The Causal Effect of Retirement on Mortality:

Evidence from Targeted Incentives to Retire Early

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Preliminary. Comments welcome.

Abstract

This paper identifies and estimates the impact of early retirement on the probability to die, using administrative micro panel data at the population level from the Netherlands. Among the older workers we focus on, a group of civil servants became earlier than expected eligible for retirement during a short time window. This exogenous policy change is used to instrument the retirement choice in a model that explains the probability to die within five years. Exploiting the panel structure of our data, we allow for individual fixed effects in modeling the retirement choice and the probability to die. We find for men that early retirement, induced by the temporary decrease in the age of eligibility for retirement benefits, decreased the probability to die within five years by 2.5 percentage points. This is a strong effect. We find that our results are robust to specification changes.

JEL classification: C26, I1, J26

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1. Introduction

Understanding the nexus between life cycle labor supply, retirement, and morbidity and mortality is of core interest to policy makers, given observed imbalances in current pension systems in the aging societies of OECD countries. In pension systems that are of the defined benefit type, or that rely on pay-as-you-go social security, *ceteris paribus*, an increase (decrease) in effective retirement age triggers either higher (lower) aggregate pension contributions or lower (higher) aggregate payouts, and hence may help alleviating the financial pressure on the system. The ceteris paribus clause in this statement is important, however, as the discussion spawned by the academic literature on morbidity and mortality effects of the retirement decision forcefully demonstrates. If longer working lives or later retirement lead to adverse effects on health and even increase the likelihood of dying within a certain horizon, the positive effect of changing the retirement age parameter on the sustainability of pensions is amplified. We find evidence from the Netherlands that is consistent with such an adverse effect, albeit from a policy measure that reduced effective retirement age.

The policy change that we rely on became effective in 2005 for civil servants of certain birth cohorts, employed by the central government for more than 10 years. These individuals were offered the opportunity to retire during the year 2005, by a temporary reduction of the early retirement (ER) eligibility age. According to our estimates, retirement led to a drop in the probability of men dying within five years after retirement by 42.1 percent, or by 2.5 percentage points. This is a large and significant effect.

Identifying the causal impact of retirement on morbidity or mortality is challenging, in particular as the only research design that allows doing so has to rely on observational data. The latter, in turn, calls for an approach that helps controlling the selection into retirement. Our approach uses the described policy variation as an instrument for retirement status in explaining the probability of dying from both observable characteristics and unobservables. Importantly, we rely on an individual fixed effects specification for the latter. We employ a difference-in-difference specification on data for civil servants, controlling for year fixed effects and non-linear age effects. We use a difference-in-difference-in-difference specification for data on civil servants and workers employed in other sectors. Our difference-in-difference-in-difference specification controls for differences in year effects and non-linear age effects between civil servants and other workers.

There is a range of related papers that investigated the effect of retirement on morbidity or health. Papers that use age-specific retirement rules provide inconclusive findings, however. Bound and

Waidmann (2007), Charles (2004), Hemingway et al. (2003) and Neuman (2008) find that retirement has a positive impact on health. Kuhn, Wuellrich and Zweimueller (2010), Behncke (2012) and Dave et al. (2006) find a negative impact of retirement on health.

Our contribution to this literature is threefold. First, our policy variation delivers a natural experiment that we exploit to construct a strong and exogenous instrument. Becoming eligible for retirement benefits due to the ER eligibility age for civil servants being reduced substantially increased the probability to retire. Eligible civil servants only got to know about the decrease in the ER eligibility age one year before they became eligible, so anticipation of early retirement can arguably be ruled out. Second, we focus on mortality instead of health outcomes, an event which is distinctly and objectively observed and does not raise issues of interpretation or subjectivity. Third, we use administrative population data, and thus follow a large number of individuals over a number of years. As the mortality register essentially provides measurement error-free information, we do not need to worry about attrition as an alternative reason for not being recorded in the data anymore.

The rest of the paper is organized as follows. Section 2 reviews the literature. Section 3 describes the decrease in ER eligibility age. Section 4 discusses the data. Section 5 delineates the methodology and Section 6 presents the results. Section 7 concludes.

2. Literature review

The theoretical impact of retirement on mortality is not clear-cut. Any discussion in the literature sees retirement as a one-off, irreversible event. As individuals with a poorer health are more likely to die than individuals with a better health, it seems reasonable to assume that the impact of retirement on mortality runs through health. Early retirement can have an impact on health through several mechanisms. Grossman (1972) provides a framework for analyzing the causal relation between retirement and health. He models health as a dual investment and consumption good. A healthy individual with fewer sick days is more productive and more able to work than a less healthy individual. As health raises an individual's productivity and ability to work, the agent has an incentive to invest in his or her health. Health is also a consumption good and directly features as an argument in the utility function. When the individual retires, costs and benefits from health change. On the benefits side, the incentive to invest in health to raise productivity and ability to work disappears after retirement.[1] The utility that is derived from health in a direct way may change after retirement. At the costs side, incentives to invest in health may be different after retirement than before retirement. As an individual has more leisure time after retirement, the time cost of investing in health is lower after retirement than before retirement. As a result, retirement may induce an individual to, for instance, physically exercise more frequently or go to the doctor sooner and be diagnosed and receive medical treatment when he or she has some physical or mental complaints.[2] The sign of the net effect of retirement on health in the Grossman model is unclear and depends on how retirement changes the personal valuation of the costs of investment in health and the benefits from health (Dave et al. 2006).

In empirical research, of course, health may act as a confounding variable. For instance, Bazolli (1985) and Dwyer and Mitchell (1999) have found that health has a negative impact on the probability to retire early. The literature on the impact of retirement on health addresses the endogeneity of retirement status to health and mortality outcomes using a range of different strategies. Charles (2004), Neuman (2008), Coe and Lindeboom (2008) and Kuhn et al. (2010) instrument retirement status by retirement incentives that were age and/or year specific. Coe and Zamarro (2011) and Behncke (2012) address the endogeneity of retirement status by using institutions as an exogenous shifter of the probability to retire. Many studies rely on subjective survey information from the U.S. Health and Retirement Study (HRS).

Charles (2004) uses three sources of variation in the probability to retire to instrument retirement status: age specific retirement incentives, a labor force participation enhancing change in the US Social Security system and the elimination of mandatory retirement rules. Using HRS data, the author finds that retirement has a positive impact on mental health and loneliness. Neuman (2008) uses age specific retirement incentives as an instrument for retirement status. This author also uses the HRS and finds that retirement improves subjective health of men and women, although retirement does not affect physical functioning in daily activities, mental health or the probability to have a chronic disease. The age specific retirement incentives used as an instrument by Charles (2004) and Neuman (2008) concerned expected decreases in generosity of retirement benefits for different age categories across time. The decreases in generosity of retirement benefits have

[1] Grossman does not consider productivity in household production. Individuals may value being productive in household production before and after retirement, giving an incentive to invest in health before and after retirement.

[2] Midanik et al. (1995) find that workers physically practice more once they retire. Boaz and Muller (1989) and Roos and Shapiro (1982) do not find evidence for workers receiving more ambulatory services from physicians once they retire.

induced individuals to postpone retirement. As the decreases in generosity of retirement benefits were announced years ahead, individuals may have anticipated them. Individuals who decided to postpone retirement because of the decrease in generosity of retirement benefits may have reduced the number of hours worked or may have started to live healthier, so that they would have been better able to continue working. Anticipation may have biased the treatment effect towards zero.

Coe and Lindeboom (2008) is an interesting paper since they address the endogeneity of retirement status by using retirement windows as an instrument for retirement status. Early retirement windows are incentives that promote retirement at a specific time. Employers determine to whom these incentives are offered. We shall exploit a similar set-up. With HRS data, Coe and Lindeboom find that retirement increases self-reported physical and mental health of men temporarily. The authors also find that retirement improves health of highly educated workers. The authors find no effect of retirement on mortality. As early retirement windows may be offered to workers with certain health characteristics, the results may be biased.[3] Kuhn, Wuellrich and Zweimueller (2010) use a regional change in unemployment insurance (UI) rules in Austria as an instrument for the difference between the statutory retirement age and the actual retirement age. UI can be used in Austria as a pathway to (early) retirement. The change in UI rules allowed workers in eligible regions to withdraw from the work force up to 3.5 years earlier than those in non-eligible regions. Using administrative data for blue-collar workers, the authors find that for every year a male worker retires earlier, the probability to die before age 67 increases by 2.4 percentages points or 13 percent. Hence, if a male worker retires 3.5 years earlier, the probability to die before age 67 is increased by 8.4 percentage points or 46.9 percent. Especially cardiovascular diseases are found to be responsible for the increase in the probability to die. The authors do not find an effect of early retirement on mortality for female workers.

