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Early Retirement Behaviour in the Netherlands¹

Evidence from a Policy Reform

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Abstract

In the early 1990s, the Dutch labour unions and employer organisations together agreed to transform the generous and actuarially unfair early retirement schemes into less generous and actuarially fair schemes that reward individuals for postponing retirement. The starting dates of these new retirement programs varied by industry sector. In this study, we exploit this variation in starting dates to estimate the causal impact of the policy reform on early retirement behaviour. We use a large administrative dataset, the Dutch Income Panel 1989–2000, to estimate hazard rate models for the retirement age. We conclude that the policy reform has indeed induced workers to postpone retirement. In particular, both reducing implicit taxes (the substitution effect) and reducing early retirement wealth (the wealth effect) are shown to have a positive impact on the retirement age.

Key words: early retirement, intertemporal choice, duration analysis

JEL code: C41, D91, J26

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1. Introduction

The Dutch labour force participation rate of the elderly was low compared to other western countries. In 1990 the employment-to-population ratio for age 55 to 64 was 29.7 percent. Partly due to the favourable economic circumstances at the end of the 1990s, this rate increased to 46.6 percent in 2004, but still remained below the OECD average (OECD, 2005a). Although the problem of an ageing population is less severe for the Netherlands than for many other countries, and the capital funding of occupational pensions makes government finances less vulnerable to ageing altogether, the low participation rate before the age of 65 remains high on the policy agenda.⁵ As an increasingly broad base of tax payers is required to bear the financial burden of an expanding senior citizen population, it is often advised that the labour force participation of the elderly in the Netherlands should be increased (see, e.g., OECD, 2005b).

An important aspect of the low participation rate of the elderly are the financial incentives encouraging early retirement. Empirical evidence on the effects of such financial incentives is available for several countries, such as Germany (Börsch-Supan *et al.*, 2004), the United Kingdom (Blundell *et al.*, 2004) and the Netherlands (De Vos and Kapteyn, 2004).⁶ The result for the Netherlands is further reiterated by Kerkhofs *et al.* (1999), using a different data set, the Dutch Retirement Survey (CERRA). However, on the basis of the same data, Heyma (2001) reaches a conflicting conclusion that the importance of monetary enticements is limited. In an overview article that is mostly based on US evidence, Lumsdaine and Mitchell (1999) conclude that the impact of financial incentives on early retirement is important, and that it can explain about half of the observed variation in retirement patterns in the US.

Our paper contributes to this literature in two ways. First, we are able to identify effects based on an unanticipated reform, so that in contrast to most of the previous literature we hardly need to make any identifying assumptions. That is, we may directly estimate participation effects of the reform without having to make assumptions on e.g. utility maximising behaviour of individual workers.⁷ Second, as there still remains considerable uncertainty surrounding earlier estimates, we hope to shed some more light on participation effects of different kinds of financial incentives. In particular, we are able to provide explicit estimates of labour force participation effects resulting from (i) a change in the opportunity to take up benefits at an earlier age, (ii) a change in the implicit tax rate, and (iii) a change in pension wealth.

⁵ Dutch citizens are entitled to a state pension starting at the age of 65.

⁶ These references appear in a compilation of articles, edited by Gruber and Wise (2004) (follow-up of Gruber and Wise, 1999). The German study is based on the German Socio-Economic Panel, the UK study on the UK Retirement Survey, and the Dutch study on the Dutch Socio-Economic Panel.

⁷ While most of the literature has followed a more structural approach, there are three notable exceptions who also made use of an unanticipated reform: Krueger and Pischke (1992), who identify the impact of a change in Social Security wealth on the labour supply of older men in the US; Baker and Benjamin (1999), who use the fact that a Canadian pension reform was introduced at different speeds in Quebec and the rest of Canada; and Røed and Haugen (2003), who make use of the introduction of a new early retirement scheme among a "quasi-random" group of Norwegian workers.

In the early 1990s, both labour unions and employer organisations recognised the adverse incentive effects of the prevailing early retirement programs, and jointly decided to gradually transform them into less generous and more actuarially fair schemes. Until then, the early retirement schemes were highly actuarially unfair, leading to high implicit tax rates on labour income of the elderly. This decision led to a series of changes in the early retirement schemes. The starting dates of the new early retirement programs varied by industry sector. In this study, we exploit this variation in starting dates to estimate to which extent financial incentives affect the (early) retirement decision.

The reforms affected the (early) retirement decision of individuals in total in three different ways. First, some interventions allowed employees to take up early retirement benefits at a much younger age than before. Typically, the eligibility age was 60 or 61 in the old schemes, while it became 55 in the new schemes. An important aspect of the early retirement schemes is that workers only qualify for early retirement benefits if they have paid work right before the eligibility age. Thus, the old early retirement schemes contained an incentive to continue working right until the higher eligibility ages. This incentive was removed in the new schemes. Second, as some new programs introduced actuarially adjusted early retirement benefits, this implied a ‘price effect’ (or substitution effect) as retiring employees started to pay the ‘fair price’ for leisure. This implied a huge shift compared to the previous early retirement scheme, where after becoming eligible for early retirement the price of leisure was virtually zero. In other words, the high implicit tax rates on labour income were removed for an important part under the new schemes. Finally, the new schemes affected ‘early retirement wealth’, i.e. typically less financial resources were available for the purchase of leisure. This ‘income effect’ or ‘wealth effect’ potentially leads to a postponement of early retirement. In this paper we disentangle the estimated behavioural effects into these three components.

It is important to note that although the reforms could be foreseen, they could not be evaded by the individual worker. Therefore so-called anticipation effects do not hamper our analysis. Every age-cohort faced a pre-determined retirement program and no worker had the possibility to retire with the old scheme prior to the introduction of the new regime in anticipation of harsher retirement benefits. Furthermore, it is also important to note that the timing of the introduction of the new schemes is exogenous with respect to worker preferences and with respect to the demand for labour. For instance, the reason for the accelerated introduction of the new early retirement program for civil servants was that the government had decided to cut back expenditures, and the new retirement regime offered an opportunity to do so. The early retirement arrangements for civil servants will be our main source of variation over time, while individuals in (a selection of) other sectors will principally serve as control groups.

The dataset we use, the Dutch Income Panel 1989–2000, is based on administrative records of the Dutch National Tax Office. Estimating hazard rate models for the duration until retirement we find that

the policy reform induced workers to postpone early retirement. In particular, we find that (i) removing the incentive to wait for the early retirement eligibility age has not led to increased retirement at younger ages, (ii) introducing actuarial adjustments in early retirement schemes has led to important labour supply effects of the elderly, and (iii) reducing early retirement wealth has generated a positive labour supply effect, although smaller in magnitude than the former effect.

The organisation of this paper is as follows. In section 2 we describe the early retirement schemes in the Netherlands and we explain how the reforms have affected workers' incentives. The data used in our analysis are discussed in section 3. Section 4 discusses the empirical strategy, and in section 5 the estimation results are presented. Finally, section 6 concludes.

2. The reform of the Dutch early retirement schemes

The Dutch pension system consists of both old-age pension provisions and early retirement schemes. The statutory old-age pension age is 65. From that age on, Dutch inhabitants are entitled to a state pension. In addition, most employees are entitled to a supplementary occupational pension.⁸ Before the age of 65 early retirement schemes apply. The precise retirement rules are determined by negotiations between unions and employer organisations at the sectoral level of industry and are administered by pension funds, special 'early retirement funds', or insurance companies. Together with the other terms of employment, these rules are laid down in collective labour agreements. This means that participation in the early retirement scheme is mandatory for employees (that is, paying the premiums; the (early) retirement decision is out of free will).

In the Netherlands, early retirement schemes were first introduced in the 1970s in the form of the so-called 'VUT schemes'.⁹ These schemes operated as pay-as-you-go (PAYG) systems in which the working population pays for the retirement of early retirees. The arrangement was favourable for older workers, and eligibility conditions were relatively mild. In the 1990s concerns arose about the adverse incentive effects and the long run financial sustainability of these retirement schemes. A general agreement was reached between labour unions, employer organisations, and the government to reform the system. Initially, some small changes were made to the system, such as increasing the eligibility age or lowering the replacement rate. Thereafter, the PAYG-based VUT schemes were gradually replaced by capital funded 'pre-pension' (PP) schemes. These new early retirement programs introduced actuarial adjustments between different retirement ages, so as to create better incentives to delay retirement. In addition to that, the individuals' early retirement wealth was typically lower in the new programs. In this

⁸ See Bovenberg and Meijdam (1999) for details on the Dutch old-age pension system.

⁹ In Dutch, the acronym 'VUT' stands for 'early retirement'.

section, we first discuss the original early retirement schemes and their successors (subsections 2.1-2.3). As the individuals in our sample may be subject to different schemes in different years, this may lead to quite complicated early retirement incentives at the individual level. In order to explain how this works in detail, we have included the description of a fictitious individual in subsection 2.4.

2.1 Flat-rate early retirement schemes

From the late 1970s on, early retirement schemes were agreed upon in many collective agreements and consequently put in place in many sectors of industry. A typical feature of these VUT schemes was that the replacement rate did not depend on retirement age. The eligibility age was decreased several times in most sectors and at the end of the 1980s it was age 60 or 61 for a majority of employees. The schemes were a shared responsibility of labour unions and employers organisations, and were facilitated by the government through a favourable tax treatment: pension premiums were deductible from the worker's gross salary, while early retirement benefits were being taxed as if they were a regular source of income. Due to the progressive tax system the tax advantage was considerable (see Kooiman *et al.*, 2004).

