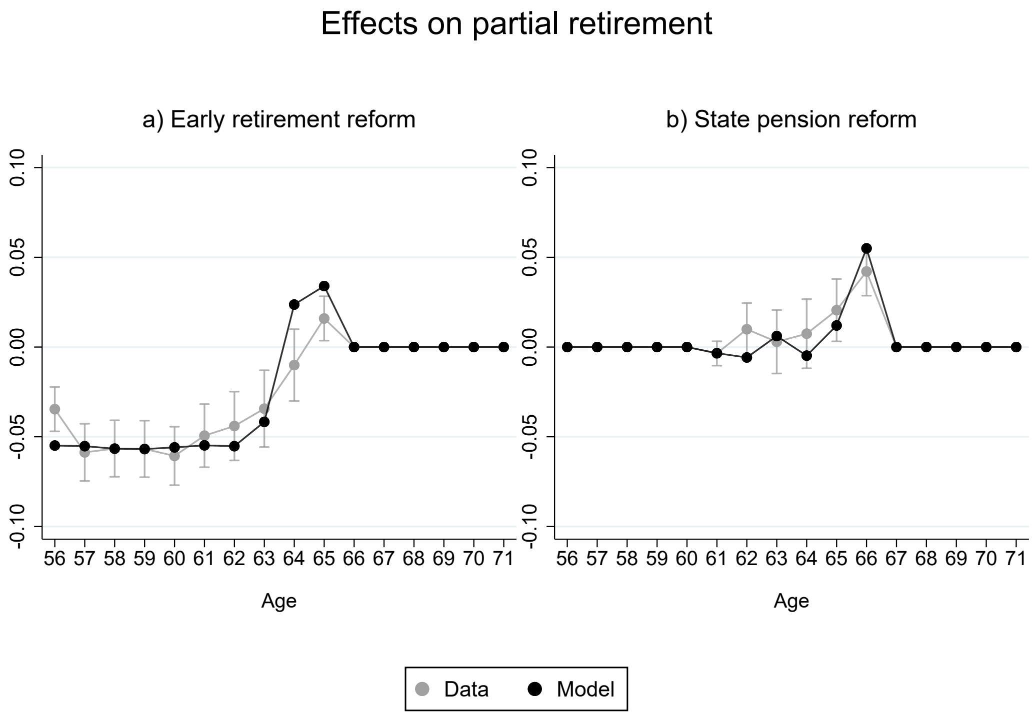

Figure 7: Model fit for the effects of the two reforms on partial retirement.

7.1 Increasing the state pension age

In this section, we investigate the effects of a further increase in the state pension age. This exercise reflects the increase planned by the Dutch pension law, as explained in Figure 1.[27] The increase of the state pension age implies two changes. First, the state pension will be received one year later. The actuarial factors applied in case of early claiming are adjusted with respect to the new state pension age, while the accrual rate does not change. This means that, keeping the work history constant, the corresponding total pension amount will be lower. Second, employees can keep working one year longer because the automatic job termination is also postponed.

We conduct this simulation exercise focusing on the 1953 cohort, for which the state pension age is 66 years and 4 months and therefore can work in the model until age 66 but not until 67 (baseline scenario). We adjust the baseline scenario by incorporating the changes described above. In particular, in the counterfactual scenario we assume that people can work until age 67, but not age 68 (see Table A.3 for the actuarial factors). We take initial conditions from cohort 1953 and simulate behaviour under both scenarios using the same random shocks to survival, wage, and health.

Figure 8 presents the results. Average savings are essentially unchanged compared to the baseline. The claiming rates are fairly similar until age 64 but are markedly different

[27] The first people who will reach the new state pension age of 67 years and 3 months are those born in 1961, meaning that only in 2028 we will be able to judge the effect of such increase.

at later ages as people postpone pension claiming due to the higher state pension age. Similarly, the full-time employment rate is higher at the same ages. Our model also predicts that the part-time rate will be higher already as of age 61, when part-time work can be combined with partial pension recipiency, in line with patterns from Figure 2. The partial retirement rate shows a trend that is very similar to that of part-time work. The share of people who choose partial retirement at some point increases from around 9 to 14% of the sample. This highlights the attractiveness of partial retirement when the state pension age increases. The employment rate for sick people shows, again, that employees would be more likely to work in the few years before the higher state pension age due to the hypothetical reform. However, the panels in the last row show that while the reform increases the average number of hours worked yearly due to people being more likely to work, there is a negative effect at the intensive margin. In fact, the reform increases the share of people working part-time among those employed, in line with the evidence presented in Section 4.

Overall, this exercise suggests that the planned increase in the state pension age will increase labour supply among older workers, although it will also increase the share of people working part-time. Findings are in line with those presented in Section 4 for the state pension reform. At the same time, the labour supply just before the state pension age is reduced by almost half. In the baseline scenario, the average person works for around 0.4 FTE at age 66. In the counterfactual scenario, however, this drops to 0.2 at age 67. This suggests that marginal returns from increasing the state pension age are decreasing, raising the question to what extent labour supply at old age can be further increased with similar policies.

It's worth noting that 4% of the sample is better off under the counterfactual scenario, meaning that their value function when entering the model is higher under the counterfactual case. That's because, for some people, the gain from postponing the automatic job termination by one year more than compensates for the negative wealth effect induced by the hypothetical reform. As we explore in Appendix C.6, increasing flexibility along this dimension might also increase labour supply and workers' welfare at the same time.

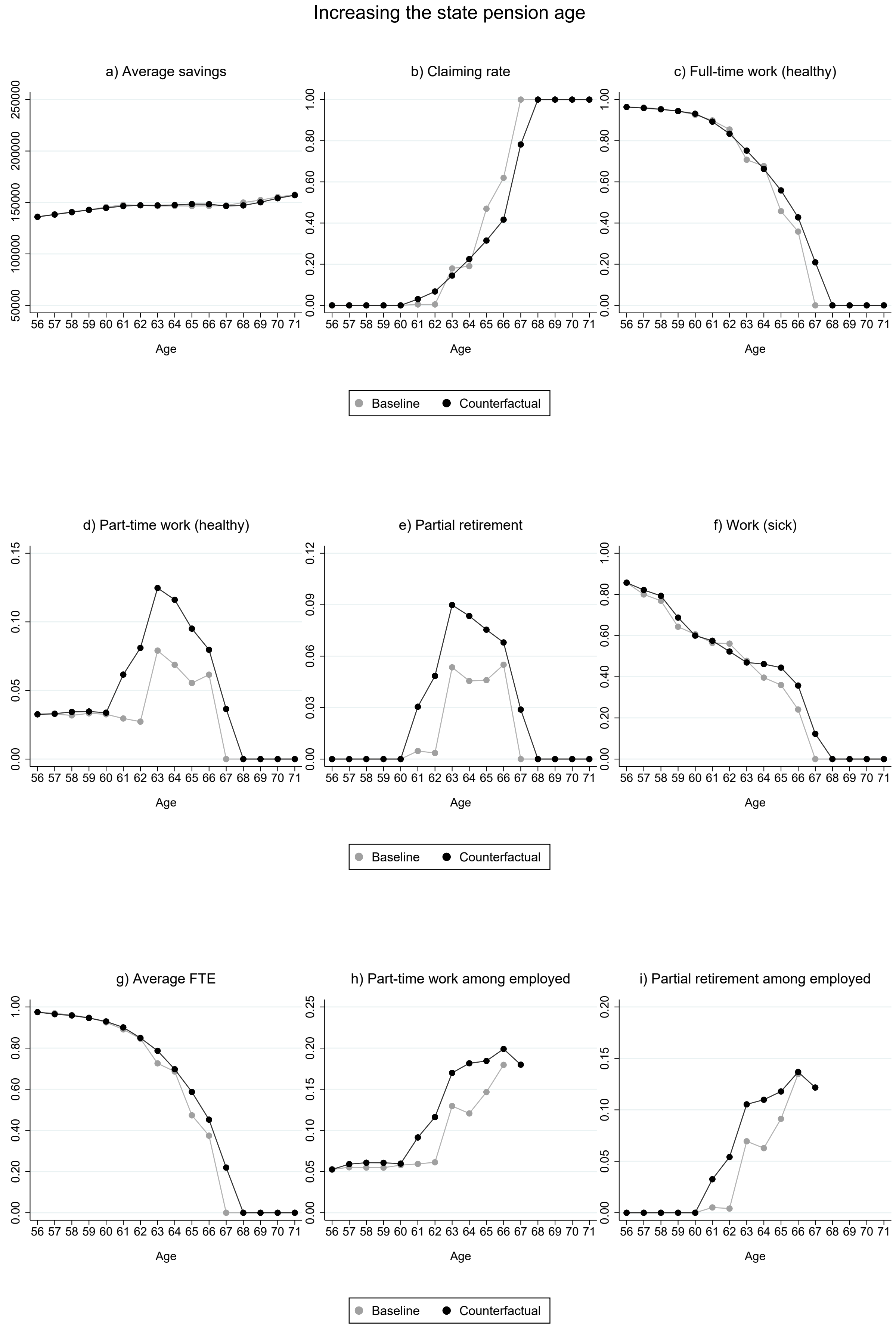

Figure 8: Results of the first counterfactual analysis: Increasing the state pension age.