Coe and Zamarro (2011) employ a fuzzy regression discontinuity design, using the eligibility age for public old-age benefits as the point of discontinuity in the probability to retire. The authors use single cross-section data from eleven European countries. The data are collected in the Survey of Health, Aging and Retirement in Europe (SHARE). The authors find a positive impact of retirement on general health for men aged 65. The authors do not find an effect for individuals younger than age 65. Behncke (2012) employs propensity score matching as well as an instrumental variable approach to estimate the impact of early retirement on health. For propensity score matching, individuals who reached the eligibility age for public old-age pension benefits are matched to similar

[3] Coe and Lindeboom (2008) also estimate their model using retirement windows incentives and age specific retirement incentives as instruments for retirement status.

individuals who did not reach the eligibility age for public old-age pension benefits yet. For the instrumental variable approach, the author uses the eligibility age for public old-age pension benefits as an instrument for retirement status. Behncke controls for anticipation of retirement by adding expectations about future work and health as control variables in her analyses. Using data from the English Longitudinal Study of Ageing (ELSA), the author finds that retirement increases the probability of being diagnosed with a chronic condition such as a heart disease or cancer.

Hemingway et al. (2003), Dave et al. (2006) and Bound and Waidmann (2007) use alternative approaches to address the endogeneity of retirement status. Dave et al. (2006) try to limit the endogeneity bias by only considering individuals who were healthy before retirement. The authors estimate models in which retirement status and health status are mutually dependent. The authors use data from the HRS. The authors find that retirement induces a six percent increase in illnesses and a six to nine percent increase in depressions.

Hemingway et al. (2003) estimate the impact of retirement on health, using data for male civil servants from the Whitehall II study. The mandatory retirement age for civil servants in the UK was 60 in the late 1980s and the early 1990s, but some civil servants were allowed to retire later. The authors compare changes in health of civil servants aged 54-59 who retired at age 60 with those who retired later. Important here is that cases of ill health retirement are excluded from the sample. The authors find no effect of retirement on physical health and a positive effect of retirement on mental health for higher socioeconomic status groups. Bound and Waidmann (2007) plot linear trends of health indicators across age and compare how health indicators follow these linear trends for ages below and above the eligibility age for public old-age pension benefits. The authors implicitly assume that measured health is linearly related to age. The authors also implicitly assume that the relation between measured health and age is the same for ages below the eligibility age for public old-age benefits as for ages above the eligibility age for public old-age benefits. Bound and Waidmann use British data. For men, the authors find a small positive impact of public pension eligibility on self-reported physical health and physical functioning and on the probability to have a metabolic syndrome. Bound and Waidmann find no effect for women.

3. Policy change

We use a temporary decrease in the ER eligibility age for civil servants in the Netherlands as a source of exogenous variation to estimate the impact of early retirement on the probability to die within five years. The decrease in the ER eligibility age took place in the context of the Dutch pension system.[4] The Dutch pension system rests on three pillars (Bovenberg and Meijdam, 2001). The first pillar is the public old-age pension, which is financed on a pay-as-you-go basis. The second pillar consists of occupational pensions, which are funded. The third pillar consists of private provisions. At the moment of the decrease in the ER eligibility age for civil servants, most occupational pension funds offered early retirement arrangements. The public sector pension fund offered arrangements for early retirement as of the ages 61 or 62 onwards.

In April 2004, a temporary decrease in ER eligibility age for civil servants was announced. We refer to the temporary decrease in the ER eligibility age for civil servants to as `the early retirement arrangement' in the following. Due to a reorganization of the central government, employers being part of the central government were allowed to offer certain civil servants early retirement in the year 2005. Employers were only allowed to offer civil servants early retirement if this would prevent the forced layoff of another civil servant.[5] The early retirement arrangement offered gross retirement benefits that could be up to 70 percent of workers' final wage.[6]

Civil servants faced several eligibility criteria for participation in the early retirement arrangement. First, civil servants had to be at least 55 at the moment of early retirement. Second, the civil servants needed to be employed as a civil servants continuously during the 10 years prior to early retirement. This requirement is of importance for our study, as it prevents self-selection of workers who would like to retire early into the public sector. Civil servants were required to have contributed to the public sector pension fund continuously during the 10 years prior to early retirement.[7] Employers were allowed to offer participation in the early retirement arrangement until 1 January 2005 and participating civil servants were not allowed to retire later than 1 December 2005. Participating civil servants were entitled to early retirement benefits until age 65 with a maximum duration of eight years. Civil servants aged 57 or older at the moment of early retirement were thus entitled to retirement benefits for the whole period until normal retirement at age 65. Civil servants born before 1 January 1948 could continue accruing pension claims at a rate of 50 percent at the expense of the employer for a maximum of four years. Civil servants born on or later than 1 January 1948, i.e. civil servants who were aged 55-57 in 2005, did not have this opportunity. The early retirement

[4] A description of the Dutch pension system and existing early retirement arrangements for civil servants can be found in the appendix of this paper.
[5] Forced layoff refers to forced layoff due to reorganization.
[6] The replacement rate depended among others on the birth date of an individual.
[7] Interruption of employment and pension contribution of at most two months was allowed, though interruption of employment and pension contribution was not allowed in the half year prior to early retirement.

arrangement was thus very attractive for civil servants aged 58 and older,[8] less attractive for civil servants aged 57 and even less attractive for individuals aged 55 or 56.

4. Data

We use Dutch administrative data for 1999-2005. The data are administered by Statistics Netherlands. We have access to data on mortality, hospital stays, and job and personal characteristics (Social Statistical Files, SSF) originating from various administrative sources that can be linked with a personal identifier.[9] [10] The mortality file provides information such as year and cause of death. The hospital stay file provides for every hospital stay information such as the start and end date of the stay, the reason for the stay and where the patient went after being released from the hospital. The job characteristics file provides information on all jobs an individual has been employed in during 1999-2005. For every job, both start and end date, the industry code and the annual wage are provided.[11] The personal characteristics file contains information on demographic characteristics such as nationality, marital status, birth year and birth month. The files we use cover all residents registered with Dutch municipalities.

For our analysis we select observations on individuals aged 53-60 during 1999-2005. We exclude observations on individuals without a Dutch citizenship during 1999-2005. For the analysis later on in this paper, we only keep observations on individuals who have been continuously employed for the 10 years prior to January 1st of the year of observation. We make this selection, as one of the eligibility criteria for the early retirement arrangement for civil servants is that civil servants have been continuously employed as a civil servant for the 10 years prior to the day on which they retire. For the same reasons, observations on workers who switched between the public sector and any other sector are excluded from the analysis as well. Observations on workers who stayed in the hospital somewhere between 1998 and retirement are also excluded from our analysis. By dropping the observations on individuals who stayed in the hospital before retirement, we aim to limit the endogeneity of retirement status to health. We also drop observations for the years after the year

[8] The offer of early retirement through the early retirement arrangement was "an offer you can't refuse" for this group of individuals.

[9] The original file names are Doodsoorzaken, Landelijke Medische Registratie (LMR), SSB Banen and SSB Personen.

[10] Statistics Netherlands only provides data that are administered by governmental institutions. These data are rather limited. Moreover, the data that are administered are not always administered for the years we are interested in. Data on financial wealth, for instance, are not available for the years of study. Hospital stays data are incomplete after 2005, so that it is not possible to estimate the effect of early retirement on alternative health measures created from hospital data.

[11] The industry code is 7511 according to the Standaard Bedrijfsindeling 1993 (SBI '93) classification.

in which a worker has retired.[12] We use about 147,000 observations on male civil servants and about 32,000 observations on female civil servants.

Table 1 shows the descriptive statistics for civil servants and workers who have been employed outside the public sector. Age is defined as the age measured on December 31st of the respective year. Married is 1 if an individual had a partner in the year of observation, 0 otherwise.[13] Lagged wage income indicates the total wage income an individual earned in the year prior to the year of observation. Lagged wage income is measured in thousands of deflated Euros. On the one hand, better paid individuals may be richer than worse paid individuals, and richer individuals may be better able to afford early retirement than relatively poor individuals. On the other hand, individuals with a relatively low wage may earn a low wage because they work relatively few hours. Working relatively few hours may be a sign of being in a process of phased retirement. The average age of individuals in our dataset is 56, which indicates that relatively young individuals are relatively overrepresented in our dataset.[14] Male civil servants are in general comparable to male workers employed in other sectors. Female civil servants are clearly different than female workers employed outside the public sector. Wage income in the year prior to the year of observation was higher for female civil servants than for workers employed outside the public sector. Moreover, female civil servants had a lower probability to have a partner than women employed outside the public sector.

The group of civil servants that could be offered early retirement due to the temporary decrease in the ER eligibility age consisted of civil servants working for the central government. The sector in which individuals work is identified by a sector code. Most civil servants working for the central government were assigned the same sector code as some groups of civil servants who were not working for the central government. Hence, we cannot precisely identify the group of civil servants working for the central government. When we refer to civil servants later on in this paper, it should be kept in mind that we mean central government civil servants including a group of other civil servants who were ineligible for the early retirement arrangement of interest.[15] Another data issue is that we do not observe to which civil servants early retirement was offered. We can thus not

[12] We assume that individuals do not work after retirement, though we can only observe employment state till January 1st, 2009. This is discussed in more detail in the data section.

[13] Having a partner includes being married and having a registered partnership, but excludes cohabitation without being married or without having a registered partnership. Registered partnership is an official agreement of partnership, similar to marriage.

[14] This is partly the result of dropping observations after having transitioned into retirement.