The financial conditions of these flat-rate early retirement schemes were favourable for older workers: gross benefits equalled up to 80% of the last earned gross wage, and old-age pension entitlements continued to grow as if retirees kept on working. To qualify for early retirement through this scheme, a worker needed to reach the eligibility age and needed to be working in a sector or firm for at least 10 years. As these schemes did not contain any actuarial adjustments, there was clearly a great incentive to retire at exactly the eligibility age (the formal argument is given in appendix A). This is well documented in, e.g., Lindeboom (1998) and Kapteyn and de Vos (1999). During the period that VUT schemes were being shaped, the employment-to-population ratio for men between the ages of 55 and 64 dropped from to 63.2 percent to 44.2 percent (1979-1990; based on OECD, 1996).

2.2 Actuarially adjusted early retirement schemes

In the 1990s concerns arose about the long run financial sustainability of VUT schemes. Labour unions, employer organisations and the government agreed that a broad base of tax payers was required to bear the financial burden of the ageing of the Dutch population. Therefore, they decided to transform the retirement programs. The reforms initially comprised of small changes in the conditions of the flat-rate VUT schemes. The eligibility age was increased and the replacement rate was lowered in several sectors, including for example the government and the educational sector.

A couple of years later, a more fundamental reform was agreed upon: all existing VUT schemes would in the long run be replaced by 'pre-pension' (PP) schemes. These schemes should differ from the VUT schemes in several ways. First of all, the PP schemes would be capital funded, unlike the VUT which was a PAYG system. In fact, PP schemes are collective (mandatory) savings arrangements in which workers save for their own early retirement. From the viewpoint of the individual elderly worker, the source of funding of his early retirement benefits is however hardly relevant, as he is mainly interested in the financial consequences of the personal choices he is able to make.

A more important difference is that the early retirement wealth was often lower in the new scheme. In a sample of 105 collective labour agreements, the Labour Inspectorate (2004) finds for a majority of cases that the gross replacement rate at a given retirement age was decreased by at least 10%-points. Moreover, the old age pension rights no longer continued to increase during early retirement, as was the case under the VUT schemes.

A second important difference is that the price of leisure would be altered in two different ways. In the first place, an important 'price effect' would be caused by the introduction of actuarial adjustments into the PP schemes. Most PP schemes would be actuarially fair, so that the price of leisure would rise substantially after the original eligibility age (this is formally written out in appendix A). However, in the scheme it is allowed to take up early retirement benefits from the age of 55 on, which may have induced employees to retire earlier than under a VUT scheme. The reason is that only individuals with paid work would qualify for early retirement benefits under the VUT scheme, implying an incentive to continue working until the eligibility age.

A last difference concerned the eligibility criteria. Since the PP schemes were individual savings arrangements, an employee would be eligible to receiving the maximum benefit only if he had contributed to a PP scheme for 35 or 40 years, depending on the exact regulations of the early retirement scheme. If the employee has a shorter employment history, then the early retirement benefits will be lower *pro rata*. This feature of the PP schemes implied that immediate introduction was not possible. Therefore, long-lasting transitional arrangements were introduced.

2.3 Transitional arrangements

Transitional arrangements were introduced in order to smooth the transition from flat-rate schemes to the actuarially adjusted schemes. In practice, however, it turned out that most older workers continued to face early retirement arrangements that were close to the old schemes. An exception was ABP, the pension fund of civil servants and individuals working in the education sector. This pension fund started reforming its early retirement schemes relatively early, and introduced some actuarial adjustments into its schemes

from 1997 on. The accelerated introduction of the transitional scheme was a consequence of the government's retrenchment policy at the time (see also section 4.1).

Table 2.1 shows the early retirement schemes for eight selected industry sectors for the period 1989–2000. For each sector of industry the replacement rate is shown for each possible retirement date and age. These replacement rates determine the level of the benefits that an employee receives from the moment of early retirement until age 65. For example, an individual born in 1944 and working in the health care sector would receive a replacement rate of 75% given retirement at age 60, while an individual in the 1939 cohort would receive 80% at this same age. Note that in some instances, employees may be subject to a combination of different transitional schemes. Consider for instance a civil servant employed by the national government who was born in January 1932. For this individual, retirement at age 61 (i.e. in 1993) implies a replacement rate of 80%, while early retirement at later ages implies a replacement rate of 75% (see the second and third row of the concerning early retirement scheme in table 2.1). In the next subsection we will provide a detailed example of an individual worker being subject to different regimes.

[insert table 2.1 here]

In four sectors (post/telecom, agriculture, catering industry, and cleaning industry), the early retirement replacement rates have not changed during the period 1989–2000. The pension funds in these sectors decided to wait with the introduction of actuarial adjustments until after 2000. Some small changes took place in the level of the replacement rates in the health care sector, but the scheme was highly actuarially unfair during the entire time period considered in this paper. The three remaining sectors (national and local government and the education sector) all have their early retirement schemes administered by the pension fund ABP. The workers in these sectors initially also faced a flat-rate VUT scheme, but starting from April 1997, ABP introduced actuarial adjustments in its schemes, so that a worker who postpones retirement is rewarded with higher benefits.

The actuarial adjustments in the early retirement schemes may affect the retirement decision of individual workers. For example, before 1995 civil servants of the local government had a large incentive to retire at age 59. This provided them with a pension benefit equal to 80% of their last earned wage for the next six years (up to age 65). Postponing retirement did not increase the level of the benefits: retiring one year later still resulted in a replacement rate of 80%, but now for five years rather than six. After April 1997, the incentive to retire at age 59 did not exist anymore. Retiring at age 59 resulted in a benefit of 45% or 48% (depending on the year of birth) and postponing retirement until age 60 increased the replacement rate to 55% or 59%. Given an interest rate of 4% and taking into account the mortality rate of 59-year old individuals, the expected discounted values of the two income streams are the same. Note that

the early retirement schemes of ABP after 1997 only contain actuarial adjustments until the age of 61.¹⁰ For higher ages the scheme was similar to a flat-rate scheme again. Hence, during the period 1989–2000 postponement of retirement until the statutory old-age pension age of 65 was always discouraged in all included sectors.

After age 65, workers do not receive an early retirement benefit anymore, but social security (state pension called ‘AOW’ in Dutch) and an old-age pension benefit. Pension funds take the social security benefits into account in the calculation of the supplementary old-age pension benefits by the use of a threshold, the so-called ‘franchise’. Individuals only build up old-age pension rights over the part of the wage that exceeds this threshold (see table 2.2 for more information). In order to receive a full old-age pension, a worker has to contribute to a pension fund for 35 or 40 years. Under the flat-rate VUT schemes, early retirees had continued to build up old-age pension rights. Under the new PP schemes this is no longer the case, implying that not every early retiree will be able to build up a complete old-age pension. Table 2.2 reports old-age pension replacement rates for a worker that would receive a complete old-age pension in case he works until age 65. The old-age pension replacement rates are relevant for constructing the financial incentive measures that we will use in the empirical analysis. Note that old-age pension replacement rates can both be higher or lower than the early retirement replacement rates, implying that retirees may experience an income change at age 65. For instance, a civil servant employed by the national government before April 1992 receives 80% of his last income in early retirement from age 60, and 70% after the age of 65. Furthermore, note that the low replacement rates for the catering and cleaning industries do not necessarily imply lower pension benefits as the franchise equals zero (i.e. the pension funds in this sector do not take the state pension into account, while they do in the other sectors).

[insert table 2.2 here]

2.4 Example

The different regimes of the transitional scheme lead to complicated early retirement schemes at the individual level. In this section we provide a detailed example for a fictitious individual, in order to get some understanding of the financial incentives faced by an individual worker. We show how the reform has affected these incentives. For the ease of exposition, we ignore the role of taxes, mortality rates and inflation in this example. In the actual empirical analysis we do take these factors into account.

¹⁰ This changed in 2003 (not shown in the table). In that year the pension fund ABP finished the transition by introducing a scheme that was actuarially fair and provided a replacement rate of 70% at age 62.

Consider an individual born on August 1, 1936 who has been working as a civil servant for the national government ever since the age of 25. He earns a real wage of 33000 euros per year. He enters our sample in August 1991, when he turns 55. When he checks the retirement scheme offered by his pension fund at that time, he sees he is not entitled to an early retirement benefit yet (first lines of table 2.1 and 2.2). Hence, if he stops working immediately, he will not have any income in the next ten years. After that, i.e. after age 65, he is entitled to the state pension (about 11475 euros per year for a single individual) and the old-age pension. Given retirement at age 55, the old-age pension will equal $53\% \cdot (33000 - 15250) = 10600$ euros per year. Hence, his total pension after age 65 amounts to 22075 euros per year.

The individual concludes that it is best to continue working until August 1996, when he turns 60 and becomes eligible to an early retirement benefit. In that case, he will receive $80\% \cdot 33000 = 28200$ euros per year for five years (from age 60 to 65). After age 65, his pension benefit will equal $70\% \cdot (33000 - 15250) + 11475 = 25475$ euros per year. Postponing retirement one more year (i.e. until age 61) does not change the level of the retirement benefits. The only difference is that he will receive the early retirement benefits for four years rather than five. Hence, although the worker gets a wage of 33000 when he works at age 61, he also loses 28200 euros of early retirement benefits. The net reward of working is therefore only 4800 euros that year. This does not seem a very attractive option, so the worker decides that he will retire at August 1, 1996.