7.2 The value of partial retirement

In this section, we quantify the effect of partial retirement on labour supply under the three considered pension regimes. We simulate choices for the three cohorts, with and without the partial retirement option, for a total of six different policy scenarios. With respect to the baseline scenario, we restrict choices from the early retirement age until the state pension age by excluding the two partial retirement options.

The panels in the first row of Figure 9 present the differences in the share of people working, working full-time, and working part-time, comparing the scenario that allows partial retirement with the scenario that does not. First, as expected, we find a positive effect of partial retirement at the extensive margin with people being around 3 percentage points more likely to work between age 62 and the state pension age when the partial retirement option is available for cohorts 1950 and 1953. The effect is smaller for cohort 1949. Second, we confirm that this increase in the employment rate comes (partially) at the expense of full-time employment, which decreases by around 1 or 2 percentage points at the same ages. Third, we find that the part-time rate increases somewhat more than the employment rate. That is, some of the people that work part-time through partial retirement would otherwise work full-time, while others would not work at all.

To quantify which effect is stronger, in panel d) we report the change in the total number of work hours between the same two scenarios, divided by the number of people (alive) at each age times 100. A value of +0.5 FTE/100 persons can be interpreted as follows: Among every 100 people, partial retirement makes one individual switch from not working to half part-time work. The figure shows that the effect is positive at all ages for cohorts 1950 and 1953. Instead, the effect is negative at most ages for cohort 1949. Over the entire period from age 56 to age 66 (i.e. summing up the bars in the left panel), the net effect is negative but close to zero for cohort 1949, but positive for cohorts 1950 and 1953. In panel e) we report the percentage changes in the total number of hours worked due to the availability of partial retirement, which suggest again that the effects are sizeable from age 63, when most people retire. Overall, these results suggest that the effect of partial retirement is heterogeneous across pension regimes, but it's positive under the current one (i.e. cohort 1953). In particular, the abolished early retirement scheme provides an incentive to claim pension benefits before the state pension age, which would otherwise be lost. Because benefits cannot be claimed while working full-time, the early retirement scheme provides an incentive to stop working but also to move from full-time work to partial retirement. Once this incentive is abolished, partial retirement has a positive effect of labour supply, meaning that it is more often used as a substitute for full retirement.

We also quantify how much partial retirees value the flexibility given by partial retirement following the approach in De Nardi et al. (2016). We define the value function of individual i when entering the model ($t = 1$) under the two scenarios as

$$V_{i1}(X_{i1}, PR = 0)$$
$$V_{i1}(X_{i1}, PR = 1)$$

where PR equals one if the partial retirement option is available and zero otherwise, and X_{i1} refers to the initial value of the state variables. We define the equivalent variation (EV) as the monetary amount the agent is willing to accept – when entering the model – in lieu of the partial retirement option, and the compensating variation (CV) as the monetary amount the agent is willing to give up to have the same option. That is, the EV_i (CV_i) is the individual-specific monetary amounts which is added to (subtracted from) the savings available when entering the model such that equation 12 (13) holds.

$$V_{i1}(X_{i1}, PR = 0, EV_i) = V_{i1}(X_{i1}, PR = 1) \tag{12}$$
$$V_{i1}(X_{i1}, PR = 0) = V_{i1}(X_{i1}, PR = 1, CV_i) \tag{13}$$

In general, the monetary amounts of the equivalent and compensating variation can differ because of the different policy regimes at which compensation is assumed to occur in these two measures of welfare change. Focusing on people in the cohorts 1950 and 1953 who would make use of partial retirement if it was available, we find an average EV and CV of around 400 euros, but with valuations ranging from zero to 5,000 euros with a long right tail in the distribution. The average monetary valuation is not large per se, but should be interpreted carefully. In the counterfactual scenario without partial retirement, individuals can still work part-time. In fact, they can still retire gradually and use private savings to smooth consumption and top up labour income. However, our result suggests that the average worker (in this selected group) would be willing to pay around 400 euros to be able to flexibly allocate pension income over time while working more hours in the years preceding full retirement (as shown by Figure 9). Essentially, partial retirement allows to move private resources across time and therefore improves workers' welfare, despite the fact that people decide to work more. The average valuation of 400 euros can be seen as the price people are willing to pay to borrow from their 'future self' pension. While partial retirement cannot decrease workers' welfare (at least in a partial equilibrium model), we expect its benefit to be larger for those with lower assets, that is people who cannot finance a gradual retirement path out of private savings. We thus regress the equivalent and compensating variation on assets, wages, and pension rights as observed when entering the model. In fact, for both outcomes, we find a negative and significant correlation between the monetary valuation of partial retirement and assets, but not with wages and pension rights. For people in the bottom decile of the wealth distribution, the partial retirement option is as valuable as 9% of their wealth.