[15] This issue may lead to our estimates of the impact of the early retirement arrangement on retirement constituting lower bounds of the real impact, and likewise to possible downward bias of the impact of early retirement on the probability to die within five years.

observe whether an eligible civil servant rejected the early retirement offer or whether a civil servant with characteristics of an eligible civil servant did not retire early because he or she was not offered the early retirement arrangement. Thus, the “treatment” group we observe in our data is somewhat wider than the “true” treatment group. We also do not know whether there was selection in offering the early retirement arrangement to some specific groups only, e.g. to workers who were relatively less productive or were relatively often ill. If there would have been selection, this could bias or results or could at least force us to reinterpret our results. The final data issue is about the absence of data on whether individuals receive retirement benefits. As we do not know whether an individual receives retirement benefits, we do not know whether an individual actually retired early. We deal with this problem by defining retirement as having quit a job and not having started working again before January 1st, 2009.

Figures 1a and 1b show that the probability that male and female civil servants die within five years increases across age for several birth year cohorts. There are birth year cohorts that follow different patterns as well. Civil servants who were born relatively long ago have in general a higher probability to die within five years than civil servants with the same age who were born relatively recently. The observed patterns are not smooth and do not show consistent patterns for all birth year cohorts.[16] We consult mortality data on the whole Dutch population from Statistics Netherlands to get a better view on mortality patterns across age and birth year cohorts. Figures 2a and 2b show that the probability to die within five years for the whole Dutch population increases smoothly across age and decreases smoothly across birth year cohorts.[17] Observed probabilities are higher than those observed for civil servants. This is intuitive, as individuals employed as a civil servant may have a relatively modest probability to die within five years compared to, for instance, individuals who do not work. The probability to die within five years is higher for men than for women. The increase in the probability to die within five years across age is higher for men than for women as well.

5. Methodology

We employ an instrumental variable approach to estimate the impact of early retirement on the probability to die within five years. We instrument retirement status by dummies for the ages for which civil servants are eligible for the early retirement arrangement interacted with a dummy for the year of the policy change and a dummy for being a civil servant. We estimate a model using a difference-in-difference specification for civil servants and a model using a difference-in-difference-

[16] This is in combination with the probabilities to die within five years being low.
[17] The cohort of individuals born in 1945 shows a slightly deviating pattern for the ages 53-57.

in-difference specification for civil servants and workers employed outside the public sector. In the model using the difference-in-difference specification, the source of exogenous variation in retirement status is the age in 2005. In the model using the difference-in-difference-in-difference specification, being or not being a civil servant in 2005 is the additional source of exogenous variation.[18] We use civil servants aged 53 or 54 in 2005 as the control group and civil servants aged 55-60 in 2005 as the treatment group.[19] Our models control for individual fixed effects. As men and women have different retirement patterns and remaining life expectancies, we estimate our model for men and women separately. The treatment effect we estimate is the Local Average Treatment Effect (LATE), i.e. the effect of early retirement on the probability to die within five years for those who are induced to retire early by variation in the instruments.

5.1 Instrument validity

The instrument we use is valid if two conditions are satisfied. First, the instrument has an impact on the probability that individuals receive the treatment. Second, the instrument does not correlate with unobserved factors having an impact on the outcome. The instruments we use are dummies for eligibility for retirement benefits due to the temporary decrease in the ER eligibility age for civil servants in 2005.

Figures 3a and 3b show retirement rates for male and female civil servants. Retirement rates for civil servants aged 58-60 were substantially higher in 2005 than in other years. Retirement rates for civil servants aged 56-57 and female civil servants aged 55 were higher in 2005 than in other years as well. Retirement rates for civil servants aged 53 and 54 were similar in 2005 as in other years. This suggests that the early retirement arrangement for civil servants induced civil servants to retire early.[20]

Figures 4a and 4b show that retirement rates for workers aged 55-60 employed outside the public sector were not higher in 2005 than in other years. The difference in retirement rates for civil

[18] Being or not being a civil servant is exogenous here, because being a civil servant in our dataset requires having been a civil servant for the past ten years and not being a civil servant in our dataset requires having worked outside the public sector for the past ten years.
[19] As we estimate a fixed effects model, observations on individuals that we observe for only one year are not used. As civil servants aged 53 in 2005 are observed for only one year, observations on these civil servants are not used. This implies that our control group consists of civil servants aged 54 in 2005.
[20] There were several other pension related policy changes around the period under review. These policy changes and their possible effects on retirement rates are discussed in the Appendix.

servants aged 55-60 between 2005 and other years is thus not caused by factors that shifted retirement rates of the entire work force in 2005. Our instruments are thus relevant.

We do not have reasons to expect that the introduction of the early retirement arrangement had a direct impact on the probability to die within five years. To our knowledge, there were no events in 2005 or in the five years after that shocked the probability to die within five years for civil servants aged 55-60 in 2005 particularly, other than the reform we study. We also do not have reasons to expect that our instruments are correlated with unobserved factors that influenced the probability to die within five years. Unobserved factors that are expected to have influenced the probability to die within five years may include the unobserved level of health, health-related behavior,[21] the number of hours worked and associated stress levels. If retirement induced by the early retirement arrangement was anticipated, the number of hours worked and health-related behavior may have been correlated with the introduction of the early retirement arrangement. However, the introduction of the early retirement was only announced in April 2004 and employers decided only later in 2004 whether they would offer a civil servant the early retirement arrangement. As civil servants were only informed late 2004 whether they were offered the early retirement arrangement, we do not expect anticipation of early retirement to be an issue.

5.2 Model specification

We estimate the LATE using a two-stage-least-squares fixed effects instrumental variable model. [22] In the first stage, retirement status is estimated and in the second stage, the impact of predicted retirement on the probability to die within five years is estimated. Our instrumental variable model has as advantage that it controls for time-invariant unobserved heterogeneity and allows the individual fixed effects to be correlated with observed characteristics. A disadvantage of the instrumental variable model is that it is parametric, which imposes a risk of misspecification. We use a difference-in-difference specification for our model and estimate it for civil servants only. We control for year effects and for differences in the probability to die within five years and the probability to retire across age. The first stage of the difference-in-difference variant of our model is specified as follows:

(1) $$R_{it} = e_0 + \sum_{j=1999}^{j=2004} b_j D_{jt} + \sum_{k=2}^{k=3} c_k A_{kit} + \sum_{l=55}^{l=60} d_{05,l} D_{05,t} E_{lit} + g M_{it} + h'_{it-1}\vartheta + e_i + v_{it}$$

[21] Including getting diagnosed and treated.

[22] The number of compliers, i.e. the civil servants that are induced to retire in 2005 due to the early retirement arrangement, is too small to allow estimation of the LATE by age.

where R_{it} is a dummy that is 1 if individual i is aged 55 or older in year t and individual i retired in year t. R_{it} is 0 otherwise. D_{jt} is a year dummy that is 1 in year j and 0 otherwise. A_{kit} denotes a kth order age polynomial. E_{lit} is an age dummy that is 1 if individual i reaches age l in year t and 0 otherwise. M_{it} is a dummy that is 1 if individual i has a partner in year t and 0 otherwise. h_{it-1} includes lagged wage income. e_i is an individual fixed effect. v_{it} is an error term. e_i is allowed to be correlated with all covariates.

The second stage is specified as follows:

$$(2) \qquad Y_{it} = \alpha_0 + \sum_{j=1999}^{j=2004} \gamma_j D_{jt} + \sum_{k=2}^{k=3} \delta_k A_{kit} + \beta M_{it} + h'_{it-1}\varphi + \omega \hat{R}_{it} + \alpha_i + u_{it}$$

where Y_{it} is a dummy that is 1 if an individual dies within five years and 0 otherwise. ω indicates the LATE. a_i is allowed to be correlated with all covariates. α_i and e_i are also allowed to be correlated. u_{it} and v_{it} are allowed to be correlated as well. Since we only use several covariates in our model, the individual fixed effects are expected to be important in explaining retirement status and the probability to die within five years.

We also estimate the LATE using a difference-in-difference-in-difference specification for data on civil servants and workers employed outside the public sector. We do so, because the retirement and mortality patterns of workers employed outside the public sector are smoother than those for civil servants. This is due to the relatively modest number of observations for civil servants. The first stage of the instrumental variable model for the entire workforce is specified as follows:

$$(3) \qquad R_{it} = e_0 + \sum_{j=1999}^{j=2004} b_j D_{jt} + \sum_{k=2}^{k=3} c_k A_{kit} + \sum_{l=55}^{l=60} d_{05,l} D_{05,t} E_{lit} + \sum_{j=1999}^{j=2004} b_{jc} D_{jt} C_{it} + h_{05nc} D_{05,it} NC_{it} + \sum_{k=2}^{k=3} c_{kc} A_{kit} C_{it} + \sum_{l=55}^{l=60} d_{05c,l} D_{05,t} E_{lit} C_{it} + g M_{it} + h'_{it-1}\vartheta + e_i + v_{it}$$

where C_{it} is a dummy that is 1 if an individual is a civil servant and 0 otherwise. NC_{it} is a dummy that is 1 if an individual works outside the public sector and 0 otherwise. The difference between (3) and (1) is the inclusion of the interactions between age polynomials and the dummy for being a civil servant, the interactions between year dummies and the dummy for being a civil servant and the interaction between the dummy for 2005 and the dummy for not being a civil servant. Moreover, the instruments in (1), i.e. the interactions between the dummy for 2005 and the age dummies, are interacted with the dummy for being a civil servant in (3). As the difference-in-difference specification does, the difference-in-difference-in-difference specification controls for non-linear age effects and year fixed effects. In addition, the difference-in-difference-in-difference specification controls for differences in non-linear age effects and year fixed effects between civil servants and workers employed outside the public sector.