However, in April 1992 the worker has to change his plans. Negotiations between labour unions and the government have resulted in a modification of the pension scheme: the eligibility age is increased from 60 to 61. This change is clearly a worsening of the worker's employment conditions. However, there is nothing he can do to avoid it. Retiring immediately is still not an attractive option. Switching to a job in a sector with a more attractive retirement is not a solution either: it would result in a loss of all his early retirement benefits, because of the requirement of a work history of ten years in a specific sector. The worker could consider to increase his private savings in order to fund retirement at 60 himself. However, given the very short time span left, this option is not feasible: within five years, the worker would have to save enough money to compensate for the loss of five years of early retirement benefits. The worker chooses to postpone his retirement to August 1, 1997, when he will become 61.

In the years between 1993 and 1997 nothing changes in the retirement scheme, except for a reduction in the replacement rate from 80% to 75%. This mainly affects the workers pension wealth, but it has no major impact on his leisure/labour supply decision (of course, this needs not be the case for every worker). On April 1, 1997 however, there is an important change again. The pension fund introduces actuarial adjustments between age 55 and 61, implying that the worker, who is 60 years old at that time, suddenly becomes eligible to an early retirement benefit. He can retire immediately and get an early retirement benefit of $59\% \cdot 33000 = 19470$ euros for the next 4 years and 4 months (until he reaches age

65 on August 1, 2001). Nevertheless, due to the actuarial adjustment it is rather attractive to work four months more and stick to retirement on August 1, 1997. Then the workers turns 61 and becomes eligible to a benefit of $75\% \cdot 33000 = 24750$ euros for the next four years. Continuing to work after that age is not attractive as the benefit level will stay 24750 euros per year.

The workers other than civil servants face a very different planning problem of early retirement (Table 2.1). Consider, for example, an individual who has been working for the Post or Telecom ever since the age of 25. During the complete period 1989–2000 the early retirement benefit was zero before age 61, and was 80% of the last earned wage from age 61 onwards. Early retirement at age 61 was very attractive, and this did not change over the period under consideration. Only for some individuals working in the health care there have been adjustments in the conditions for early retirement. Consider, for example, an individual born on December 1, 1940, who has been working in the sector ever since age 25. He enters our sample in December 1995, when he turns 55. He faces an early retirement scheme which offers 80% of the last earned wage from age 60 onwards. As retiring at an earlier or a later date is financially very unattractive (see the example of the civil servant), he decides to work until that age. On December 1, 1998 he turns 58 and he is still not entitled to an early retirement benefit. Nevertheless he is already informed about a change in the early retirement conditions: one month later, on January 1, 1999, he will become eligible to a benefit of 40% of the last earned wage. By postponing early retirement until age 60 he will however become eligible to a benefit of 79% of the last earned wage. Although early retirement at age 58 is financially unattractive as the adjustment of the benefit level is actuarially unfair, the individual may decide to retire at that age in case he sufficiently appreciates leisure.

As the examples illustrate, civil servants and some workers of the health care sector could face different incentives at different moments in time. In the empirical analysis we take this in to account by modelling the hazard rate of exiting into retirement as a function of the incentives at the individual's age. More details are given in section 5.

3. Data

The data for this study are drawn from the Dutch Income Panel (*Inkomens Panel Onderzoek*, IPO) 1989–2000, which is a one percent sample of income histories of registered citizens of the Netherlands with at least one registration during the 12-year period. Our selected sub-sample consists of observations on 2937 individuals who are employed at their 55th birthday in one of eight selected sectors of industry, and not living on welfare, unemployment insurance or disability insurance at this initial age. We observe these individuals from their 55th birthday on.

The IPO dataset is drawn from registers made available by the Dutch National Tax Office and is administered by Statistics Netherlands (CBS). In total, the dataset contains about 75 thousand individuals per year. The dataset contains individuals that are included in the Dutch municipal registers. Attrition occurs only because of migration or death, or because of moving to an institution (like a nursing home or a prison). New individuals are added to the sample every year to compensate for the loss in numbers of observations because of attrition.

The IPO dataset is particularly suitable for studying early retirement behaviour. Besides its accuracy, an important advantage is the long time period over which we observe individuals. Furthermore, the dataset contains industry sector codes (SBI74, SBI93), which allows us to merge the individual data with information from collective labour agreements, including information on institutional early retirement ages and gross replacement rates. The dataset has some disadvantages as well, as the Dutch official registers lack information on education, health and pension wealth.

As the information on pension and early retirement arrangements is crucial for our study, we need to select sectors of industry that match to one and only one collective agreement on the four-digit level code for the industry sector. Each of these sectors has a pension fund which carries out the pension and early retirement regulations. The industry sectors and their respective pension funds that we selected for this study were shown in table 2.1. Note that the selected pension funds cover about 40% of all employees in the Netherlands aged between 25 and 65. The resulting dataset contains 2937 individuals, of which 1232 are employed in the government sector, 741 in the education sector, 445 in the health care sector, 224 in the post/telecom sector and 295 in one of the other sectors. Unfortunately, we cannot use the exact classification of tables 2.1 and 2.2 as the industry sector codes do not allow us to differentiate between national and local government. In the empirical analysis we will therefore assume that a civil servant works at the national government with a given probability (see section 5).

Men are the largest group in our sample of individuals who are employed at age 55; only 22% of the sample consists of women (table 3.1). The low share of women is in line with the low employment rate of Dutch women in this cohort; later cohorts of women have substantially higher employment rates. The health care pension fund (PGGM) has by far the largest proportion of women. Only few individuals are single at age 55, while the individuals have on average 0.17 children under the age of 18.

As can be read from the table, the individuals in our sample have relatively high incomes and are relatively wealthy: about 71% earns more than the Dutch median income. This is in line with the prevailing system of seniority wages. In particular, employees in the government, education and post/telecom sectors have relatively high incomes. Despite the relatively small number of employees in the health care sector with a high income, the housing value and mortgage debt is relatively high. This

may be due to the rather heterogeneous group of participants with nursing personnel on the one hand and medical personnel on the other hand.

[insert table 3.1 here]

For a proper measurement of the effect of the reform it is important to have a sufficient number of observations under the different early retirement schemes. Of the 1232 observations in the government sector, 356 individuals retired before April 1997 (table 3.2). Hence, these individuals were only subject to the old scheme. On the other hand, 312 employees in this sector reached the age of 55 after April 1997, implying that they only faced the new scheme. The remaining 564 observations have been subject to both schemes, in a way that has been discussed in subsection 2.4. They became 55 before April 1997, but only retired after that date. The ones who were aged between 55 and 61 suddenly became eligible for a benefit as a result of the reform. A comparable categorisation of the observations holds for the 741 observations in the education sector. Of the 445 observations in the health care sector, 298 observations became eligible for a benefit according to the transitional scheme on January 1, 1999. Note, however, that this scheme is highly actuarially unfair (see table 2.1). A descriptive analysis on the basis of aggregated data is not straightforward, because the regulation of the different early retirement schemes changed at different points in time during our observational period. Hence, we turn to the empirical analysis.

[insert table 3.2 here]

4. Empirical strategy

4.1 Identification

The purpose of this paper is to estimate the impact of the policy reforms on early retirement behaviour. Our identification strategy is based on the variation in the starting dates of the new schemes.. We compare the early retirement behaviour of civil servants before and after the reforms, and we use workers for which the reform did not take place yet as a control group. We use a control group, because early retirement behaviour may have changed because of the favourable economic conditions during the late 1990s. The two most important pension funds in our control group concern workers in the health sector and the post and telecommunications sector. Workers in these sectors can presumably best be compared with workers

who are subject to the ‘treatment pension fund’ ABP.¹¹ Nonetheless, we will take account of both observed and unobserved heterogeneity of workers in different sectors in the empirical analysis.

To be able to estimate the causal impact, it is important to note that the reforms could not be evaded by the individual worker. That is to say, so-called anticipation effects do not hamper our analysis as every age-cohort faced a pre-determined transitional arrangement and alternative early retirement options hardly existed.¹² Moreover, endogenous switching to other sectors was also not an option, as a result of work-history requirements in order to qualify for the early retirement scheme (see section 2). Furthermore, it is also important to note that the timing of the introduction of transitional schemes is exogenous with respect to worker preferences and with respect to the demand for labour. The reason for the accelerated introduction of the new early retirement scheme for civil servants was that the government had decided to cut back expenditures, and one way of doing so was to cut back expenditures on early retirement. In other words, the government did not, for example, anticipate an increase in its demand for labour. Figures from the Dutch National Accounts show that the number of workers of the government and education sector remained rather constant during our period of investigation, while, for example, the number of workers in the agricultural sector slightly decreased and the number of workers in the health care sector increased. The increase in labour demand of the health care sector was and still is partly predictable due to the ageing of society. So if one sector should have accelerated the introduction of the new early retirement scheme to anticipate an increase in the demand for labour it should have been the health care sector. This did not happen. We are therefore confident that the timing of the reform was truly exogenous both with respect to worker preferences and with respect to labour demand.

4.2 Incentive measures

Before specifying our empirical model, we first discuss some quantitative indicators for the financial incentives faced by individuals. Some of these indicators have been derived from the theoretical life-cycle model. As was mentioned in the introduction, we will not follow a structural approach in estimating the effects of the pension reform, but instead use these indicators in a reduced-form context.¹³

Stock and Wise (1990a, 1990b) proposed the option value model, where an economic agent chooses the retirement date for which expected utility is at its maximum, i.e. immediate retirement is optimal iff

¹¹ The government owned a majority of shares in the (then combined) post and telecom company until 1995.