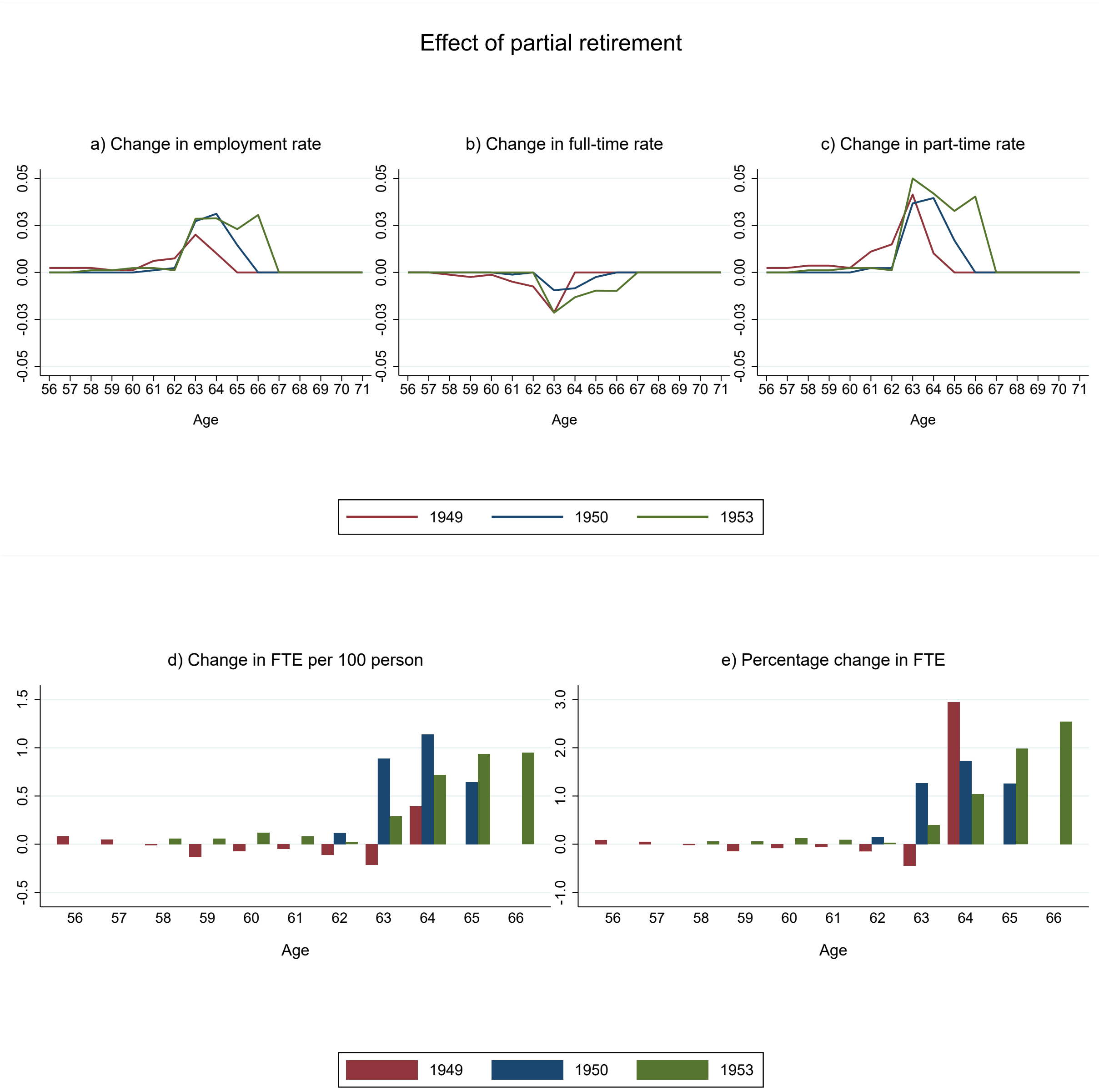

Figure 9: Results of the second counterfactual analysis: The effect of partial retirement.

8 Conclusion

This paper studies the effect of partial retirement on labour supply at old age and retirees' well-being. We start by exploiting two pension reforms implemented in the Netherlands to show how different pension regimes affect labour supply decisions at old age also due to their effects on part-time work choices. First, we document that part-time work at old age is often combined with partial pension income, that is partial retirement. Second, we show that the 2006 reform, which abolished a generous early retirement scheme, led people to work longer but also to work full-time more often before retirement. This is because the early retirement scheme provided a financial incentive to claim early retirement benefits before the state pension age, which would otherwise be lost. Because pension benefits cannot be claimed while working full-time, the scheme induced people to stop working but also to move from full-time work to partial retirement. Third, we show that the 2011 reform, which increased the state pension age, resulted in a higher share of people working part-time already a few years before the old state pension age. In other words, on average, people retire later but also work fewer hours in the years preceding full retirement.

Based on these findings, we develop a structural model of retirement which accounts for assets and pension rights accumulation, the bunching of work hours at four discrete levels, and the possibility to retire partially. We estimate the model exploiting the exogenous variation stemming from the 2011 state pension reform, while we use the 2006 early retirement reform, which greatly changed retirement behaviour, to validate our model estimates. Given that the model is able to replicate the effects of non-targeted policy changes well, we use it for counterfactual policy simulations.

In a first simulation exercise, we find that further increasing the state pension age increases the average retirement age, but it also stimulates part-time work before retirement. Moreover, the model suggests that marginal returns – in terms of labour supply – from increasing the state pension age are decreasing, raising the question to what extent labour supply at old age can be further increased with similar policies.

In a second policy simulation exercise, we find that the net effect of partial retirement on labour supply is heterogeneous across pension regimes, but positive under the current reformed scheme in the Netherlands. In this case, the positive effect on total work hours is substantial and up to 2.5 percent at age 66. We thus show that partial retirement increases labour supply and workers' well-being at the same time, with poorer workers benefiting most. For people in the bottom decile of the wealth distribution, we find that the partial retirement option is as valuable as 9% of their wealth. Our analysis, however, is limited to public sector employees and external validity of our results for other sectors remains to be examined, although the public sector covers a large share of the workforce.

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Appendix

A Details on the model setup

A.1 Timeline of the model

Table A.1 presents the timeline of the model for a healthy person born in 1950. A sick person would face a different choice set for h_t as he/she cannot work full-time nor 0.8 FTE. A person born in 1949, instead, could claim pension benefits already from 56, meaning that the choice set for op_t would be unrestricted from the beginning of the model. A person born in 1953 could still work at age 66.

The state pension age for birth cohorts 1949 and 1950 is 65 and 3 months. Since we model annual choices and match them to actual behaviour as observed on the birthday, we assume that people from these cohorts can decide to work at age 65 but cannot work at age 66. The state pension age is therefore 66 in our model for cohorts 1949 and 1950 and 67 for cohort 1953. Similarly, the early retirement age is 61 for birth cohorts 1950 and 1953 and 56 for birth cohort 1949.

Period	Age	Choice set h_t	Choice set op_t	Possible status ret_t	Notes
1	56	0,0.5,0.8,1	0	1,3,5,7	
2	57	0,0.5,0.8,1	0	1,3,5,7	
3	58	0,0.5,0.8,1	0	1,3,5,7	
4	59	0,0.5,0.8,1	0	1,3,5,7	
5	60	0,0.5,0.8,1	0	1,3,5,7	
6	61	0,0.5,0.8,1	0,1	1,3,5,7	Can start claiming
7	62	0,0.5,0.8,1	0,1	1,...,8	
8	63	0,0.5,0.8,1	0,1	1,...,8	
9	64	0,0.5,0.8,1	0,1	1,...,8	
10	65	0,0.5,0.8,1	0,1	1,...,8	Last period to work
11	66	0	1	1,...,8	Mandatory retirement
12	67	0	1	8	
...	...	...	...	...	
45	100	0	1	8	Last period (if alive)

Table A.1: Timeline of the model for a healthy person born in 1950

Note: The labour supply choice h_t is expressed in terms of full-time equivalent. The claiming choice op_t takes value 1 when claiming occupational pension and 0 otherwise. The retirement status is the status at the beginning of t, before making any choice and reflecting choices in $t-1$, as explained in Table A.2.

ret_{t+1}		op_t 0	op_t 1
h_t	1.0	1	2
	0.8	3	4
	0.5	5	6
	0.0	7	8

Table A.2: Retirement status evolution

Note: The table shows how work and claiming choices this year, h_t and op_t, affect retirement status next year, ret_{t+1}. h_t is expressed here in terms of FTE, and op_t as a binary claiming (1)/not claiming (0) variable. Status 2 cannot realize and $ret_{t+1} \geq ret_t$ in the model.

A.2 Taxes and contributions

This tax function is based on OECD (2004), with all nominal amounts expressed in 2006 Euros using the CPI published by Statistics Netherlands. Taxes are levied at the individual level in the Netherlands. The starting point is gross income, which is defined as the sum of earnings, DI benefits, and pension benefits

$$Grossinc_t = Earnings_t + DI_t + b_t$$

Workers pay unemployment contributions and contributions to public health based on their gross income, which are then deducted from gross income to arrive at taxable income

$$UIcontr_t = \begin{cases} 0 & Grossinc_t < 15,562 \\ 0.058 \times (Grossinc_t - 15,562) & 15,562 \leq Grossinc_t < 44,800 \\ 0.058 \times (44,800 - 15,562) & Grossinc_t \geq 44,800 \end{cases}$$

$$Pubmed_t = \begin{cases} 0.0125 \times Grossinc_t + 399 & Grossinc_t < 30,320 \\ 0.0125 \times 30,320 + 399 & 30,320 \leq Grossinc_t < 33,514 \\ 0 & Grossinc_t \geq 33,514 \end{cases}$$

$$Taxable_t = \max\{0; Grossinc_t - UIcontr_t - Pubmed_t\}$$

Social insurance contributions and income taxes are levied on taxable income. Social insurance contributions only pertain to the first two taxable income brackets and discriminate by age

$$Soc_t = \begin{cases} 0.324 \times Taxable_t & Taxable_t < 30,371 \text{ \& until state pension age} \\ 0.324 \times 30,371 & Taxable_t \geq 30,371 \text{ \& until state pension age} \\ 0.145 \times Taxable_t & Taxable_t < 30,371 \text{ \& from state pension age} \\ 0.145 \times 30,371 & Taxable_t \geq 30,371 \text{ \& from state pension age} \end{cases}$$

$$IncTax_t = \begin{cases} 0.01 \times Taxable_t & Taxable_t < 16,721 \\ 0.01 \times 16,721 & \\ \quad +0.0795 \times (Taxable_t - 16,721) & 16,721 \leq Taxable_t < 30,371 \\ 0.01 \times 16,721 & \\ \quad +0.0795 \times (30,371 - 16,721) & \\ \quad +0.42 \times (Taxable_t - 30,371) & 30,371 \leq Taxable_t < 52,072 \\ 0.01 \times 16,721 & \\ \quad +0.0795 \times (30,371 - 16,721) & \\ \quad +0.42 \times (52,072 - 30,371) & \\ \quad +0.52 \times (Taxable_t - 52,072) & Taxable_t \geq 52,072 \end{cases}$$