The second stage of the instrumental variable model for the entire work force is specified as follows:

(4) $$Y_{it} = \alpha_0 + \sum_{j=1999}^{j=2004} \gamma_j D_{jt} + \sum_{k=2}^{k=3} \delta_k A_{kit} + \sum_{j=1999}^{j=2004} \gamma_{jc} D_{jt}\, C_{it} + \sum_{k=2}^{k=3} \delta_{kc} A_{kit} C_{it} + \kappa_{05nc} D_{05,t} NC_{it} + \beta M_{it} + h'_{it-1}\, \varphi + \omega \hat{R}_{it} + \alpha_i + u_{it}$$

The differences between (4) and (2) are essentially the same as those between (3) and (1).

The validity of the difference-in-difference-in-difference approach depends on the justification of the common trend assumption. The common trend assumption implies that the probability to die within five years and the probability to retire for civil servants follow trends similar to those of workers employed outside the public sector. Figures 5a and 5b show that the probabilities to die within five years for workers employed outside the public sector follow similar patterns as those for civil servants for only several birth year cohorts. We have discussed above that retirement rates of civil servants aged 59 or younger follow similar patterns as those of workers employed outside the public sector. As the patterns for the probability to die within five years across age for civil servants differ from those for workers employed in other sectors, the common support assumption is violated. Nevertheless, the approach is valuable, as it provides estimates based on imposing a rather smooth probability to die within five years across age patterns on civil servants.

6. Results

We instrument retirement status because of the assumed endogeneity of retirement status to health. Tables 2 and 3 show the fixed effects difference-in-difference and difference-in-difference-in-difference estimates for when retirement is not instrumented, i.e. the estimates for (2) and (4) with retirement status R_{it} instead of predicted retirement status $\hat{R}_{it}$. The coefficient estimates on retirement are positive and significant at the five percent significance level for men. The difference-in-difference-in-difference coefficient estimate for women is positive and significant as well. The difference-in-difference coefficient estimate for women is not significant. For men, retirement is associated with a 0.7 percentage point, or 14 percent, higher probability to die within five years according to the difference-in-difference approach. The difference-in-difference-in-difference estimate for men and women are 0.4 percentage point, or 8 percent, and 0.1 percentage point, or 6 percent respectively. If retirement status would not be endogenous to health, we would expect the coefficient estimate on retirement status in the uninstrumented fixed effects model to be similar to that in the instrumental variable model.

6.1 *Instrumental variable estimates*

Table 4 shows the difference-in-difference instrumental variable estimates.[23] The estimates show that retirement induced by the early retirement arrangement decreased the probability to die within five years by 2.5 percentage points, or 42.1 percent, for men. This percentage effect, which is significant at the ten percent significance level, is of a similar size as the effect found by Kuhn et al. (2010). The LATE for women is not significant at the ten percent significance level. Table 5 shows that the difference-in-difference-in-difference instrumental variable estimates are very similar to the difference-in-difference instrumental variables estimates.

The F statistics for the first stage estimation for men and women show that our instruments are relevant at the one percent significance level. The introduction of the early retirement arrangement did induce eligible civil servants to retire. The J statistics for exogeneity of our instruments show that the null hypothesis that our instruments are exogenous cannot be rejected at the five percent significance level for men. However, the instruments suffer from endogeneity for women. We can thus not interpret the LATE estimate for women as a causal effect.

6.2 *Causes of death*

To get more insight into the mechanism through which early retirement affects mortality, we estimate the instrumental variable models in (1)- (2) and (3)-(4) using a dummy for dying within five years due to a specific cause of death as a dependent variable. The causes of death for which we estimate our models are grouped according to the 10th Revision of the International Statistical Classification of Diseases and Related Health Problems (ICD, 2010). The ICD is a health care classification system by the World Health Organization (WHO). The ICD provides diagnostic codes for classifying diseases. The diseases are grouped into 22 categories, so called chapters. We estimate the causes of death for the chapters, or, in case of the frequent causes of death cancer and diseases of the circulatory system, subchapters, so called blocks. Chapters counting less than ten observations on fatalities are merged in the category “Other diseases”. Tables 6 and 7 show that early retirement has a negative LATE of 0.5 percentage point or 8.4 percent on the probability to die within five years due to stroke (cerebrovascular diseases). This LATE is significant at the one percent significance level. This LATE implies that 11 individuals do not die within five years because individuals that were induced to retire by the early retirement arrangement. The LATEs of early retirement on the probability to die within five years due to liver diseases (diseases of the digestive

[23] The probability to die within five years is negative in lagged wage income, positive in lagged health and positive in age.

system) and accidents (external causes of morbidity and mortality) are negative and significant as well, respectively at the one percent and ten percent significance level. The LATEs of early retirement on the probability to die within five years due to liver diseases is 0.7 percentage point or 11.8 percent, implying a reduction in the number of fatalities of 16 individuals. The LATE of early retirement on the probability to die within five years due to accidents is 0.4 percentage point or 6.7 percent. This LATE implies a reduction in the number of fatalities within five years of 6.

Stroke as a cause of death is interesting in the context of this paper, since life style can have a significant impact on the probability of dying from stroke. Hypertension, diabetes, obesity, alcohol use, smoking and lack of physical exercise are among the modifiable risk factors for stroke.[24] Hypertension is the most important modifiable risk factor for stroke. Risk factors for hypertension include obesity, smoking, alcohol consumption and lack of physical exercise (Appel et al., 2006, Begg et al., 2006), so obesity and smoking pose a direct and indirect threat for contracting stroke. Stress may result in hypertension as well (Nunes, 2003). Accidents as a cause of death are interesting as well, since accidents may occur during work or when travelling between home and the work place. Unfortunately, we cannot observe whether accidents occur during work.

6.3 Robustness checks

We included the second and third order age polynomial in our instrumental variable model. We also estimate the difference-in-difference instrumental variable model if only the second order age polynomial is included and if the fourth order age polynomial is added to the model. Table 8 shows that the LATE estimates for the alternative models are similar to the LATE estimate for the model we use. Similarly, we estimate the difference-in-difference-in-difference instrumental variable model in case the third order age polynomial and its interaction with the dummy for being a civil servant are excluded from the model. We also estimate the difference-in-difference-in-difference instrumental variable model if the fourth order age polynomial and its interaction with the dummy for being a civil servant are included in the model. Table 9 shows that the difference-in-difference-in-difference model specification is robust for age adding and subtracting an age polynomial.

Table 10 shows that our results do not change much if we only consider individuals who are married. Table 11 shows that our results are robust for including individuals aged 52 in our dataset as well.

[24] Risk factor indicates a factor that is correlated with the prevalence of a disease. There is not necessarily a causal relation between a risk factor and the prevalence of a disease.

We also verify how sensitive our results are for the apparent failure of the parallel trend assumption due to the jump in the retirement rate for workers employed outside the public sector at age 60. We do so by estimating the model including a dummy for age 60 and an interaction between the dummy for being aged 60 and the dummy for being a civil servant. Table 12 shows that the LATE for men is insensitive to the failure of the parallel trend assumption.

We estimated the LATE using instrumental variable models with individual fixed effects. We estimate the instrumental variable models with random effects to verify whether our individual fixed effects LATE estimates are sensitive to imposing the assumption that individual effects are uncorrelated with all covariates. We estimate the random effects instrumental variable models using the difference-in-difference specification as in (1) and (2), and the difference-in-difference-in-difference specification in (3) and (4). Table 13 shows that the LATE estimates for men estimated by the random effects models are insignificant and that the random effect estimates are significantly different from the fixed effects estimates at the 1 percent significance level. The difference between the LATE estimated by the instrumental variable with fixed effects and the instrumental variable model with random effects indicates that individual effects are correlated with at least some covariates. Individual effects may, for instance, be correlated with lag wage income. Individuals with a higher wage income in the previous period may have time invariant characteristics that make them more or less likely to retire or more or less likely to die within five years. As individual effects and at least some covariates are correlated, the instrumental variable model with individual fixed effects is preferred over the instrumental variable model with random effects.

We estimate the models similar to those specified in (1) and (2), and (3) and (4) using Ordinary Least Squares (OLS) estimation to show how the LATE estimates are changed when the individual effects are dropped from our fixed effects instrumental variable model.[25] Table 14 shows that the LATEs estimated by the OLS instrumental variable models have a similar size as the LATE estimated using the fixed effects instrumental variable models. However, the LATEs estimated by OLS are insignificant due to relatively large standard errors. The difference in standard errors between the coefficient on the treatment effect between the fixed effects instrumental variable and OLS instrumental variable model can be explained by the strong explanatory power of the individual effects.