¹² It is possible that alternative exit routes – such as Disability Insurance – become relatively more attractive as a consequence of the reform. The impact of the reform on these exit routes is beyond the scope of this paper. Another alternative exit route that may become important in the future is part-time work combined with partial early retirement. Partial early retirement was however hardly possible during the period of our investigation.

¹³ For papers who did follow the structural life-cycle approach (typically under some set of simplifying assumptions), see a.o. Rust (1989), Rust and Phelan (1997), Van der Klaauw and Wolpin (2003), Blau (2004), Heyma (2004), French (2005), and Gustman and Steinmeier (2005)

$$(4.1) \quad G(t) = \max_{R:R>t} \left\{ V_t(Y_t | R) + \sum_{s=t+1}^T \beta_{st} E_t V_s(Y_s | R) \right\} - \sum_{s=t}^T \beta_{st} E_t V_s(Y_s | t) < 0$$

where $G(t)$ is the option value (OV) of continued work, i.e. a negative value corresponds to immediate retirement being the optimal decision of the individual. The amount of cash flow to or from the pension fund at age s given retirement age R is denoted by $B_s(R)$, the indirect utility function by V , and cash flows at some future time s are discounted with a factor β_{st} at present time t . In words, the option value gives the difference between the utility enjoyed by retirement at the optimal age of retirement and that obtained by immediate retirement. This option value model is in fact a simplification of the life-cycle model, and is obtained by interchanging the maximum and expectation-operators in the dynamic programming rule of the life-cycle model. As Stock and Wise note, the expected value of the maximum of a set of random variables is larger than the maximum of their expected values, so that the option value of continued work is necessarily smaller than would be implied by the dynamic programming rule based on the life-cycle model. Several authors have questioned whether going from the full DP model to the OV model in (4.1) should be regarded as a simplification, as the latter might as well be a more ‘realistic’ alternative to describe the individual’s retirement behaviour. Lumsdaine et al. (1992) conclude that the DP model and the OV model perform equally well in explaining and predicting the retirement behaviour of individuals. In a different context (viz. the application for social security disability insurance benefits in the United States), Burkhauser et al. (2003) even conclude that the OV model outperforms the DP model.

In their econometric specification, Stock and Wise (1990a; 1990b) allow for individual specific random effects in both wage and retirement income. However, only very few authors have succeeded in estimating the full-fledged option value model as originally specified by Stock and Wise. Instead, most applications based on (4.1) use the variable $G(t)$ in a reduced form context. The most common application is to fix the parameters γ , k , and ρ at some given values, and let $G(t)$ enter as a linear regressor in a probit model (e.g., Samwick, 1998; Börsch-Supan, 2000; Berkel and Börsch-Supan, 2003; Asch et al., 2005).¹⁴ This is equivalent to estimating the full option value model with fixed parameters, and deterministic wages and retirement income (Lumsdaine et al., 1992). A common specification for the expected indirect utility function is

$$(4.2) \quad E_t V_s(Y_s | R) = \begin{cases} \sigma_{st} [w_s]^\gamma & \text{if } s < R \\ \sigma_{st} [kB_s(R)]^\gamma & \text{if } s \geq R \end{cases}$$

¹⁴ The values at which the parameters are fixed in the mentioned references are between 0.75 and 1.00 for γ (risk aversion up to risk neutrality); between 0.03 and 0.05 for ρ (discount rate between 3 and 5%); and between 1.5 and 3.1 for k . Note that none of these ranges is in accordance with the ‘original’ estimates ($\gamma=0.63$; $\rho=0.22$; $k=1.25$) of the full option value model obtained by Stock and Wise (1990a).

where σ_{st} is the conditional survival probability (of reaching age s conditional on having reached age t), w_s is the wage at time s , γ is the risk aversion parameter and k represents the relative valuation of leisure. We will employ this specification in our empirical model.

Coile and Gruber (2000) note that a potential drawback of the option value measure is that it is a function of future wages, and the latter may be a major source of variation across individuals. This implies that the researcher who is interested in identifying the behavioural effects induced by the early retirement scheme may find that the OV is for a large part measuring the effects of income dispersion rather than the effects he is interested in. Furthermore, this approach does not allow for estimating the separate effects of different (complementary) pension schemes. As an alternative the authors propose making use of the ‘peak value’, which is defined as

$$(4.3) \quad H(t) = \max_{R:R>t} \left\{ \sum_{s=t}^T \beta_{st} E_t B_s(R) \right\} - \sum_{s=t}^T \beta_{st} E_t B_s(t)$$

In words, the peak value is the difference between total discounted pension wealth at its maximum expected value and its value if retirement occurs immediately. As discussed in Samwick (2001), the peak value is the same as the option value under the assumptions that future wages do not affect the optimal retirement age, workers are not risk averse ($\gamma=1$), and income in retirement has the same utility value as income before retirement ($k=1$). The peak value (with fixed discount rate) is mostly used as an explanatory variable in a reduced form probit model, just like the option value (with fixed parameters). Applications are found in Coile and Gruber (2000) and Asch et al. (2005).

In addition to the OV and PV measures, we also use a financial incentive measure for the wealth effect. Total pension wealth at age t is computed as:

$$(4.4) \quad PW(t) = \sum_{s=t}^T \beta_{st} E_t B_s(t)$$

Using this incentive measure we may estimate the size of the income effect, that is, the extent to which pension wealth is used to finance retirement (at the margin).

4.3 Mixed proportional hazard rate model

We use a mixed proportional hazard rate model to describe the time spent in employment since the age of 55. The advantage of a hazard rate model over probit estimations for every age from 55 to 64 (which are often used in the literature) is that hazard rate models account for the endogenous selection of those still working at older ages. A probit regression at, e.g., age 63 gives the probability of early retirement at this age conditional on working at the birthday of age 63. This model is suitable for policy simulations with changing incentives at this particular age. The model is however not suitable for policy simulations with changing incentives over the whole range from age 55 to 64, as the model does not account for the endogenous change of the population that still works at the birthday of age 63. Hazard rate models are designed to take this selection into account. Having estimated such a model, both the conditional and unconditional retirement probabilities can be predicted given some set of financial parameters.

We model the duration T_i of an individual i as the time that elapses between his 55th birthday and the moment of (early) retirement. Although the data allow us to measure T_i in days, we round this duration to *years* for two reasons. First, data are to a large extent clustered around (especially *right after*) birthdays so that measuring T_i in days would not add much variation. Second, closer inspection of the data reveals that measurement in days may be not very precise, as the tax authorities are not so much interested in daily information but rather in information on a yearly basis. Since retirement is mandatory at the age of 65, this implies that T_i will not exceed the value of ten. Retirement is supposed to be an absorbing state: an individual who is retired will not start working again.¹⁵ The hazard rate (or instantaneous exit rate) $\lambda_i(t|x_{it}, \varepsilon_i)$ for individual i at time t is defined as the marginal probability of immediate retirement, conditional on not having retired yet before time t . Define a vector of time-dependent individual characteristics x_{it} , a conformable parameter vector β , and an unobserved individual heterogeneity term ε_i and let

$$(4.5) \quad \lambda_i(t|x_{it}, \varepsilon_i) = \lambda_0(t) \exp(x_{it}' \beta + \varepsilon_i).$$

In this equation $\lambda_0(t)$ is the baseline hazard, and ε_i is a random term representing unobserved heterogeneity between individuals. We specify the baseline hazard semi-parametrically, such that the age effect follows a step function with one parameter for each age (cf. Meyer, 1990). The probability that a spell lasts until time $t+1$ given that it has lasted until t then reads as:

$$(4.6) \quad h(t, x_{it}, \varepsilon_i) = P(T_i \geq t+1 | T_i \geq t, x_{it}, \varepsilon_i) = \exp[-\bar{\lambda}_0(t) \exp(x_{it}' \beta + \varepsilon_i)],$$

¹⁵ This is however not a heavy constraint in our analysis. First, practice shows that the early retirement event is indeed absorbing in the overwhelming majority of cases. Second, even if it would not be absorbing, then we could simply redefine the duration to be equal to the moment of *first* (early) retirement.

where

$$(4.7) \quad \bar{\lambda}_0(t) = \int_0^{t+1} \lambda_0(u) du.$$

The distribution $\bar{\lambda}_0 = [\bar{\lambda}_0(t)]_{t=0}^9$ can be estimated along with the parameters in β . Note that the baseline hazard function in (4.7) carries a bar to indicate that this concerns the average age effect over one year.

Next, we assume that unobserved heterogeneity can be characterised by a mixture of two mass points:

$$(4.8) \quad P(\varepsilon_i = \eta) = \alpha,$$

with the second mass point chosen such that $E[\exp(\varepsilon_i)] = 1$, i.e. $P(\varepsilon_i = \eta_2) = 1 - \alpha$, with $\eta_2 = (1 - \alpha \exp(\eta)) / (1 - \alpha)$.¹⁶

Furthermore, note that on the basis of the information in our dataset we cannot differentiate between workers of the national and the local governments. We assume workers of the government to be part of the national government with a given probability 0.39. This probability is based on the proportion of civil servants which is working for the national government.