A general tax credit of 1,876 euro applies and is deducted from income tax. Also, a work credit is deducted from income tax which depends on earnings

$$WorkCredit_t = \begin{cases} 0.01753 \times Earnings_t & Earnings_t < 8,328 \\ 0.01753 \times 8,328 & \\ \quad +0.11213 \times (Earnings_t - 8,328) & 8,328 \leq Earnings_t < 18,147 \\ 0.01753 \times 8,328 & \\ \quad +0.11213 \times (18,147 - 8,328) & Earnings_t \geq 18,147 \end{cases}$$

Wealth is taxed at a rate of 1.2% above the threshold of 39,568 euro

$$WealthTax_t = \begin{cases} 0 & a_t < 39,568 \\ 0.012 \times (a_t - 39,568) & a_t \geq 39,568 \end{cases}$$

Workers also pay a pension premium to the occupational pension fund at a rate of 6.36% for wages above a state pension offset of 9,839 2006 euro

$$ABPpremium_t = \begin{cases} 0 & W_t < 9,839 \\ 0.0639 \times FTE_t \times (W_t - 9,839) & W_t \geq 9,839 \end{cases}$$

The net income is then given by

$$\begin{aligned}NetIncome_t = & Grossinc_t - UIcontr_t - Pubmed_t - Soc_t - IncTax_t \\ & + 1,876 + WorkCredit_t - WealthTax_t - ABPpremium_t\end{aligned}$$

A.3 Pension rights and benefits

Since we model retirement decisions in different pension schemes that are specific to different birth cohorts, here we explain how we calculate pension rights across the different schemes. We closely follow the information reported in the FPU regulation (version January 1, 2014) and the pension regulation (version January 1, 2015) published by ABP.[1]

Cohort 1949 For each individual, pension rights when entering the model are calculated as

$$PR_1 = Years \times 0.0175 \times (W - 15,000)$$

The accrued component depends on the number of accrued years (provided by ABP for each individual), an accrual rate of 1.75%, a state pension offset of 15,000 euros and the last earned wage. The number of accrued years already takes into account the work history in terms of full-time or part-time work (the number of years is the sum of the full-time equivalent worked over the years).

Given the initial condition as described above, in the the model pension rights continue to accumulate as follows

$$PR_{t+1} = PR_t + FTE_t \times 0.0175 \times (W_t - 15,000)$$

Pension rights are further adjusted to take into account that actuarial penalties apply for early claiming, but only to the share of pension rights that is claimed (that is 100% for full retirement and $(1 - FTE_t)$% for partial retirement). Furthermore, when claimed early, pension benefits are increased by a basic component of 15,000 euros (to which the actuarial adjustment also applies). As of the state pension age, instead, pension benefits include the state pension of 9,600. Importantly, old age pension benefits are not penalized due to early claiming.

$$b_t = \begin{cases} [early\ retirement\ rights_t] \times (1 - FTE_t) \times Act.Adj._{\cdot t,cohort} & \text{if } t < 66 \\ [PR_t + state\ pension] \times (1 - FTE_t) & \text{otherwise} \end{cases}$$

[1] Available at https://abppensioen.nl/wp-content/uploads/2018/05/FPU-reglement-2014-1.pdf and https://abppensioen.nl/wp-content/uploads/2018/05/ABP-Pensioenreglement-2015.pdf, respectively.

Cohort 1950 For each individual, pension rights when entering the model are computed as the sum of two components: The accrued rights as of age 56 and the compensation for the abolishment of the early retirement scheme

$$PR_1 = Accrued + Compensation$$

The accrued component depends on the number of accrued years, an accrual rate of 1.75%, a state pension offset of 15,000 euros and the last earned wage. Note that the accrual rate and the state pension offset are those which applied to rights accrued before the occupational pension reform of 2006, because cohort 1950 enters the model at age 56. In theory, until 2004 only the last wage earned is used to compute pension rights, while after 2004 the per-period accrual is proportional to the period-specific wage. Since the largest share of pension rights are accrued before 2004, and since wages – only observed from 2005 – follow a very persistent process, we only use the last earned wage.

$$Accrued = Years \times 0.0175 \times (W - 15,000)$$

The compensation is equal to 22.5% of the rights accrued under the early retirement scheme, which effectively means that

$$Compensation = 0.225 \times Accrued$$

Given the initial condition as described above, in the the model pension rights then accumulate as follows. The second component is the part accrued when working in period t, where now the accrual rate and the state pension offset are as defined by the 2006 reform.

$$PR_{t+1} = PR_t + FTE_t \times 0.0205 \times (W_t - 9,600)$$

Pension benefits equal pension rights plus the state pension times an actuarial adjustment that depends on the first age of claiming times the share that is claimed.

$$b_t = (PR_t + state\ pension) \times Act.Adj._{\cdot t} \times (1 - FTE_t)$$

Cohort 1953 Pension rights for the 1953 cohort are computed similarly as to the 1950 cohort. There are, however, two main differences. The 1953 cohort enters the model at 56 in year 2009, which means they already faced the new accrual rate and state pension offset for three years. Also, the compensation is lower compared to the 1950 cohort as they had less time to build rights under the early retirement regime.

$$
\begin{aligned}
PR_1 = &\ Accrued\ until\ 2006 + Accrued\ after\ 2006 \\
&+ Compensation
\end{aligned}
$$

where

$$
\begin{aligned}
Accrued\ until\ 2006 &= Years\ until\ 2006 \times 0.0175 \times (W - 15{,}000) \\
Accrued\ after\ 2006 &= Years\ after\ 2006 \times 0.0205 \times (W - 9{,}600)
\end{aligned}
$$

and

$$
Compensation = 0.225 \times Accrued\ until\ 2006
$$

The state pension is again equal to 9,600. Pension rights accumulate as for the 1950 cohort, and benefits are computed in the same way (using the cohort-specific actuarial adjustments).

$$
\begin{aligned}
PR_{t+1} &= PR_t + FTE_t \times 0.0205 \times (W_t - 9{,}600) \\
b_t &= (PR_t + state\ pension) \times Act.Adj._t \times (1 - FTE_t)
\end{aligned}
$$

Actuarial factors Table A.3 reports the actuarial factors we used for the model simulations. The actuarial factors for cohort 1949 apply when claiming early retirement benefit under the FPU regime. We compute the actuarial factors as described in Annex A of the FPU regulation, version January 1, 2014, as published by ABP. That is, we divide the actuarial factors for each age by that corresponding to the pivotal age of 62 years and three months. We report an actuarial factor of one at age 66 meaning that no actuarial factor applies when claiming benefits under the old age pension (as opposed to the early retirement FPU benefits).

The actuarial factors for cohort 1950 and 1953 apply to the old age pension and are reported in the corresponding columns. We compute them using the factors reported in the ABP regulation, version January 1, 2015. We use the factors from the regulation and adjust them to the relevant state pension ages of 65 and 3 months and of 66 and 4 months, respectively.

The last column reports the actuarial factors used in the first counterfactual exercise, reported in Section 7.1, when we increase the state pension age. These actuarial factors are computed as they would be for someone born in 1963, that is for people with a state pension age of 67 and 3 months (the last step of the currently planned increase by the Dutch regulation).

Age/Cohort	1949	1950	1953	C. 1
56	0.25	/	/	/
57	0.28	/	/	/
58	0.32	/	/	/
59	0.37	/	/	/
60	0.44	/	/	/
61	0.54	0.74	0.73	0.71
62	0.69	0.79	0.78	0.76
63	0.94	0.85	0.84	0.81
64	1.44	0.89	0.88	0.86
65	2.94	0.95	0.94	0.91
66	1.00	1.00	0.98	0.96
67	/	/	1.04	1.01
68	/	/	/	1.07

Table A.3: Actuarial factors by age and cohort and for the counterfactual exercise.