We estimate the instrumental variable models without individual effects by probit to verify whether probit estimates differ from the OLS estimates. Table 15 shows that the LATEs estimated by probit

[25] The difference between the models estimated here and the models specified in (1) and (2), and (3) and (4) is that the models specified in (1) and (2), and (3) and (4) include individual effects.

estimation are small and insignificant. This may be due to the absence of individual effects in the probit model and due to probit models performing relatively poor in explaining treatment effects for probabilities that are in the tail of the distribution.

7. Conclusion

We have studied the impact of early retirement on mortality. We have found that retirement induced by a temporary decrease in the ER eligibility age for civil servants in the Netherlands significantly decreased the probability to die within five years for men by 42.1 percent.

The impact of early retirement on mortality is sizable, indicating that civil servants' probability to survive is sensitive to early retirement. In terms of the Grossman model, the negative impact of early retirement through health on mortality could be explained by a decrease in costs to invest in health after retirement. The decrease in costs of investment in health may induce retirees to invest more in health, reducing their probability to die within five years. An alternative explanation would be that working brings about stress. After retirement, individuals' body and mind are possibly discharged, reducing the probability to die within five years. As men were working more hours than women, work may have been more stressful and demanding for men than for women, discharging men from a heavier weight at retirement than women. In turn, retirement may have had a negative and significant impact on the probability to die within five years for men.

Our main results are that early retirement induced by the decrease in the ER eligibility age had a negative impact on mortality. Our results have policy implications in the short and long run. In the short run, in times of crisis, companies may consider reducing their work force by offering early retirement to workers. Retirement of the work force imposes a cost to pension funds in the form of retirement benefits that are paid. The cost faced by pension funds depend amongst others on retirees' age at which payment of retirement benefits end, or, retirees' age of death. The negative impact of early retirement on mortality increases the longevity risk born by pension funds. Pension funds need to be aware of this and take measures that enhance their sustainability if necessary. In the long run, the ER eligibility age increases. Our results have policy implications in the long run if we assume that the impact of an increase in the ER eligibility age on mortality is the equivalent of the reverse of the impact of a decrease in the ER eligibility age on mortality, which is a very strong assumption. An increase in the ER eligibility age would have a positive impact on mortality and thus a negative impact on the longevity risk born by pension funds. This may allow pension funds to make their pension arrangements more generous.

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Appendix

The Dutch pension system

The Dutch pension system rests on three pillars (Bovenberg and Meijdam, 2001). The first pillar is the public old-age pension. The public old-age pension is financed on a pay-as-you-go basis. Contributions stem from workers and employers. All residents registered in the Netherland accrue public old-age pension rights. Public old-age pension benefits for couples equal the minimum wage. Singles receive 70 percent of the minimum wage. For every year between the ages 15 and 65 that an individual did not reside in the Netherlands, public old-age benefits are cut by two percentage points. The second pillar consists of occupational pensions. Occupational pensions are funded pensions and are generally managed on the sector level.[26] About 90 percent of the workers participate in an occupational pension plan. Occupational pension schemes receive contributions from workers and employers. Workers who participate in a pension plan pay contributions over the difference between their wage and the "franchise". As every firm or sector has its own pension plan and pension conditions, there is a large heterogeneity among occupational pensions. At the time at which the early retirement arrangement under review was introduced, there was also a large heterogeneity in early retirement arrangements. The third pillar consists of private provisions. Private provisions include amongst others annuity insurance.

Regular early retirement arrangements for civil servants

As of April 1st, 1997, early retirement benefits for civil servants consisted of two parts. The first part was in general 70 percent of the "franchise" for civil servants who had worked full time during their working life.[27] The first part intended to compensate early retirees for the lack of old-age pension benefits for the period between early retirement and normal retirement. Civil servants were eligible for the first part if they satisfied two conditions. First, they had to have been employed as a civil servant continuously during the ten years prior to early retirement. Second, they had to have contributed continuously to the public pension fund during the ten years preceding early retirement. The first part of early retirement benefits was in general higher when a civil servant retired at a later age. The first part was financed on a pay-as-you-go-basis. Workers and employers contributed to the early retirement benefit scheme. Part two of early retirement benefits was funded. Workers and employers contributed to the accrual of benefits in the second part. When a civil servant would have accrued benefits for 40 years, the sum of the first and second part would have been 70 percent of

[26] Various large employers have their own pension fund.
[27] This replacement rate is based on retirement at the ER eligibility age. The ER eligibility age depends on the birth date of an individual.

the final wage.[28] [29] The replacement rate was reduced by 1.75 percentage points for every year a civil servant would have accrued benefits less than 40 years. Civil servants were allowed to do paid work after early retirement. However, total income of a retired civil servant was not allowed to exceed 100 percent of the final gross wage.[30] If the total income of a retired civil servant exceeded 100 percent of the final gross wage, early retirement benefits were cut as much as needed to bring the total income earned on 100 percent of the final gross wage.

Other policy changes

On January 1st, 2004, the public sector pension fund switched from a final wage pension system to a mean wage pension system.[31] However, due to a transition arrangement, civil servants born before January 1st, 1954 were hardly affected by the switch.

On January 1st, 2006, the so-called fiscal facilitation of early retirement benefits for individuals born January 1st, 1950 or later was terminated.[32] This implied that most early retirement arrangements for the affected individuals disappeared. Early retirement among civil servants usually occurred at age 61 or 62. The termination of the fiscal facilitation of early retirement benefits could have been anticipated as of 2003 and may have induced anticipation effects of civil servants aged 53-55 in 2005.

[28] This replacement rate is based on retirement at the ER eligibility age. The ER eligibility age depends on the birth date of an individual.
[29] On January 1st, 2004, the public sector pension fund switched from a final wage pension system to a mean wage pension system.
[30] Income does not only include wage income here, but also some other specified sources of income.
[31] The pension fund for the health care sector also switched from a final wage system to a mean wage system on January 1st, 2004. Many other pension funds also switched in the years before or after January 1st, 2004.
[32] The fiscal facilitation of the early retirement contributions implied that the early retirement benefits were taxed, and that the early retirement contributions paid by workers and employers were exempted from taxation. As effectively less tax was paid, the fiscal facilitation made early retirement very attractive for eligible workers and employers.

Figures and Tables

Figure 1: Probability to die within five years, civil servants, by birth cohort (percentages)

Figure 1a: men

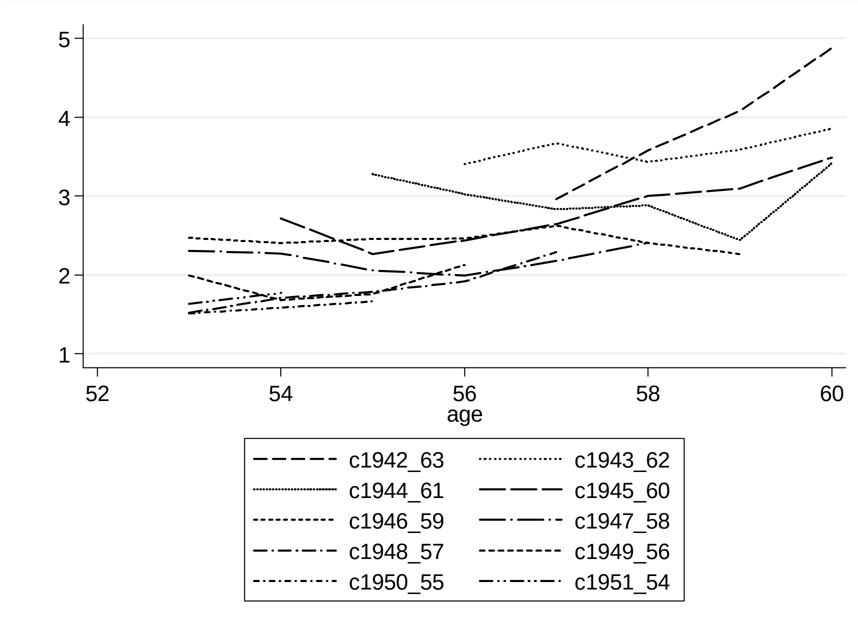
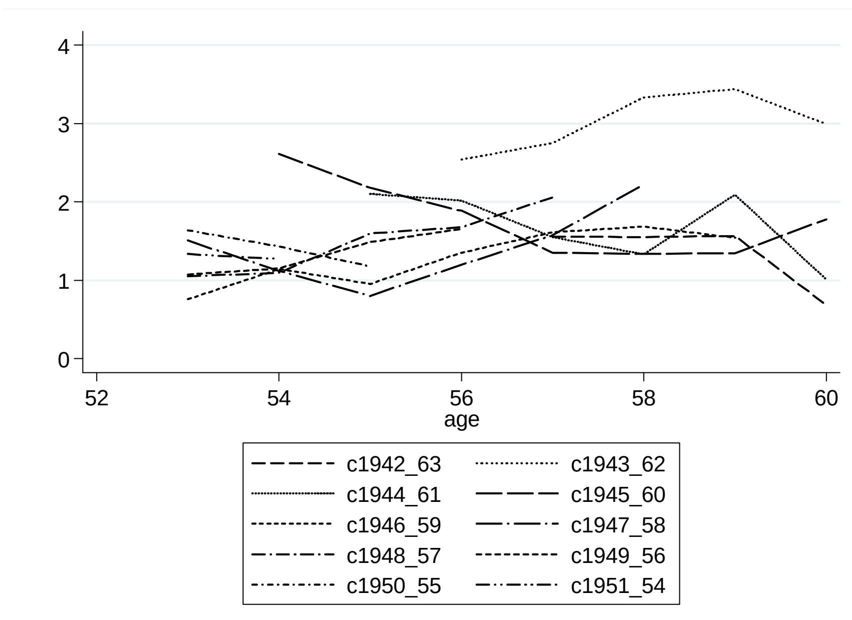


Figure 1b: women



Age on December 31st, 2005 is indicated behind each birth year cohort.