The likelihood of observing a particular retirement date follows from (4.6), after taking the expectation with respect to the unobserved heterogeneity term using (4.8). Thus, summing over individual workers indexed by i , the likelihood function reads as:

$$(4.9) \quad L = \sum_i \log \left(\alpha \left((1 - h(t_i, x_{it}, \eta))^{\delta_i} \prod_{s=0}^{t_i - \delta_i} h(s, x_{is}, \eta) \right) + (1 - \alpha) \left((1 - h(t_i, x_{it}, \eta_2))^{\delta_i} \prod_{s=0}^{t_i - \delta_i} h(s, x_{is}, \eta_2) \right) \right),$$

where δ_i equals one if individual i is observed until the age of (early) retirement, and zero otherwise, and t_i is the length of the observed (either completed or uncompleted) spell. Maximisation of this likelihood function with respect to $\theta = (\beta, \bar{\lambda}_0, \alpha, \eta)$ yields consistent and asymptotically efficient parameter estimates.

5. Estimation results

¹⁶ Heckman and Singer (1984) argued that results may be very sensitive to the choice of a particular functional form for the distribution of ε_i , and therefore, the authors proposed using a non-parametric characterisation of ε_i by means of a finite set of points of support, whose number, locations, and weights are empirically determined. Guo and Rodriguez (1994) have found that, in practice, two or three points of support often suffice.

5.1 Specification with dummy indicator variables

Our first specification makes a distinction between actuarially unfair and actuarially fair schemes using dummy variables. We estimate the impact of the reforms on the basis of these dummy variables for the different relevant early retirement schemes. The results should be interpreted as an *average* effect of the reform from a generous actuarially unfair to a less generous actuarially fair scheme. However, what exactly drives the change in early retirement behaviour remains unclear. For this reason, the next subsection will implement a specification with the measures for the financial incentives discussed in section 4, the peak value and the option value.

A worker may be subject to either one of the following three cases: (1) a worker may be *not yet eligible* for an early retirement benefit. In this case, early retirement is unattractive as the worker will lose all his early retirement rights; (2) A worker may be *eligible to a flat-rate early retirement benefit*. In that case, early retirement is attractive as continuing to work hardly leads to a higher life-time income (see appendix A); (3) A worker may be *eligible to an actuarially fair early retirement scheme*. To allow for the three different regimes in the empirical hazard rate model, we define two dummy variables: one dummy variable *incentive to retire* and one dummy variable *incentive to wait*. The latter dummy variable equals unity if the worker will become eligible for early retirement benefits at some moment in the future, leading to an incentive to wait (i.e. case (1)). The dummy variable ‘incentive to retire’ equals one for individuals who are subject to a flat-rate early retirement scheme (i.e. case (2)), and zero for others. Thus, the reference case is an actuarially fair early retirement scheme which can be taken up at any age starting at the age of 55. Because of the reforms, the values of these two dummy variables change over time for civil servants and workers in the education sector (participants of the pension fund ABP). The dummy variables for the other industry sectors do not change over time, which makes an interpretation as ‘control group’ possible.

The estimation results show that the baseline hazard is upward sloping until age 61 and downward sloping after that age (table 5.1). The null hypothesis that the baseline hazard is constant is strongly rejected by a likelihood ratio or a Wald test. We take this as evidence for the presence of age dependence. On the basis of deteriorating health conditions and a possibly increasing preference for leisure with age we could expect a monotonically increasing baseline hazard. An explanation for the peak at age 61 may be interdependence of preferences, but measurement error may play a role as well. This last argument is a consequence of the fact that the dummy variables can take only two values, while there may be much more variation in incentives to wait and to retire. In the next subsection we will further exploit this variation.

[insert table 5.1 here]

The early retirement behaviour differs significantly between participants of different industry sectors. Even after correction for individual characteristics, the government employees and the workers in the education, post, telecom and agriculture sectors retire significantly earlier than the workers in the other sectors. Individuals with children have a lower propensity to retire than those without. The dummy variable *high income* has a positive sign, while the variable *house value* has a significantly negative sign. Neither the other individual characteristics nor the year dummies have a significant effect on the hazard rate. On the other hand, unobserved heterogeneity turns out to be important.

The estimate of the dummy variable *incentive to retire* is significantly positive. Thus, the old flat-rate early retirement schemes indeed resulted in a higher propensity to withdraw from the labour market than an actuarially fair scheme. The dummy variable *incentive to wait* has the theoretically correct sign but is not significantly different from zero. One would expect that a worker who has not yet reached the eligibility age would have a strong incentive to postpone retirement. But after April 1, 1997 only few workers decided to retire at the ages of 55 to 59 anyhow. These results show that the policy reform is effective in the sense that it induced workers to postpone early retirement. The major cause of this result is that the high implicit tax at the eligibility age was removed.

5.2 Specification with financial variables

Our second specification attempts to capture the impact of financial incentives more precisely by making use of measures for the price effect by both the peak value and the option value, respectively, and the wealth effect by the pension wealth variable. Compared to the earlier specification, the current setting offers the advantage that we can now make use of different sources of variation in financial incentives in order to identify the effects separately. Clearly, we need to make some assumptions in order to be able to compute the incentive measures. First, it should be noted that both early retirement and old-age pension benefits are *conditionally indexed*, that is, these benefits are adjusted annually in order to account for the inflation rate and the development of contractual wages, conditional on the pension fund's financial status. While computing financial incentive measures we assume full indexation of early retirement benefits, which is a realistic assumption for the period under consideration (1989–2000). Second, we assume that workers have worked sufficient number of years making them eligible for the full benefits as specified in tables 2.1 and 2.2. This assumption becomes essential in the absence of detailed employment histories of individuals.

Table 5.2 and 5.3 present the results with the peak value (equation (4.3)) and the option value measures (equation (4.1)), respectively. For the latter measure we assume the marginal utility of income to fall with consumption; to be precise $\gamma = 0.75$ (see equation (4.2)). The relative valuation of leisure parameter (k) is set equal to 1.7, and the individual discount rate (ρ) equals 4%.¹⁷ The same discount rate is used for the calculation of pension wealth, and mortality rates are obtained from the life table that is used by all large insurance companies in the Netherlands.

[insert table 5.2 here]

[insert table 5.3 here]

Both specifications of the model yield a clear wealth effect as the coefficient of the variable *pension wealth* is significantly larger than zero. So, a larger pension wealth induces workers to retire at a younger age. Furthermore, both specifications yield a clear price effect as well. The parameters for both the *option value* and the *peak value*, are significantly negative, which is consistent with theory. A financial reward to delay early retirement, in the form of a higher benefit level in case of postponement, induces workers to continue working. Most parameters continue to be similar to the estimates of the preceding section. A remarkable change however is that the baseline hazard now continues to increase after age 61. The propensity to retire increases with age, which is in line with, for example, decreasing health with age.¹⁸

In order to interpret the estimated coefficients we may translate these into marginal effects ξ_k as follows (for variable x_k):

$$(6.1) \xi_k = \frac{\partial \xi}{\partial x_k} = \frac{\partial(10 - E[T])}{\partial x_k} = - \frac{\partial E[T]}{\partial x_k},$$

where ξ denotes the individual's expected time spent in early retirement (measured in years). Details on the exact computation of ξ_k are provided in appendix B. Measuring x_k in 100,000s of euro, we compute marginal effects at sample average values for the *peak value* and *option value* at 0.67 and 0.62,

¹⁷ We experimented with different parameter values. Within the ranges mentioned in footnote 14 there was not much variation in the results.

¹⁸ According to the testing procedure for non-nested models proposed by Vuong (1989), the peak value and the option value model perform about equally well: the concerning test statistic is not statistically significant at a five percent significance level. The two models with financial variables are however outperformed by the model with the dummy indicator variables as the test statistic gives a highly statistically significant outcome in favour of the latter model.

respectively. Thus, increasing the *peak value* with 100,000 euros¹⁹ would induce the average worker to extend his career by about 8 months ($\approx 0,67 \cdot 12$). The marginal effect of an increase in *pension wealth* with 100,000 euros is estimated at -0.39 and -0.47, respectively, depending on which specification is used. Decreasing *pension wealth* with 100,000 euros would induce the average worker to extend his career by 5 to 6 months. Stated differently, the average worker would extend his working life by one year either if he receives about 150,000 euros extra paid out in wages (price effect), or if his pension wealth is decreased by about 250,000 euros (wealth effect). Thus, the early retirement decision is more sensitive to changes in the price of leisure than to changes in an individual's pension wealth. This could be expected, since wealth changes may equally affect the demand of other goods besides leisure.

6. Conclusion

In this study, we estimate the causal impact of financial incentives on early retirement behaviour in the Netherlands. We exploit the variation in the starting dates of the transitional arrangements from actuarially unfair schemes to more actuarially fair schemes. It is important to note that the reforms could not be evaded by the individual worker so that the so-called anticipation effects do not hamper our analysis: Every age-cohort faced a pre-determined retirement program and no worker had the possibility to retire with the old scheme prior to the introduction of the new regime in anticipation of harsher retirement benefits. Second, the reforms, which took place earlier in the government and education sectors than in other sectors, can be considered as an exogenous shock. The reason is that it was driven by the government's policy to cut back expenditures, and not by worker preferences. The dataset we use for this purpose, the Dutch Income Panel 1989–2000, is based on administrative records of the Dutch National Tax Office. Estimating hazard rate models for early retirement, we find that the policy reforms have induced workers to postpone early retirement.