B Details on the solution and estimation of the model

B.1 Computational details on the solution of the model

In order to estimate and simulate the model we first need to solve it. Since there is no analytical solution to the maximization problem, we approximate numerically the policy functions for labour supply, consumption, and pension claiming choices conditionally on the information at each age (the state variables, jointly denoted by X in Section 5.2). We solve the model using backward recursion, starting from the end of life (age 100). A key feature of our work is that we jointly model the consumption, labour supply and pension claiming decisions over the life-cycle, where the former is a continuous choice while the latter are discrete choices. The numerical solution of problems with simultaneous discrete and continuous choices is considerably harder than that of problems with only continuous or only discrete choices, which explains the scarce literature considering such models. Studies related to ours opted for different approaches, such as French (2005) or Iskhakov and Keane (2021). We follow a procedure similar to that in French (2005).

The main difficulty in solving dynamic problems that combine discrete and continuous choices is that the smoothness and concavity of the value function – which is typical of continuous problems and ensures the existence and uniqueness of a solution that is itself continuous and, if interior, is the root of the optimality condition – does not hold in a problem with a discrete choice variable. The addition of a discrete choice makes the value function piecewise concave, with kinks falling at the points where the agent is indifferent between any two possible alternatives along the discrete choice domain; these then translate into discontinuities in the optimal choice of the continuous variable (consumption or savings).

As discussed in previous work (e.g. Blundell et al., 2016), kinks can be eliminated and the expected continuation value can be 'concavified' by introducing uncertainty in the model. In our model, kinks in the value function occur at the level of assets where the agent is indifferent between the different labour supply options or between claiming or not claiming pension, or at points of indifference with respect to the same decisions but in the future.

At the same time, we also deal with both continuous (savings, wage, pension rights) and discrete state variables (health, retirement status, pension regime). To address this, we discretize the continuous variables over a predetermined grid and solve the model over a finite number of grid points.[2] We then use linear interpolation to approximate the value function at points for which a solution was not computed as we move backward in time.[3]

[2] We use a grid with 10 points for assets, 5 points for full-time wage, and 5 points for pension rights. We use the method described in Tauchen (1986) to compute the transition matrix for discretized wages.

[3] We also need to rely on interpolation and extrapolation when simulating behaviour at points for which the optimal choices were not computed. We thus rely on linear interpolation for consumption/saving choices, and on nearest neighbour interpolation for work and claiming choices.

The recursive formulation of the problem presented in Section 5.2 can be rewritten by combining the work and pension claiming decisions in a unique discrete choice d_t with (at most) seven possible options. Note that the options are seven and not eight because full-time work while claiming pension is not an option, and the available choice set $\mathcal{D}$ is a function of past choices which are reflected in the current state variables X_t.

$$V_t(X_t) = \max_{c_t \in \mathcal{C}(X_t, d_t), d_t \in \mathcal{D}(X_t)} \{u(c_t, d_t) + p_t \beta \mathbb{E}_t[V_{t+1}(X_{t+1})|X_t, c_t, d_t] + (1 - p_t)B(a_{t+1})\}$$

When we solve the model numerically, in a first step we look for the optimal consumption level conditional on each of the k (available) discrete options $\mathsf{d_k}$

$$V_t(X_t|d_t = \mathsf{d_k}) = \max_{c_t \in \mathcal{C}(X_t, \mathsf{d_k})} \{u(c_t, \mathsf{d_k}) + p_t \beta \mathbb{E}_t[V_{t+1}(X_{t+1})|X_t, c_t, \mathsf{d_k}] + (1 - p_t)B(a_{t+1})\}$$

In particular, if the expected value function is smooth and concave we can simply rely on 'golden section' search (we also code the problem in terms of optimal saving level rather than optimal consumption). We then select the discrete choice associated with the highest value in the second step.

$$V_t(X_t) = \max_{d_t \in \mathcal{D}(X_t)} \{V_t(X_t|d_t = \mathsf{d_1}), V_t(X_t|d_t = \mathsf{d_2}), \dots\}$$

We finally compute the expected value function before moving to period $t-1$ and verify that it is smooth and concave over assets.

B.2 Second-step estimation: Wage and health processes

Wage process We assume that the logarithm of full-time gross wage evolves according to an AR(1) process. As explained above, this is in line with the rules governing wage determination in the Netherlands in which wages are set at the national level based on wage scales which determine wage levels and increases. Furthermore, we focus on workers who most likely have reached the end of their wage scale (people older than 55) and face little uncertainty.

$$\ln(W_{it}) = (1 - \rho)\mu + \rho \ln(W_{it-1}) + \xi_{it} \tag{B.1}$$

$$\ln(W_{it}) = \alpha + \rho \ln(W_{it-1}) + \xi_{it} \tag{B.2}$$

Since there are no particular differences across birth cohorts with respect to wage setting rules, we estimate the model pooling the different cohorts and therefore use the same estimates when solving and simulating the structural model. We also do not make any adjustment to take into account that full-time wages are observed only for working people, because the same wage scale applies to everyone. We therefore estimate (B.1) with ordinary least squares and cluster standard errors at the individual level. Before estimating the model, we deflate monetary amounts using the Consumer Price Index published by Statistics Netherlands taking 2006 as the baseline year.

Results are presented in Table B.1. The autoregressive parameter ρ is very close to unity, in line with the estimate from de Bresser (2023). We estimate $\mu = \alpha/(1-\rho) = 10.98$, which represents the expected value of the logarithm of wages. The variance of the error term is estimated to be equal to 0.005.

Health process Health status only takes two values: good or bad. The probability of being healthy or unhealthy next year depends on age and the health status in the current year.

$$\Pr(health_{it} = bad|health_{it-1}, t) = \frac{\exp[\pi_0 + \pi_1 t + \pi_2 I\{health_{it-1} = bad\}]}{1 + \exp[\pi_0 + \pi_1 t + \pi_2 I\{health_{it-1} = bad\}]} \tag{B.3}$$

We define bad health as being eligible for DI, which implies having at most 65% of the work capacity left in the Dutch DI scheme. As we adopt an institutional definition for health, we argue that our health measure is an objective one. Since we use administrative data, we lack alternative (subjective) measures of the health status. An alternative measure could be based on medical expenditures available from Statistics Netherlands, but this data is only available from 2009 and therefore does not fully span our study period.

Given these considerations, we use information from Statistics Netherlands about DI recipiency. We assume that eligible people would always claim DI, and therefore treat DI recipiency as being independent from people's choices (i.e. being a measure of exogenous health shocks). Since people are insured under DI only until the state pension age, we use observations until age 65 or 66 to estimate the health process. We estimate the parameters in equation (B.3) with maximum likelihood by regressing health on age and the lag of health, and we assume that the error terms have a logistic distribution. Since there are no particular differences across the birth cohorts, we estimate the model pooling the different cohorts and therefore use the same probabilities when solving and simulating the structural model. Results are presented in Table B.1.

B.3 MSM estimates distribution

Our discussion of the Method of Simulated Moments (MSM) estimator is based on French and Jones (2011). The objective of MSM estimation is to find the preference vector that yields simulated life-cycle decision profiles that "best match" (as measured by a GMM

	Wage		Health
α	0.30***	π_0	-5.45***
	(0.04)		(0.16)
ρ	0.97***	π_1	-0.01
	(0.00)		(0.02)
		π_2	10.36***
			(0.27)
N	33,698	N	45,531

Table B.1: Estimates of the auxiliary processes.

Note: Standard errors are clustered at the individual level.

criterion function) the profiles from the data. Formally, the estimator is given by

$$\hat{\theta} = \arg\min_{\theta} \varphi(\theta, X)^T \widehat{W} \varphi(\theta, X)$$

where θ is an $l \times 1$ vector of unknown parameters; $\varphi(\cdot)$ is the $k \times 1$ vector of moment conditions, whose k-th entry is given by $m_k^d(X) - m_k^s(\theta)$, where m_k^d is the k-th moment from the data and m_k^s the corresponding moment from the model simulation. $\widehat{W}$ is a $k \times k$ weighting matrix. Even though the optimal weighting matrix is asymptotically efficient, it can be severely biased in small samples (see, e.g., Altonji and Segal, 1996). We therefore use a diagonal weighting matrix that contains only inverses of the estimated variances of the data on the diagonal, e.g. the first entry is $\widehat{W}_{1,1} = [\widehat{Var}(m_1^d)]^{-1}$.