Figure 2: Probability to die within five years, full Dutch population, by birth cohort (percentages)

Figure 2a: men

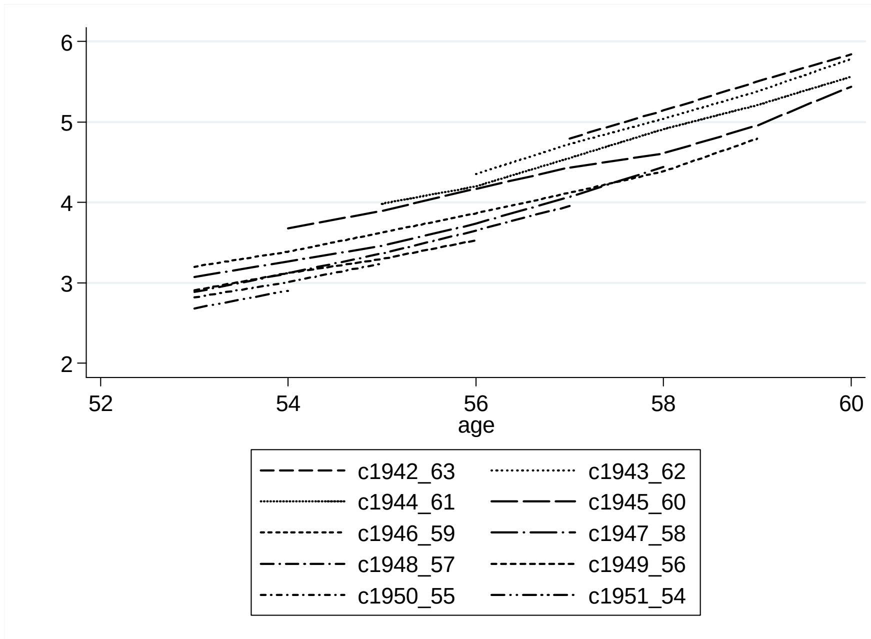
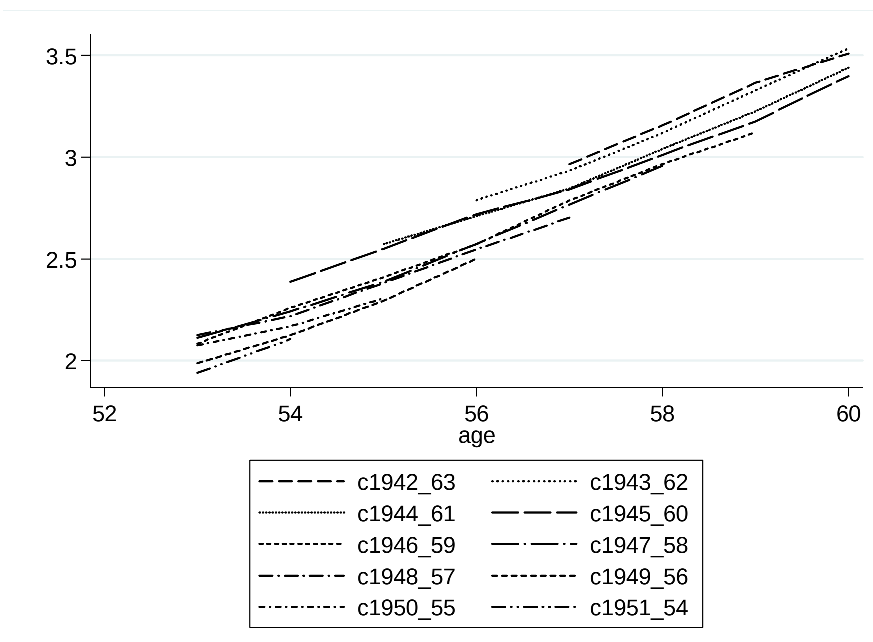


Figure 2b: women



Age on December 31st, 2005 is indicated behind each birth year cohort.

Figure 3: Retirement rates for civil servants, by birth cohort (percentages)

Figure 3a: men

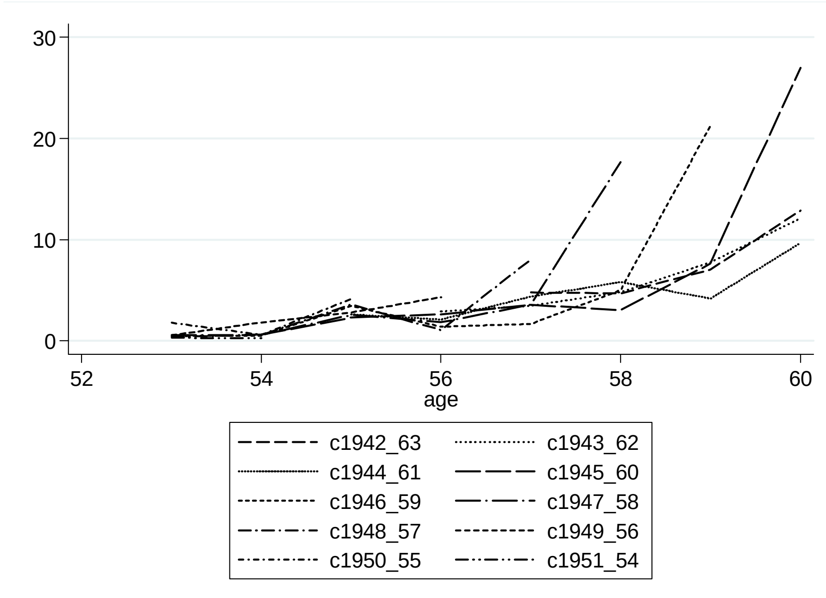
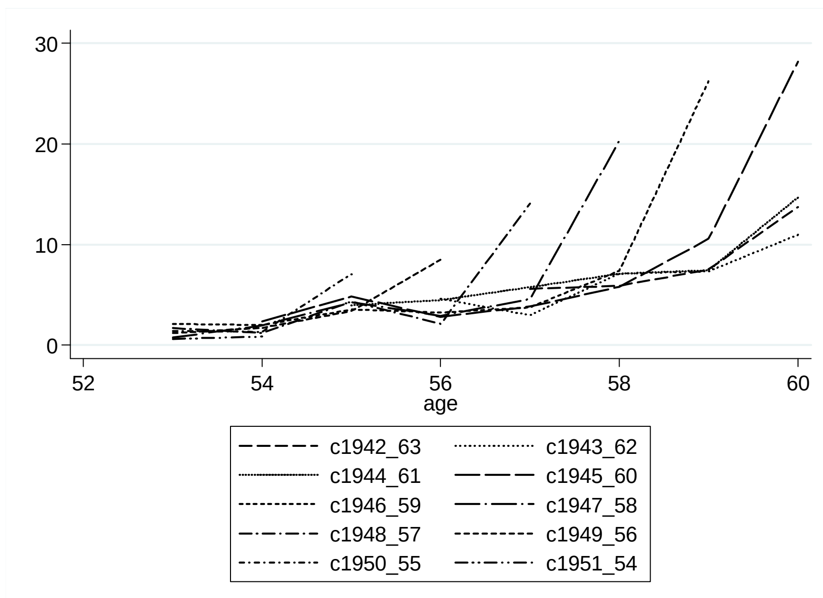


Figure 3b: women



Age on December 31st, 2005 is indicated behind each birth year cohort.