The reform of the Dutch early retirement system causes major changes in the individual early retirement rights. First, the actuarial adjustments in the new schemes introduce a price effect as the price for leisure becomes 'more fair'. Second, the new schemes entail lower early retirement wealth which potentially leads to a wealth effect, i.e. less resources to purchase leisure time. By modelling the exact financial incentives and using them in our empirical model specification, we try to disentangle the empirical relevance of these two effects. According to our estimates, an increase in the peak value of 100,000 euros would make the average worker extend his career by 8 months,²⁰ while a decrease in his early retirement wealth by the same amount would induce a career extension of 5 months. A third change

¹⁹ Note that the peak value is measured in terms of net future cash flows, viz. equation (A.1). An additional incentive of 100,000 euros thus equals about 3 to 4 net year salaries of the average worker (compare table 3.1 which reports average gross salaries).

²⁰ The peak value is defined as a worker's increase in lifetime wealth if he decides to continue working for one year (see section 4).

in the early retirement schemes was the possibility to retire at an earlier age than under the old scheme. That is, an incentive to continue working until the eligibility age was removed. We however did not find any evidence that this has led to an increased use of the early retirement scheme at younger ages. All in all, we conclude that the policy reform was effective in increasing the labour supply of the elderly.

As early retirement will retain its place of importance on the policy agenda, more research to answer some open questions is needed. First of all, better data obtained by merging information on individual early retirement and pension rights with administrative data from the Dutch National Tax Office will largely rule out possible problems due to measurement error. This will help to get a better identification of the price and wealth effects in early retirement behaviour. Second, behavioural aspects are likely to be important. Therefore, the incorporation of behavioural elements into the empirical analysis of early retirement is still a major challenge for the future.

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Appendix

A. Early retirement schemes and individual behaviour

In this appendix we write out the financial incentives faced by the worker in two extreme types of retirement schemes: one with full actuarial adjustments across different retirement ages and one without any actuarial adjustments.

From the viewpoint of the individual, early retirement schemes can be characterised by only a few parameters. First, in order to receive ‘pension wealth’ P at a given age t_0 , individuals are required to fulfil certain eligibility conditions. These conditions usually include an employment constraint and work history requirements. The latter is obviously a natural condition in the case of capital funded schemes. Second, retirement at a higher age than t_0 alters pension wealth by p_t at time t ($t \geq t_0$). We define p_t here as the *net increment* in pension wealth as a result of an additional year of work at age t . Values for p_t may both be positive or negative, and are typically close to zero in case of an actuarially fair early retirement scheme. A deviation from zero may be caused by differing discount rates of individuals and pension funds; see the end of this section. Both ‘pension wealth’ P and the net increment in pension wealth p_t are important for early retirement behaviour. We illustrate this with two simple hypothetical early retirement schemes: one flat-rate early retirement scheme, and one actuarially fair scheme. For ease of exposition, we only focus on early retirement benefits in this section. In the empirical analysis (section 4) the old-age pension benefits are also taken into account.

Consider the individual’s behaviour in the extreme case of a flat-rate early retirement scheme with eligibility age t_A . That is, the replacement rate – pension income as a fraction of labour income²¹ – does

²¹ Several definitions for ‘labour income’ are used in practice; e.g. the ‘final pay’ system uses the last observed labour income, while ‘average pay’ uses the lifetime average labour income. In the following we will assume a final pay scheme, but results can be easily generalised to an average pay scheme or combinations of both types of schemes.

not depend on retirement age, and always equals r_A . Assume that the wage profile $\{w_t\}$ is unaffected by characteristics of the early retirement scheme and the individual's timing of retirement. In this scheme, pension wealth at eligibility age t_A simply equals the product of benefits, the number of time periods until old-age pension, and a discount factor. Denoting by t_p the age at which the old-age pension starts, and by $\beta_{st} := (1+\rho)^{-(s-t)}$ the individual's discount factor for age s , we thus have

$$(A.1) \quad P_A = \sum_{s=t_A}^{t_p-1} \beta_{st} r_A w_{t_A-1} = \bar{\beta} r_A w_{t_A-1}$$

where some composite discount factor $\bar{\beta}$ is used on the right-hand side. Furthermore, it is easily checked that retirement after the eligibility age results in a reduction in pension wealth. To be precise, for $t \geq t_A$ we have

$$(A.2) \quad \begin{aligned} p_t &= \sum_{s=t+1}^{t_p-1} \beta_{st} r_A w_t - \sum_{s=t}^{t_p-1} \beta_{st} r_A w_{t-1} = -r_A w_{t-1} + \sum_{s=t+1}^{t_p-1} \beta_{st} r_A (w_t - w_{t-1}) \\ &= -r_A w_{t-1} + \bar{\beta}_t r_A (w_t - w_{t-1}) \end{aligned}$$

where again some composite individual discount factor $\bar{\beta}$ is used. Hence for a nearly constant wage rate ($w_t \approx w_{t-1}$) the implicit tax on continued work simply equals a year's early retirement benefits ($p_t \approx -r_A w_t$). In the more general case of non-constant wages in (A.2) an extra term is added representing potential gains (losses) stemming from the fact that early retirement benefits are based on the last observed wage rate. That is, individuals with an increasing wage profile experience a lower disincentive to continue working than individuals with a constant wage rate.

The option value measure $G(t)$ of (4.1) discounts the losses due to the future implicit taxes on continued work and takes into account potential future changes in wages. The peak value measure $H(t)$ in (4.3) does not take the potential future changes in wages into account and can be directly computed from (A.2),

$$(A.3) \quad H(t) = \max_{\tau \in \{t, \dots, t_p\}} \left\{ \sum_{s=t}^{\tau-1} p_s \right\},$$

where we define $\sum_{s=t}^{t-1} p_s = 0$. Clearly, for the current case of a flat-rate early retirement scheme the peak value measure implies that the optimal timing of retirement τ^* equals the current time t , for which $H(t)=0$.

Next, assume that the pension fund adjusts replacement rates according to some discount factor δ , so that from its own viewpoint the scheme is actuarially fair and pension wealth P remains constant over time. Denoting by r_t the replacement rate given that the (early) retirement age is t , and defining $\eta_{st} := (1+\delta)^{-(s-t)}$, we have

$$(A.4) \quad \sum_{s=t+1}^{t_p-1} \eta_{st} r_{t+1} w_t - \sum_{s=t}^{t_p-1} \eta_{st} r_t w_{t-1} = 0.$$

Empirical evidence suggests that an important share of individuals do have a discount rate which is significantly higher than that used by pension funds (Samwick, 1998; Gustman and Steinmeier, 2005). For this reason, even in the case of actuarial fairness from the viewpoint of the pension fund, pension wealth P may not be constant over all retirement ages, and the net increment in retirement wealth p_t may not be equal to zero. Hence, we write the net increment as

$$(A.5) \quad \begin{aligned} p_t &= \sum_{s=t+1}^{t_p-1} \beta_{st} r_{t+1} w_t - \sum_{s=t}^{t_p-1} \beta_{st} r_t w_{t-1} \\ &= -r_t w_{t-1} + \sum_{s=t+1}^{t_p-1} \beta_{st} (r_{t+1} w_t - r_t w_{t-1}) \end{aligned}$$

Finally, rewriting (A.4) as $r_t w_{t-1} = \bar{\eta}_t (r_{t+1} w_t - r_t w_{t-1})$ and substituting this expression into (A.5) gives

$$(A.6) \quad p_t = \left(\frac{\beta_t}{\bar{\eta}_t} - 1 \right) r_t w_{t-1}.$$

Hence, if the individual discount factor precisely equals the discount factor used by the pension fund ($\rho=\delta$), then $p_t=0$ for all $t \geq t_0$, which is equivalent to stating that the pension scheme is actuarially neutral. In this case, the peak value equals zero, $H(t) = 0$, but the option value measure $G(t)$ still depends on future wages. The latter is precisely in line with the criticism of Coile and Gruber (2000) mentioned in section 4.2. However, if the individual discount rate exceeds the discount rate of the pension fund, then generally $\beta_t < \bar{\eta}_t$, so that $p_t < 0$ and $H(t) \leq 0$, i.e. the peak value indicates that working longer leads to a loss in pension wealth.

B. Computation of marginal effects

In this appendix we show how the estimated coefficients of the hazard model can be translated into marginal effects. The coefficients of the hazard model are gathered in the vector β (see equation (4.5)) and may contain financial incentive measures such as the peak value, option value, and pension wealth.

Given some early retirement hazard rate $\lambda(t)$, it is standard to show that the corresponding probability for retirement at time t is given by²²

$$(B.1) \quad f_0(t) = \lambda(t) \prod_{s=0}^{t-1} (1 - \lambda(s)).$$

It is however possible that workers make use of alternative exit routes, such as Disability Insurance (DI). Denote the DI hazard rate at time t by $\mu(t)$. Equation (B.1) then generalises to

$$(B.2) \quad f(t) = \lambda(t) \prod_{s=0}^{t-1} (1 - \lambda(s) - \mu(s)).$$

Now, the probability that the individual retires at time t conditional on retirement through the official early retirement scheme equals

$$(B.3) \quad g(t) = \frac{f(t)}{\sum_{s=0}^{10} f(s)},$$

so that the expected period spent in early retirement equals

$$(B.4) \quad \xi = 10 - \frac{\sum_{t=0}^{10} tf(t)}{\sum_{t=0}^{10} f(t)}.$$

²² This is the discrete time analogue of equation (2.4) on p. 9 in Lancaster (1990).