Under the regularity conditions stated in Pakes and Pollard (1989) and Duffie and Singleton (1993), the MSM estimator $\hat{\theta}$ is both consistent and asymptotically normally distributed:

$$\sqrt{n}(\hat{\theta} - \theta_0) \to_d N(0, V)$$

with the variance–covariance matrix V given by

$$V = \left(1 + \frac{1}{N_{sim}}\right) (D^T W D)^{-1} D^T W S W D (D^T W D)^{-1}$$

where $N_{sim} = 1$ is the number of times we simulate each individual in the estimation procedure.[4] S is the $k \times k$ variance–covariance matrix of the data, and D is the $k \times l$ Jacobian matrix of the moment vector evaluated at the MSM estimate $\hat{\theta}$

$$D = \left.\frac{\partial \varphi(\theta, X)}{\partial \theta^T}\right|_{\theta = \hat{\theta}}$$

In our baseline setting, when using cohorts 1950 and 1953 for estimation, we have $k = 112$

[4] Since the estimator is consistent for a fixed number of simulation (Adda and Cooper, 2003), and because we are not particularly interested in making inference on the model estimates, we only simulate each individual once to save time in the estimation process.

moments and $l = 6$ parameters. We compute D by numerical approximation and estimate S using the method of bootstrap (we use 500 bootstrap samples with replacements, as in de Bresser, 2023).

B.4 Moment construction

As discussed in Section 5, we use the Method of Simulated Moments to estimate preferences. In particular, we target the evolution of work, pension claiming and savings decisions at each age when the choices are active in the model. We use administrative data from Statistics Nederland on wealth to construct the savings moments. Wealth is measured at the household level on the 1st of January of every year and we use data from 2006 to 2021. Wealth includes financial assets, bank savings, real estate, debts and mortgages. We consider the sum of all components. We make several adjustments to the raw data. First, as wealth is measured at the household level and we focus on married men, we divide reported wealth by the squared root of two, which is the OECD equivalence scale measure. Second, we deflate wealth using the Consumer Price Index published by Statistics Nederland and express monetary amounts in terms of 2006 Euros. Third, we are concerned that business cycle and financial market fluctuations, which are not captured by our model, could differentially affect savings across cohorts.

We use a regression approach to net out year effects. For this, we use a larger panel including all available cohorts from 1919 to 1956, and regress wealth on a set of dummies for age and calendar year. We then subtract the estimated coefficients for the corresponding years form observed wealth. Finally, we aggregate the data by averaging over age and birth cohorts for our main sample to construct the targeted moments. For this adjustment we use, again, 2006 as base year (which corresponds to age 56 for cohorts 1949 and 1950, but not for cohort 1953).

Figure B.1 reports average wealth, before and after we net out year fixed-effects, for the sample used in the reduced-form analysis and in the structural model. The left panel shows that the average wealth is substantially affected by macroeconomic trends, with a decrease from 2008 to 2015 and an increase afterwards.[5] In the right panel, the version adjusted for year fixed effects does not show any particular trend over age and also no large differences across cohorts. It is consistent with the fact that neither net income nor consumption change substantially at retirement age in the Netherlands (Knoef et al., 2017; Been and Goudswaard, 2023).

[5]See the evolution of Dutch Gross Domestic Product for a comparison over the same years (link).

Figure B.1: Average wealth across cohorts before and after removing year fixed-effects.

C Additional results

C.1 Part-time employment by health status

Figure 2 shows that the part-time work patterns differ notably by health status. We define the health status based on DI receipt as discussed above. DI recipients cannot work full-time (eligibility for disability insurance requires having at most 65% of work capacity left), which means that the part-time rate is the same as the employment rate for this group.

Panel a) of Figure C.1 shows part-time work patterns similar to those presented in Figure 2 for the whole sample. The main differences are that (i) the part-time rate is lower among healthy people compared to the whole sample, as expected; (ii) the increase in part-time work after age 60 for groups 2 to 6 is even more pronounced among healthy people, because sick people tend to stop working earlier – as shown by panel b). Panel b) also suggests that people in different groups behave differently only from age 62, when the employment rate becomes lower for group 1, and around the cohort-specific state pension ages, with younger cohorts working slightly longer.

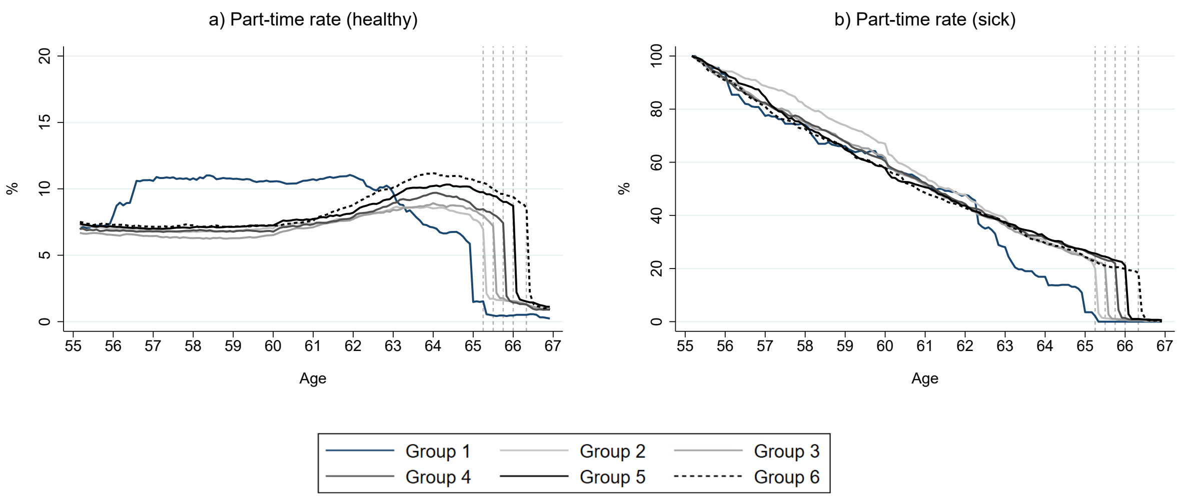

Figure C.1: Part-time employment by health status over age.

Note: Left: Share of people working part-time among people who do not receive disability insurance benefits. Right: Share of people working part-time among people who receive disability insurance benefits Vertical lines refers to the different state pension ages that apply to the different groups.

C.2 Part-time work contracts

Figure C.2 shows the distribution of the full-time equivalent in the sample for people working part-time (less than 0.875 FTE) on the left, and for people in partial retirement (working part-time and claiming pension rights) on the right. Both figures show bunching corresponding to 0.50 and 0.80 FTE, which are the two most popular levels of part-time work. For computational reasons and to take into account constraints form the demand side of the labour market, we only allow these two levels of part-time work in our model.

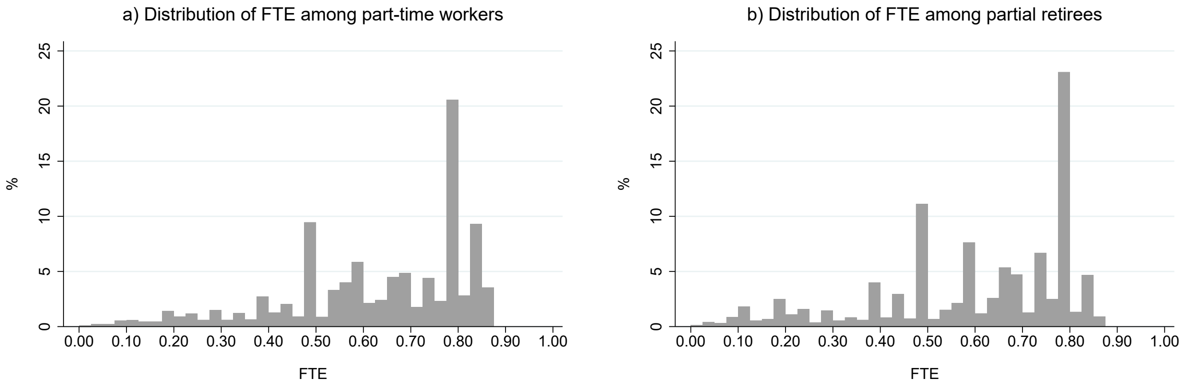

Figure C.2: Distribution of FTE for part-time workers and partial retirees.