Figure 4: Retirement rates for employees outside the public sector, by birth cohort (percentages)

Figure 4a: men

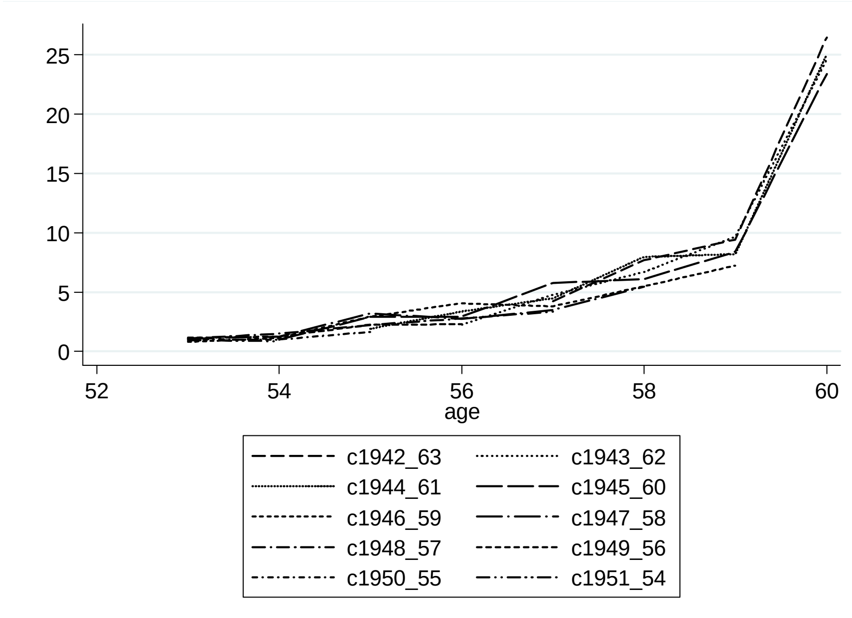
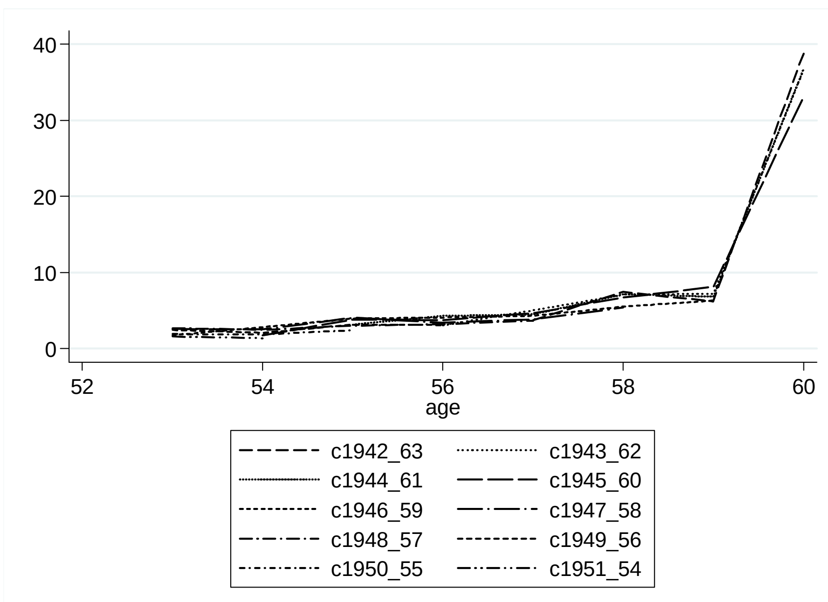


Figure 4b: women



Age on December 31st, 2005 is indicated behind each birth year cohort.

Figure 5: Probability to die within five years for employees outside the public sector, by birth cohort (percentages)

Figure 5a: men

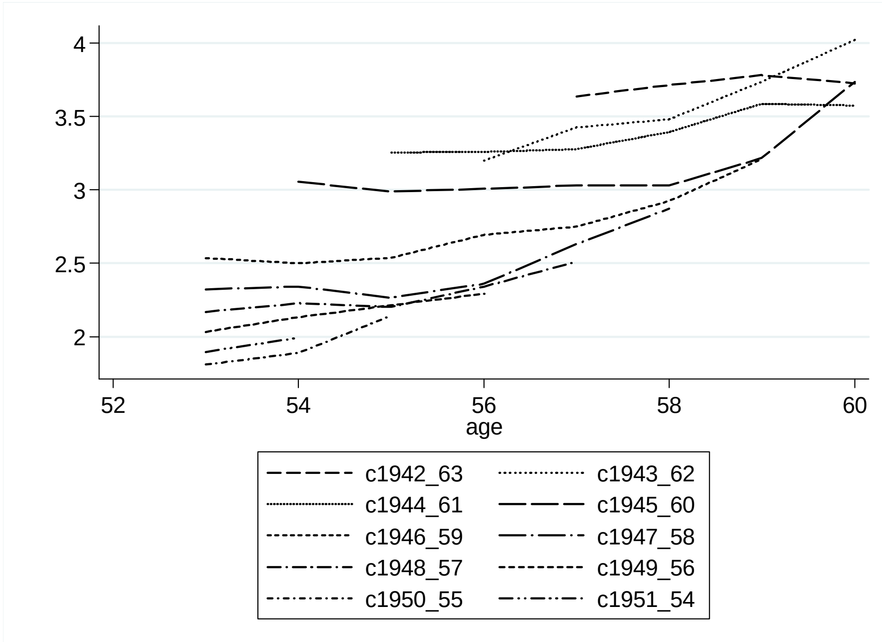
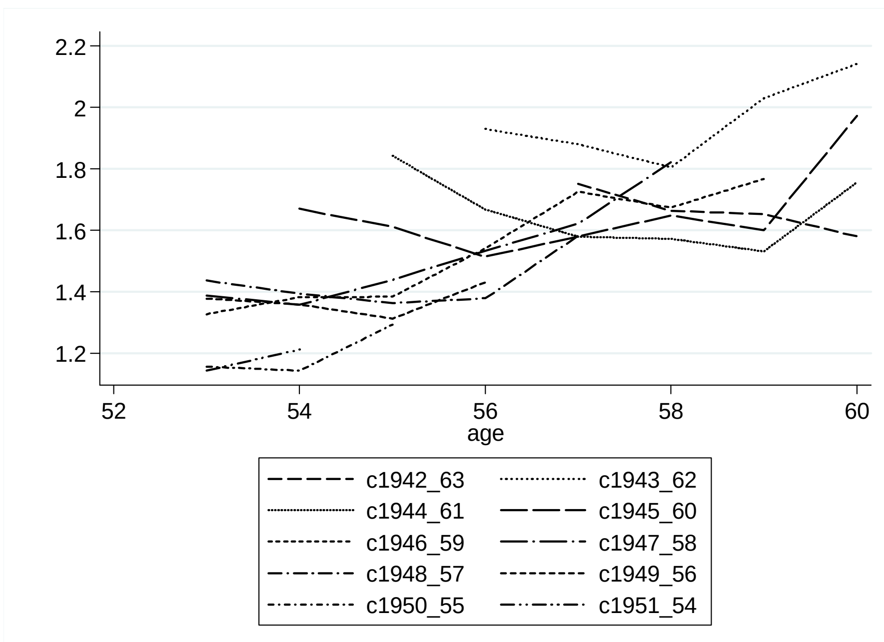


Figure 5b: women



Age on December 31st, 2005 is indicated behind each birth year cohort.

Table 1: Descriptive Statistics

Men

Variable	**Civil servants** Mean	**Civil servants** Std. dev.	**Other workers** Mean	**Other workers** Std. dev.
Age	55.90	2.21	55.98	2.18
Married	0.85	0.36	0.84	0.37
Lagged wage income	37.41	13.39	37.41	22.42

Women

Variable	**Civil servants** Mean	**Civil servants** Std. dev.	**Other workers** Mean	**Other workers** Std. dev.
Age	55.82	2.19	55.93	2.18
Married	0.63	0.48	0.71	0.45
Lagged wage income	24.62	12.97	18.41	11.55

Table 2: Fixed effects estimates for the probability to die within five years for civil servants (difference-in-difference)[33]

	Men	**Women**
N	181,101	40,771
Coefficient estimate retirement ($\hat{\omega}$)	0.007	-0.001
P-value	0.000	0.454
Fraction of total variation explained by individual fixed effects	0.819	0.808

[33] The model estimated here controls for lagged wage income, marital status, year fixed effects, non-linear age effects and individual fixed effects.

Table 3: Fixed effects estimates for the probability to die within five years (difference-in-difference-in-difference)[35]

	Men	Women
N	1,293,040	541,887
Coefficient estimate retirement ($\hat{\omega}$)	0.004	0.001
P-value	0.000	0.007
Fraction of total variation explained by individual fixed effects	0.824	0.826

Table 4: Fixed effects instrumental variable estimates for the probability to die within five years (difference-in-difference)[34]

	Men	Women
N	147,422	32,440
Coefficient estimate retirement ($\hat{\omega}$)	-0.025	-0.003
P-value	0.056	0.860
F statistic on instruments in first stage	196.70	32.83
P-value J statistic	0.261	0.048
Fraction of total variation explained by individual fixed effects in first stage	0.520	0.496
Fraction of total variation explained by individual fixed effects in second stage	0.823	0.822

[34] The model estimated here controls for lagged wage income, marital status, year fixed effects, non-linear age effects and individual fixed effects.

Table 5: Fixed effects instrumental variable estimates for the probability to die within five years (difference-in-difference-in-difference)[35]

	Men	**Women**
N	1,233,758	514,018
Coefficient estimate retirement ($\hat{\omega}$)	-0.025	-0.003
P-value	0.055	0.861
F statistic on instruments in first stage	173.58	34.90
P-value J statistic	0.260	0.050
Fraction of total variation explained by individual fixed effects in first stage	0.620	0.757
Fraction of total variation explained by individual fixed effects in second stage	0.825	0.826

[35] The model estimated here controls for lagged wage income, marital status, year fixed effects, non-linear age effects and individual fixed effects.