Although not shown explicitly in the current notation, λ and f are still conditional on a vector of exogenous variables x (compare equation (4.5)). Hence, the change in ξ resulting from a marginal change in the variable x_k equals

$$(B.5) \quad \xi_k = \frac{\partial \xi}{\partial x_k} = - \frac{\partial}{\partial x_k} \left(\frac{\sum_{t=0}^{10} t f(t)}{\sum_{t=0}^{10} f(t)} \right).$$

Using equation (B.2), this quantity can be computed for each individual using numerical differentiation. A straightforward estimator of ξ_k is then simply the average of all individual values for ξ_k . The DI hazard rates used in equation (B.2) are obtained from aggregate statistics.

Tables and figures

Table 2.1 Early retirement replacement rates for 8 selected sectors, 1989–2000^a

| Date of retirement | Date of birth | Retirement age | | | | | | | | | |
|---|-----------------|----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| | | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 |
| National government, education (ABP) | | | | | | | | | | | |
| < April 1, 1992 | | 0% | 0% | 0% | 0% | 0% | 80% | 80% | 80% | 80% | 80% |
| April 1992 – April 1993 | | 0% | 0% | 0% | 0% | 0% | 0% | 80% | 80% | 80% | 80% |
| May 1993 – March 1997 | | 0% | 0% | 0% | 0% | 0% | 0% | 75% | 75% | 75% | 75% |
| ≥ April 1, 1997 | < April 1, 1942 | 27% | 30% | 35% | 40% | 48% | 59% | 75% | 75% | 75% | 75% |
| | ≥ April 1, 1942 | 25% | 28% | 32% | 38% | 45% | 55% | 70% | 70% | 70% | 70% |
| Local government (ABP) | | | | | | | | | | | |
| < June 1, 1993 | | 0% | 0% | 0% | 0% | 80% | 80% | 80% | 80% | 80% | 80% |
| June 1993 – Dec. 1994 | | 0% | 0% | 0% | 0% | 75% | 75% | 75% | 75% | 75% | 75% |
| Jan. 1995 – March 1997 | | 0% | 0% | 0% | 0% | 0% | 75% | 75% | 75% | 75% | 75% |
| ≥ April 1, 1997 | < April 1, 1942 | 27% | 30% | 35% | 40% | 48% | 59% | 75% | 75% | 75% | 75% |
| | ≥ April, 1 1942 | 25% | 28% | 32% | 38% | 45% | 55% | 70% | 70% | 70% | 70% |
| Health care (PGGM) | | | | | | | | | | | |
| < January 1, 1999 | | 0% | 0% | 0% | 0% | 0% | 80% | 80% | 80% | 80% | 80% |
| ≥ January 1, 1999 | in 1939 | - | - | - | - | 40% | 80% | 80% | 80% | 80% | 80% |
| | in 1940 | - | - | - | 40% | 40% | 79% | 79% | 79% | 79% | 79% |
| | in 1941 | - | - | 0% | 39% | 39% | 78% | 78% | 78% | 78% | 78% |
| | in 1942 | - | 0% | 0% | 39% | 39% | 77% | 77% | 77% | 77% | 77% |
| | in 1943 | 0% | 0% | 0% | 38% | 38% | 76% | 76% | 76% | 76% | 76% |
| | in 1944 | 0% | 0% | 0% | 38% | 38% | 75% | 75% | 75% | 75% | 75% |
| Post/telecom (TPG/KPN) | | | | | | | | | | | |
| Full period | | 0% | 0% | 0% | 0% | 0% | 0% | 80% | 80% | 80% | 80% |
| Agriculture (BPL) | | | | | | | | | | | |
| Full period ^b | | 0% | 0% | 0% | 0% | 80% | 80% | 80% | 80% | 80% | 80% |
| Catering industry (PHC) | | | | | | | | | | | |
| Full period | | 0% | 0% | 0% | 80% | 80% | 80% | 80% | 80% | 80% | 80% |
| Cleaning industry (BPSG) | | | | | | | | | | | |
| Full period ^b | | 0% | 0% | 0% | 0% | 0% | 80% | 80% | 80% | 80% | 80% |

^a We select industry sectors for which (i) workers can be identified on the basis of their industrial sector code (SBI) in the dataset that we will use, and (ii) for which we are able to construct the early retirement replacement rates. Arrangements for workers born after 1945 are not reported, as these are irrelevant for our analysis. Replacement rates are constant over time from the moment of early retirement until age 65. Names of pension funds are reported between parentheses. Note that only seven early retirement schemes are presented, as the national government and education sectors share the same scheme.

^b Although not reported in this table, both the Agriculture and Cleaning industries changed their early retirement schemes between 1989 and 2000. However, these changes did not affect any person in the dataset that we will use, and are therefore omitted.

Table 2.2 Old-age pension replacement rates for 8 selected sectors, 1989–2000^a

| Date of retirement | Franchise ^b | Retirement age | | | | | | | | | | |
|---|------------------------|----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| | | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 |
| National government, education (ABP) | | | | | | | | | | | | |
| < April 1, 1992 | 15 250 ^c | 53% | 54% | 56% | 58% | 60% | 70% | 70% | 70% | 70% | 70% | 70% |
| April 1992 – March 1997 | 15 250 ^c | 53% | 54% | 56% | 58% | 60% | 61% | 70% | 70% | 70% | 70% | 70% |
| ≥ April 1, 1997 | 15 250 ^c | 53% | 54% | 56% | 58% | 60% | 61% | 63% | 65% | 67% | 68% | 70% |
| Local government (ABP) | | | | | | | | | | | | |
| < January 1, 1995 | 15 250 ^c | 53% | 54% | 56% | 58% | 70% | 70% | 70% | 70% | 70% | 70% | 70% |
| Jan. 1995 – March 1997 | 15 250 ^c | 53% | 54% | 56% | 58% | 60% | 70% | 70% | 70% | 70% | 70% | 70% |
| ≥ April 1, 1997 | 15 250 ^c | 53% | 54% | 56% | 58% | 60% | 61% | 63% | 65% | 67% | 68% | 70% |
| Health care (PGGM) | | | | | | | | | | | | |
| Full period | 13 580 ^d | 53% | 54% | 56% | 58% | 60% | 70% | 70% | 70% | 70% | 70% | 70% |
| Post/telecom (TPG/KPN) | | | | | | | | | | | | |
| Full period | 15 881 ^e | 53% | 54% | 56% | 58% | 60% | 61% | 70% | 70% | 70% | 70% | 70% |
| Agriculture (BPL) | | | | | | | | | | | | |
| Full period | 13 739 ^e | 53% | 54% | 56% | 58% | 70% | 70% | 70% | 70% | 70% | 70% | 70% |
| Catering industry (PHC) | | | | | | | | | | | | |
| Full period | 0 ^e | 14% | 15% | 15% | 19% | 19% | 19% | 19% | 19% | 19% | 19% | 19% |
| Cleaning industry (BPSG) | | | | | | | | | | | | |
| Full period | 0 ^e | 9% | 9% | 10% | 10% | 10% | 12% | 12% | 12% | 12% | 12% | 12% |

^a See note a in table 3.1.

^b The franchise serves as a threshold in the calculation of the supplementary occupational pension benefits. Individuals only build up old-age pension if their wage exceeds the franchise. In this way pension funds take into account the state pension that individuals receive.

^c In 2004.

^d In 2003.

^e In 2002. A zero franchise together with a replacement rate of 19% implies that an individual receives 19% of his last earned wage income plus a state pension. With a nonzero franchise, the individual only receives an 'additional' pension benefit if his (past) wage income exceeds a certain threshold level. 'Additional' here means 'supplementary to the state pension'. Thus, the first case in general leads to higher pension benefits for lower incomes.

Table 3.1 Sample statistics of workers in 7 selected industry sectors at age 55, 1989–2000

| | government | education | health care | post/telecom | agriculture | catering | cleaning | Total |
|--------------------------------------|------------|-----------|-------------|--------------|-------------|----------|----------|-------|
| Observations | 1232 | 741 | 445 | 224 | 172 | 71 | 52 | 2937 |
| Individual characteristics | | | | | | | | |
| Female | 0.13 | 0.26 | 0.50 | 0.12 | 0.10 | 0.24 | 0.31 | 0.22 |
| Single | 0.09 | 0.09 | 0.14 | 0.04 | 0.07 | 0.10 | 0.12 | 0.09 |
| Children ($\leq 18y$) | 0.12 | 0.23 | 0.16 | 0.16 | 0.31 | 0.25 | 0.31 | 0.17 |
| Financial characteristics | | | | | | | | |
| Gross wage ($\times \text{€}1000$) | 42.00 | 48.37 | 36.87 | 34.51 | 34.90 | 37.95 | 28.30 | 41.50 |
| High income ^a | 0.75 | 0.81 | 0.54 | 0.79 | 0.53 | 0.58 | 0.42 | 0.71 |
| House value ^b | 1.65 | 2.00 | 2.02 | 2.05 | 1.75 | 1.14 | 0.89 | 1.76 |
| Mortgage ^b | 1.06 | 1.28 | 0.94 | 0.97 | 0.58 | 0.68 | 0.27 | 1.02 |

^a Dummy which equals 1 if income is higher than the Dutch median income.

^b Relative to yearly income.

Source: Dutch Income Panel (Statistics Netherlands), 1989–2000, own calculations.