Note: Part-time work is defined as working less than 0.875 FTE (30 hours/week compared to a full-time contract of 40).

C.3 Regression Discontinuity Approach

Here we present evidence about the causal effects of the two reforms taking a Regression Discontinuity (RD) approach. Figure C.3 presents RD plots, with the mean value of selected variables plotted against date of birth. In particular, we compute the share of people working, working part-time, and in partial retirement at age 65 (left panels) and at age 66 (right panels). Vertical lines mark the date of birth at which pension rules change, as reported in Table 1. We also report linear fits using observations for people subjected to the same pension regime.

The panels in the top row show clear effects of both reforms on the retirement age. The left panel shows how the abolishment of the early retirement scheme had a large effect – about 40 percentage points – on the probability of working at age 65. Similarly, the right panel shows how increasing the state pension age from 65 years and 9 months to 66 years increases the share of people working at 66 by around 40 percentage points.

The panels in the middle row show results for the probability of working part-time. The left panel shows that the abolishment of the early retirement increased the share of people working part-time at 65 (mainly because people postponed retirement). It also suggests that the increase of the state pension age increased the probability of working part-time, as this probability discontinuously jumps at the third and fourth cut-offs. The right panel shows a similar behaviour for the probability of working and working part-time at 66.

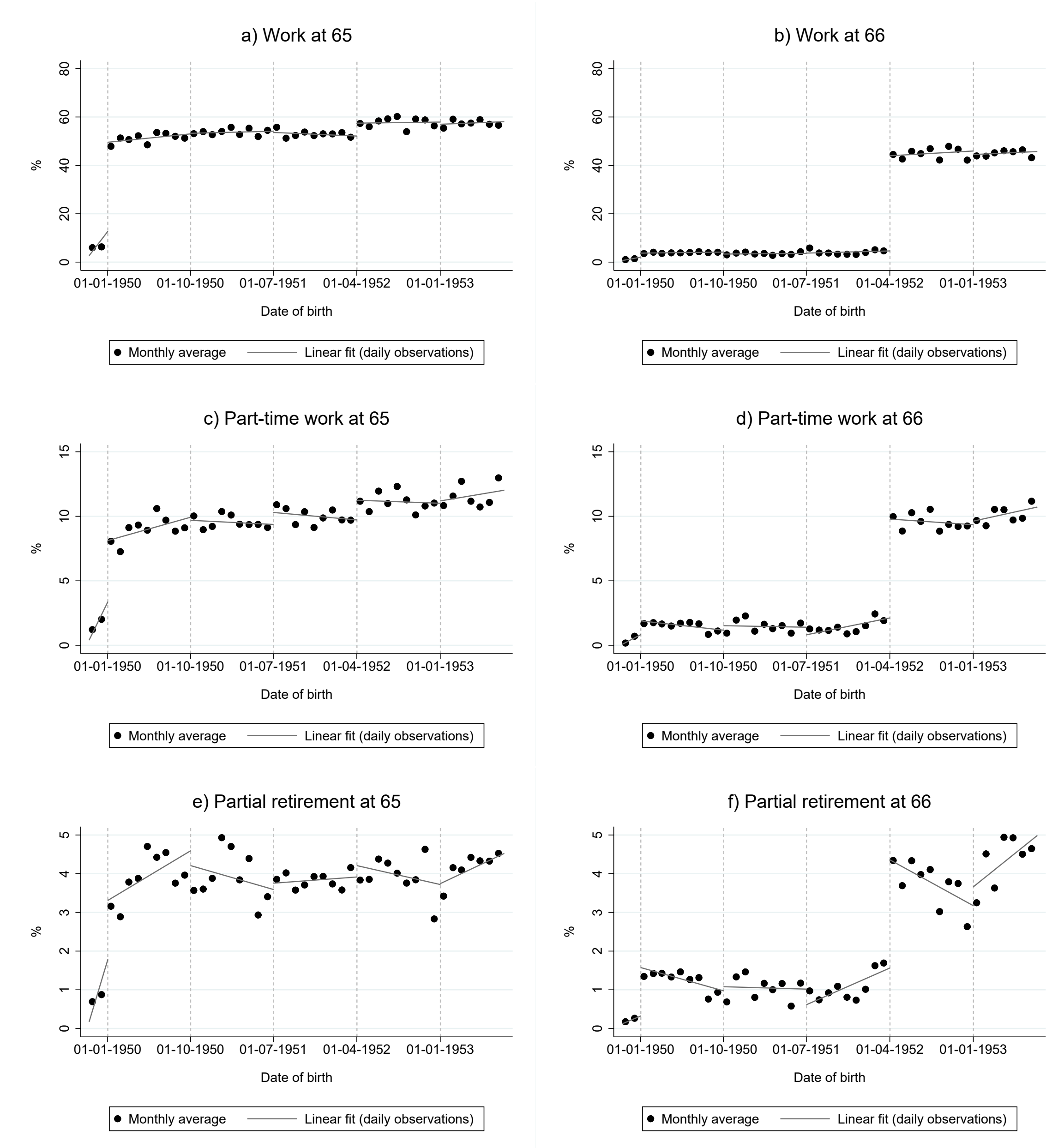

Figure C.3: Regression Discontinuity plots.

Note: The dots in the figures represent the mean value of the outcome variable computed at age 65 or 66 for people born in the same month. The lines represent the linear fit using for a given pension regime. Vertical lines define the different policy regimes depending on the date of birth.

C.4 Additional life-cycle profiles

We do not target average FTE (i.e. the number of hours worked) because this is mainly driven by the full-time work rate. In fact, the data and model profiles for the average FTE closely resembles those of full-time work, shown respectively in Figures C.4 and 5. We also do not target consumption patterns since data is not available. However, since we target savings and model realistically the budget constraint, we expect to be able to replicate consumption behaviour. The lower panels of Figure C.4 present the model predictions for average consumption showing a smooth age profile which does not exhibit any drop around retirement, in line with existing evidence for the Netherlands (Been and Goudswaard, 2023).