Table 6: Fixed effects instrumental variable estimates for the probability to die within five years for male civil servants (difference-in-difference)[33]

Cause of death	LATE	P-value	P-value J statistic	LATE (in # of deaths)
Neoplasms	-0.003	0.755	0.003	-9.1
Malignant neoplasms of lip, oral cavity and pharynx	-0.001	0.316	0.189	-3.4
Malignant neoplasms of digestive organs	0.003	0.635	0.115	8.5
Malignant neoplasms of respiratory and intrathoracic organs	-0.002	0.698	0.457	-6.1
Melanoma and other malignant neoplasms of skin	0.000	0.939	0.238	0.3
Malignant neoplasms of mesothelial and soft tissue	-0.000	0.784	0.366	-1.2
Malignant neoplasms of male genital organs	-0.001	0.465	0.666	-4.3
Malignant neoplasms of urinary tract	-0.001	0.565	0.079	-4.4
Malignant neoplasms of eye, brain and other parts of central nervous system	-0.003	0.184	0.168	-7.8
Malignant neoplasms of ill-defined, secondary and unspecified sites	0.001	0.615	0.082	3.3
Malignant neoplasms, stated or presumed to be primary, of lymphoid, haematopoietic and related tissue	0.002	0.555	0.311	5.1
Neoplasms of uncertain or unknown behavior	0.000	0.371	0.708	0.9
Endocrine, nutritional and metabolic diseases	-0.001	0.625	0.480	-1.8
Mental and behavioural disorders	-0.001	0.202	0.250	-2.3
Diseases of the nervous system	-0.001	0.568	0.834	-1.9
Diseases of the circulatory system	-0.007	0.311	0.995	-19.4
Hypertensive diseases	-0.002	0.257	0.088	-4.5
Ischaemic heart diseases	-0.006	0.200	0.876	-16.4
Other forms of heart disease	0.007	0.103	0.035	20.1
Cerebrovascular diseases	-0.005	0.004	0.561	-14.8
Diseases of arteries, arterioles and capillaries	-0.001	0.296	0.619	-3.9
Diseases of the respiratory system	0.002	0.470	0.150	4.4
Diseases of the digestive system	-0.007	0.004	0.096	-21.1
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	-0.004	0.213	0.983	-11.1
External causes of morbidity and mortality	-0.004	0.085	0.858	-11.5
Other diseases	-0.000	0.981	0.453	-0.1
Total	-0.025			-73.9

Table 7: Fixed effects instrumental variable estimates for the probability to die within five years for male civil servants (difference-in-difference-in-difference)[33]

Cause of death	**LATE**	**P-value**	**P-value J statistic**	**LATE (in # of deaths)**
Neoplasms	-0.003	0.750	0.003	-9.3
Malignant neoplasms of lip, oral cavity and pharynx	-0.001	0.297	0.186	-3.5
Malignant neoplasms of digestive organs	0.003	0.647	0.113	8.2
Malignant neoplasms of respiratory and intrathoracic organs	-0.002	0.691	0.457	-6.2
Melanoma and other malignant neoplasms of skin	0.000	0.913	0.235	0.4
Malignant neoplasms of mesothelial and soft tissue	0.000	0.782	0.367	-1.2
Malignant neoplasms of male genital organs	-0.001	0.470	0.666	-4.2
Malignant neoplasms of urinary tract	-0.001	0.568	0.078	-4.3
Malignant neoplasms of eye, brain and other parts of central nervous system	-0.002	0.186	0.167	-7.7
Malignant neoplasms of ill-defined, secondary and unspecified sites	0.001	0.611	0.079	3.3
Malignant neoplasms, stated or presumed to be primary, of lymphoid, haematopoietic and related tissue	0.001	0.554	0.312	5.1
Neoplasms of uncertain or unknown behavior	0.000	0.367	0.666	0.9
Endocrine, nutritional and metabolic diseases	-0.001	0.627	0.482	-1.7
Mental and behavioural disorders	-0.001	0.198	0.251	-2.3
Diseases of the nervous system	-0.001	0.581	0.839	-1.8
Diseases of the circulatory system	-0.007	0.306	0.995	-19.6
Hypertensive diseases	-0.002	0.262	0.085	-4.4
Ischaemic heart diseases	-0.006	0.196	0.877	-16.5
Other forms of heart disease	0.007	0.105	0.033	19.9
Cerebrovascular diseases	-0.005	0.004	0.556	-14.8
Diseases of arteries, arterioles and capillaries	-0.001	0.294	0.601	-3.9
Diseases of the respiratory system	0.002	0.469	0.148	4.4
Diseases of the digestive system	-0.007	0.004	0.101	-20.9
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	-0.004	0.215	0.983	-11.1
External causes of morbidity and mortality	-0.004	0.086	0.857	-11.4
Other diseases	-0.000	0.976	0.468	-0.2
Total	-0.025			-73.9

Table 8: Robustness check for age polynomials: fixed effects instrumental variable estimates for the probability to die within five years (difference-in-difference)[36]

	3rd order age polynomial excluded	**4th order age polynomial included**
N	147,422	147,422
Coefficient estimate retirement ($\widehat{\omega}$)	-0.029	-0.024
P-value	0.060	0.067
F statistic on instruments in first stage	175.35	201.98
P-value J statistic	0.260	0.324
Fraction of total variation explained by individual fixed effects in first stage	0.501	0.497
Fraction of total variation explained by individual fixed effects in second stage	0.822	0.822

Table 9: Robustness check for age polynomials: fixed effects instrumental variable estimates for the probability to die within five years (difference-in-difference-in-difference)[37]

	3rd order age polynomial excluded	**4th order age polynomial included**
N	1,233,758	1,233,758
Coefficient estimate retirement ($\widehat{\omega}$)	-0.029	-0.024
P-value	0.059	0.067
F statistic on instruments in first stage	152.33	178.64
P-value J statistic	0.260	0.323
Fraction of total variation explained by individual fixed effects in first stage	0.523	0.526
Fraction of total variation explained by individual fixed effects in second stage	0.824	0.825

[36] The model estimated here controls for lagged wage income, marital status, year fixed effects, non-linear age effects and individual fixed effects.

Table 10: Robustness check for being married: fixed effects instrumental variable estimates for the probability to die within five years for married men[38]

	Diff-in-diff	**Diff-in-diff-in-diff**
N	131,882	1,038,054
Coefficient estimate retirement ($\widehat{\omega}$)	-0.024	-0.024
P-value	0.078	0.078
F statistic on instruments in first stage	172.00	149.05
P-value J statistic	0.160	0.159
Fraction of total variation explained by individual fixed effects in first stage	0.526	0.620
Fraction of total variation explained by individual fixed effects in second stage	0.820	0.827

Table 11: Robustness check for including individuals aged 52: fixed effects instrumental variable estimates for the probability to die within five years for men[37]

	Diff-in-diff	**Diff-in-diff-in-diff**
N	173,162	1,427,950
Coefficient estimate retirement ($\widehat{\omega}$)	-0.027	-0.027
P-value	0.029	0.029
F statistic on instruments in first stage	266.46	228.79
P-value J statistic	0.383	0.381
Fraction of total variation explained by individual fixed effects in first stage	0.511	0.517
Fraction of total variation explained by individual fixed effects in second stage	0.819	0.823

[37] The model estimated here controls for lagged wage income, marital status, year fixed effects, non-linear age effects and individual fixed effects.

Table 12: Robustness check for failure of parallel trend assumption: fixed effects instrumental variable estimates for the probability to die within five years for men (dummy for age 60 and dummy for age 60 and being a civil servant included)[39]

	Diff-in-diff-in-diff
N	1,233,758
Coefficient estimate retirement ($\widehat{\omega}$)	-0.025
P-value	0.058
F statistic on instruments in first stage	179.16
P-value J statistic	0.539
Fraction of total variation explained by individual fixed effects in first stage	0.513
Fraction of total variation explained by individual fixed effects in second stage	0.825

Table 13: Random effects instrumental variable estimates for the probability to die within five years for men[38]

	Diff-in-diff	Diff-in-diff-in-diff
N	155,166	1,293,040
Coefficient estimate retirement ($\widehat{\omega}$)	-0.012	-0.012
P-value	0.306	0.299
F statistic on instruments in first stage	382.46	331.972
P-value Hausman test FE vs RE	0.000	0.000
Fraction of total variation explained by individual random effects in first stage	0.222	0.215
Fraction of total variation explained by individual random effects in second stage	0.758	0.763

[38] The model estimated here controls for lagged wage income, marital status, year fixed effects, non-linear age effects and individual fixed effects.

Table 14: Ordinary Least Squares instrumental variable estimates for the probability to die within five years for men[39] [40]

	Diff-in-diff	**Diff-in-diff-in-diff**
N	155,166	1,293,040
Coefficient estimate retirement ($\widehat{\omega}$)	-0.027	-0.028
P-value	0.110	0.092
F statistic on instruments in first stage	210.4	208.8
P-value Sargan test	0.446	0.526

Table 15: Probit instrumental variable estimates for the probability to die within five years for men[40] [41]

	Diff-in-diff	**Diff-in-diff-in-diff**
N	155,166	1,293,040
Marginal effect on retirement	-0.003	0.009
P-value	0.814	0.323
F statistic on instruments in first stage	60.8	59.5
P-value Sargan test	0.446	0.526

[39] The model estimated here controls for lagged wage income, marital status, year fixed effects, non-linear age effects and individual fixed effects.

[40] The p-value on the retirement coefficient is based on heteroskedasticity robust standard errors.

[41] The marginal effect on retirement is estimated for civil servants in 2005. The p-value for the marginal effect on retirement is based on bootstrapped standard errors, performing 200 iterations.