Table 3.2 Number of observations per regime, workers in 7 selected industry sectors, 1989–2000

| Industry sector | Start of transition | VUT ^a | Both ^b | Transition ^c | Total |
|---------------------------------|---------------------|------------------|-------------------|-------------------------|-------|
| Government (ABP) | April 1997 | 356 | 564 | 312 | 1232 |
| Education (ABP) | April 1997 | 116 | 412 | 213 | 741 |
| Health care (PGGM) ^d | January 1999 | 147 | 298 | 0 | 445 |
| Post/telecom (TPG/KPN) | - | 224 | | | 224 |
| Agriculture (BPL) | - | 172 | | | 172 |
| Catering industry (PHC) | - | 71 | | | 71 |
| Cleaning industry (BPSG) | - | 52 | | | 52 |
| Total | | 1138 | 976 | 525 | 2937 |

^a Generous flat-rate early retirement scheme (see section 2.1)

^b Individuals may first face a VUT scheme, but then from a certain date onwards they may a transitional arrangement (see section 2.4)

^c Transitional arrangement to less generous and actuarially fair early retirement scheme (see section 2.3)

^d Note that the transitional arrangement of the health care sector is highly actuarially unfair (table 2.1).

Source: Dutch Income Panel (Statistics Netherlands), 1989–2000, own calculations.

Table 5.1 Estimation results, model specification with dummy variables

| Variable | Estimate ^a | Std. error ^b | Variable | Estimate ^a | Std. error ^b |
|------------------------|-----------------------|-------------------------|--|-----------------------|-------------------------|
| Baseline hazard | | | Industry sectors | | |
| Age 55 | - 4.87 * | (0.58) | Gov/Edu (ABP) | 1.02 * | (0.29) |
| Age 56 | - 4.84 * | (0.62) | Post/telecom | 2.19 * | (0.34) |
| Age 57 | - 4.29 * | (0.61) | Agriculture (BPL) | 1.24 * | (0.35) |
| Age 58 | - 4.63 * | (0.62) | Catering (PHC) | 0.01 | (0.42) |
| Age 59 | - 4.08 * | (0.62) | Cleaning (BPSG) | - 0.98 | (0.70) |
| Age 60 | - 2.85 * | (0.60) | | | |
| Age 61 | - 1.95 * | (0.90) | Indiv. charact. | | |
| Age 62 | - 2.42 * | (1.02) | Single woman | - 0.09 | (0.28) |
| Age 63 and 64 | - 2.70 * | (1.07) | Single man | 0.16 | (0.24) |
| | | | Non-single woman | - 0.27 | (0.20) |
| Year dummies | | | Children | - 0.28 * | (0.13) |
| 1990 | 0.20 | (0.50) | High income | 0.60 * | (0.15) |
| 1991 | - 0.36 | (0.49) | Mortgage debt | 0.01 | (0.03) |
| 1992 | 0.50 | (0.45) | House value | - 0.07 * | (0.03) |
| 1993 | 0.26 | (0.45) | | | |
| 1994 | 0.10 | (0.45) | Incentive variables^c | | |
| 1995 | 0.22 | (0.45) | Incentive to retire | 2.28 * | (0.29) |
| 1996 | - 0.27 | (0.45) | Incentive to wait | - 0.08 | (0.21) |
| 1997 | 0.01 | (0.47) | | | |
| 1998 | - 0.31 | (0.48) | Heterogeneity | | |
| 1999 | - 0.07 | (0.48) | α | 0.46 * | (0.05) |
| | | | η | - 2.56 * | (0.68) |
| Statistics | | | | | |
| Number of observations | | 2937 | | | |
| Log-likelihood | | - 1924.86 | | | |

^a Reference groups: health care (PGGM), 1989, pre-pension scheme, non-single man, no high income.

^b Variables marked with * are significant at the 5% significance level.

^c The dummy variable *incentive to retire* is defined as being eligible for a flat-rate early retirement benefit, while the dummy variable *incentive to wait* is defined as not yet being eligible for an early retirement benefit.

Source: Dutch Income Panel (Statistics Netherlands), 1989–2000, own calculations

Table 5.2 Estimation results, model specification with peak value

| Variable | Estimate ^a | Std. error ^b | Variable | Estimate ^a | Std. error ^b |
|------------------------|-----------------------|-------------------------|-----------------------------|-----------------------|-------------------------|
| Baseline hazard | | | Industry sectors | | |
| Age 55 | - 3.91 * | (0.50) | Gov/Edu (ABP) | 0.13 | (0.22) |
| Age 56 | - 3.90 * | (0.54) | Post/telecom | 1.22 * | (0.27) |
| Age 57 | - 3.40 * | (0.55) | Agriculture (BPL) | 0.73 * | (0.31) |
| Age 58 | - 3.69 * | (0.56) | Catering (PHC) | 0.21 | (0.36) |
| Age 59 | - 2.96 * | (0.56) | Cleaning (BPSG) | - 1.16 * | (0.60) |
| Age 60 | - 1.83 * | (0.54) | | | |
| Age 61 | - 0.19 | (0.57) | Indiv. charact. | | |
| Age 62 | 0.60 | (1.20) | Single woman | - 0.15 | (0.27) |
| Age 63 and 64 | 1.39 | (1.29) | Single man | 0.03 | (0.22) |
| | | | Non-single woman | - 0.53 * | (0.16) |
| Year dummies | | | Children | - 0.17 | (0.12) |
| 1990 | 0.31 | (0.50) | Mortgage debt | 0.02 | (0.02) |
| 1991 | - 0.24 | (0.49) | House value | - 0.07 * | (0.03) |
| 1992 | 0.59 | (0.45) | | | |
| 1993 | 0.45 | (0.45) | Financial variables | | |
| 1994 | 0.25 | (0.45) | Pension wealth ^c | 3.27 * | (0.76) |
| 1995 | 0.35 | (0.44) | Peak value ^d | - 5.66 * | (1.35) |
| 1996 | - 0.10 | (0.45) | | | |
| 1997 | - 0.20 | (0.46) | Heterogeneity | | |
| 1998 | - 0.65 | (0.46) | α | 0.27 * | (0.03) |
| 1999 | - 0.45 | (0.46) | η | - 4.14 * | (1.06) |
| Statistics | | | | | |
| Number of observations | | 2937 | | | |
| Log-likelihood | | - 1974.37 | | | |

^a Reference groups: health care (PGGM), 1989, pre-pension scheme, non-single man.

^b Variables marked with * are significant at the 5% significance level.

^c Pension wealth is the discounted value of future pension benefits (subsection 2.2). We assume an individual discount rate of 4%.

^d Peak value is the difference between total discounted pension wealth at its maximum expected value and its value if retirement occurs immediately (equation (4.3)).

Source: Dutch Income Panel (Statistics Netherlands), 1989–2000, own calculations.

Table 5.3 Estimation results, model specification with option value

| Variable | Estimate ^a | Std. error ^b | Variable | Estimate ^a | Std. error ^b |
|------------------------|-----------------------|-------------------------|-----------------------------|-----------------------|-------------------------|
| Baseline hazard | | | Industry sectors | | |
| Age 55 | - 3.77 * | (0.54) | Gov/Edu (ABP) | 0.23 | (0.22) |
| Age 56 | - 3.84 * | (0.58) | Post/telecom | 1.34 * | (0.27) |
| Age 57 | - 3.44 * | (0.57) | Agriculture (BPL) | 0.76 | (0.31) |
| Age 58 | - 3.81 * | (0.58) | Catering (PHC) | 0.23 * | (0.37) |
| Age 59 | - 3.14 * | (0.56) | Cleaning (BPSG) | - 1.06 * | (0.61) |
| Age 60 | - 2.04 * | (0.54) | | | |
| Age 61 | - 0.37 | (0.57) | Indiv. charact. | | |
| Age 62 | 0.31 | (1.09) | Single woman | - 0.09 | (0.27) |
| Age 63 and 64 | 1.04 | (1.16) | Single man | 0.01 | (0.22) |
| | | | Non-single woman | - 0.46 * | (0.16) |
| Year dummies | | | Children | - 0.18 | (0.12) |
| 1990 | 0.32 | (0.51) | Mortgage debt | 0.02 | (0.02) |
| 1991 | - 0.19 | (0.50) | House value | - 0.07 * | (0.03) |
| 1992 | 0.63 | (0.46) | | | |
| 1993 | 0.49 | (0.46) | Financial variables | | |
| 1994 | 0.28 | (0.45) | Pension wealth ^c | 3.96 * | (0.75) |
| 1995 | 0.37 | (0.45) | Option value ^d | - 0.35 * | (0.09) |
| 1996 | - 0.08 | (0.45) | | | |
| 1997 | - 0.18 | (0.47) | Heterogeneity | | |
| 1998 | - 0.63 | (0.47) | α | 0.27 * | (0.03) |
| 1999 | - 0.43 | (0.47) | η | - 3.95 * | (0.90) |
| Statistics | | | | | |
| Number of observations | | 2937 | | | |
| Log-likelihood | | - 1975.79 | | | |

^a Reference groups: health care (PGGM), 1989, pre-pension scheme, non-single man.

^b Variables marked with * are significant at the 5% significance level.

^c Pension wealth is the discounted value of future pension benefits (subsection 2.2). We assume an individual discount rate of 4%.

^d Option value is the difference between utility from delayed optimal retirement and immediate retirement (equation (4.1)). We assume $k = 1.7$ and $\gamma = 0.75$ (equation 2.5).

Source: Dutch Income Panel (Statistics Netherlands), 1989–2000, own calculations