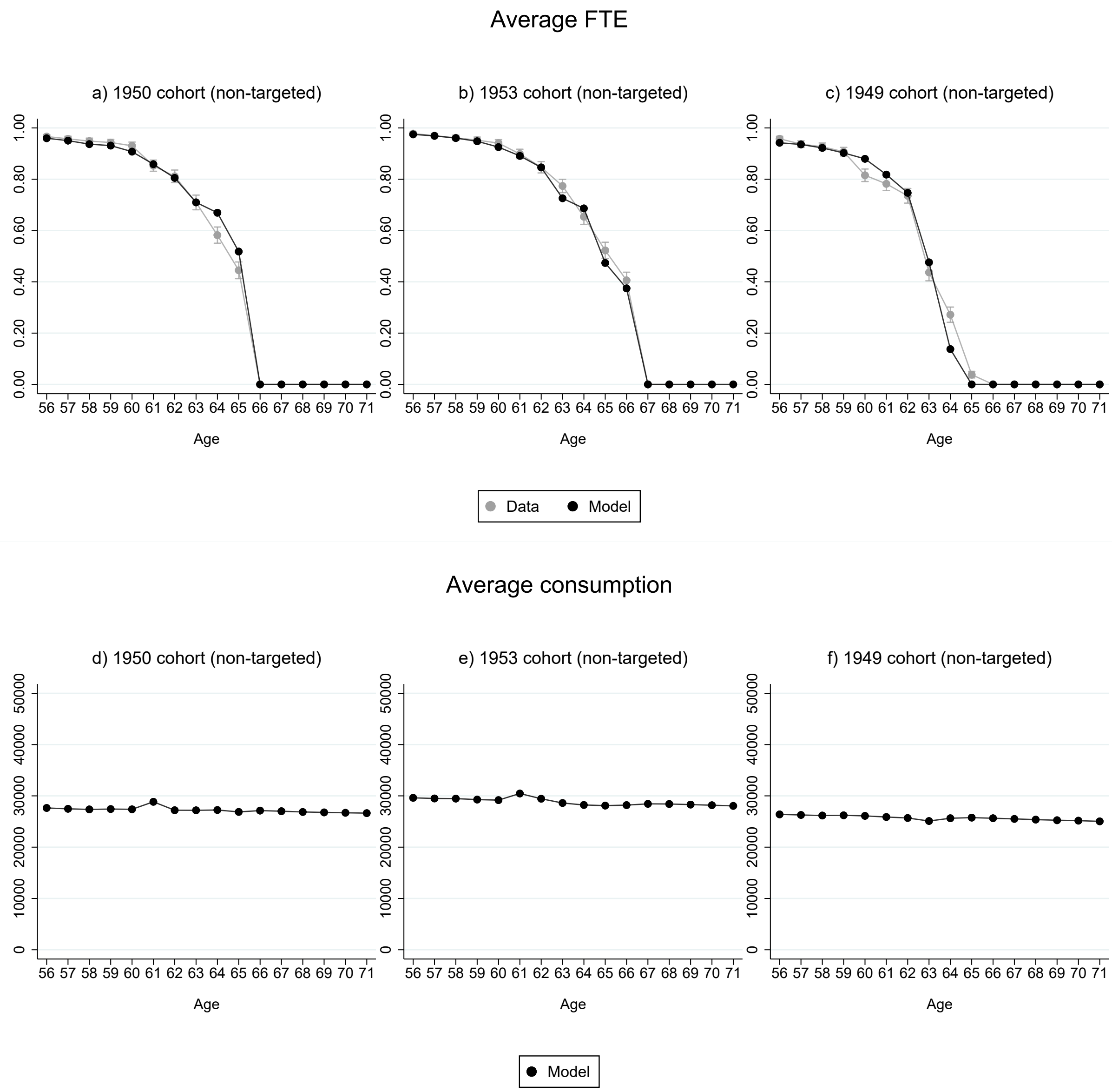

Figure C.4: Model fit for non-targeted moments.

C.5 Robustness check: Switching the role of the reforms used for estimation and validation

As explained in Section 5.3, in our baseline approach we exploit the 2011 state pension reform to estimate the structural model parameters, and the 2006 early retirement reform to validate our estimates. That is, our Method of Simulated Moments estimates are computed by matching the life-cycle choices of the 1950 and 1953 cohorts, whose pension rules differ because of the 2011 state pension age reform. Instead, for out-of-sample validation, we use the 1949 birth cohort whose regime differs because of the 2006 early retirement reform. The reason behind this choice is that the 2006 reform had larger effects on retirement choices as the changes in pension rules were more drastic due to this reform. Therefore, this reform provides a more demanding test to check whether our model can replicate well non-targeted pension regimes.

We analyse how the model estimates change if we switch the role of the two reforms, that is if we target the 1949 and 1950 cohorts for estimation.[6] Table C.1 reports the result of this exercise (column 'Robustness'), along with the baseline estimates presented in Table 5. The two sets of estimates are very similar and consequently the model fit does not change compared to the baseline (for all three cohorts, not shown). This is not surprising because, as long as the parameters are identified by the two (partially) different set of moments, we would not expect the results to largely differ. The results, therefore, also suggest that the model is not (too) misspecified.

Parameter	Baseline	Robustness
γ	-0.149	-0.141
λ	-0.359	-0.358
ψ	0.040	0.040
δ	643.974	595.008
b_1	49.617	44.540
b_2	272,556.868	246,604.023

$u(c_t, l_t) = \frac{1}{\lambda} c_t^{\lambda} + \psi \frac{1}{\gamma} l_t^{\gamma}$

$l_t = (4,000 - h_t - \delta I\{health_t = bad\})/4{,}000$

$B(a_{t+1}) = b_1 \frac{1}{\lambda} (b_2 + a_{t+1})^{\lambda}$

Table C.1: MSM estimates.

Note: 'Baseline' estimates are MSM estimates obtained targeting cohorts 1950 and 1953, i.e. the 2011 reform; 'Robustness' estimates are MSM estimates obtained targeting cohorts 1949 and 1950, i.e. the 2006 reform.

[6] The number of moments targeted is now 120, instead of 112. We have 65 moments for cohort 1949, 55 for 1950, and 57 for 1953. That's because (i) savings for cohort 1949 are observed from age 56 to 71, while for cohort 1953 only from 56 to 68 (+3 moments); (ii) cohort 1949 can start claiming five years earlier compared to cohort 1953 (which means five more moments for claiming and also for partial retirement: +10 moments); (iii) cohort 1949 can work one less year compared to cohort 1953 (which means one less moments for full-time work, for part-time work, for work of sick people, for claiming, for partial retirement: -5 moments).

C.6 Policy simulation: Relaxing automatic job termination

By comparing employees to self-employed workers, Atav et al. (2023) find that automatic job termination, rather than financial incentives and social norms, is the main driver of the observed bunching of retirement at the state pension age in the Netherlands. Job protection is strong for permanent work contracts but it only lasts until the state pension age, when contracts are terminated. A new contract has to be negotiated with the employer if an employee wants to work beyond the state pension age, or a new job has to be found. From a labour demand perspective, the bunching could be explained by the fact that employers are finally able to lay off expensive workers with declining productivity. Wage rigidity and default effect could be alternative explanations. It is therefore interesting to study how many of the people employed right before the state pension age would continue working if their contracts were not automatically terminated.

While our model explicitly incorporates financial incentives, it does not capture social norms – which should have a minor role according to Atav et al., 2023 – and demand side constraints. Therefore, we provide an upper bound of the effect of relaxing the automatic termination policy. In particular, as explained in Section 2, working beyond the state pension age is attractive because employers and employees are exempted from social insurance contributions. Moreover, it is financially attractive to postpone claiming (part) of accrued pension rights as they are actuarially increased for delayed claiming. Both of these incentives to work longer are effectively shut down by automatic job termination.

In this simulation exercise, we focus on cohort 1953 and simulate behaviour given its initial conditions and pension rules, but we postpone automatic job termination to age 70. We then compare this simulation with the baseline results and the first counterfactual simulation exercise, where we increase the state pension age by one year (Section 7.1). Figure C.5 presents the results. The figure shows that relaxing automatic job termination ('Counterfactual 3') could substantially increase labour supply at old age. In particular, the employment rate would be higher already in the years preceding the state pension age, because future rewards keep forward looking workers employed. Moreover, the effect would be larger compared to that due to an increase of the state pension age by one year ('Counterfactual 1'). While the figure provides an upper bound for the treatment effect, it suggests that there are potentially large gains from the supply side: Employees would work longer and their welfare would increase due to the additional flexibility and higher income.

Regarding welfare gains, we define, as in Section 7.2, the equivalent and compensating variation such that

$$V_{i1}(X_{i1}, JT = 1, EV_i) = V_{i1}(X_{i1}, JT = 0)$$
$$V_{i1}(X_{i1}, JT = 1) = V_{i1}(X_{i1}, JT = 0, CV_i)$$

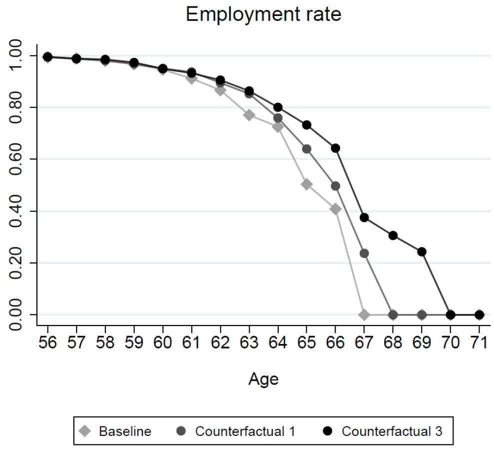

Figure C.5: Result of the third counterfactual analysis: Relaxing automatic job termination.

Note: The figure compare simulations under the baseline scenario with the ‘Counterfactual 1’, where we increase the state pension age by one year, and with the ‘Counterfactual 3’, where we relax automatic job termination at the state pension age, which stays the same as in the baseline.

where JT is a dummy equal to one if jobs are terminated at the state pension age and zero otherwise. We find that, on average, the EV and CV are close to 40,000 euros. The amounts refer to the average worker – not just those that would work anyway until the state pension age – and are fairly substantial for two reasons. First, abolishing automatic job termination gives additional flexibility to workers. The choice to work longer can help to insure against an unexpected drop in earnings, for example. Second, life-time earnings increase because labour supply is much higher under the counterfactual. The valuation of 40,000 euros is then comparable to the additional income due to an extra year of work compared with respect to the baseline (the average wage when entering the model is around 55,000 euros).