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ABSTRACT

Early Retirement Behaviour in the Netherlands: Evidence from a Policy Reform*

In the early 1990s, the Dutch social partners agreed upon transforming the generous and actuarially unfair PAYG early retirement schemes into less generous and actuarially fair capital funded schemes. The starting dates of the transitional arrangements varied by industry sector. In this study, we exploit the 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 early retirement. We conclude that the policy reform induced workers to postpone early retirement. In particular, both the price effect (reducing implicit taxes) and the wealth effect (reducing early retirement wealth) are shown to have a positive impact on the early retirement age. Yet, we show that model specifications including the most commonly used financial incentive measures are open to further improvements, given that these are outperformed by a simple specification with dummy variables.

JEL Classification: C41, D91, J26

Keywords: early retirement, intertemporal choice, duration analysis

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1. Introduction

The Dutch labour force participation rate of elderly is low compared to other western countries. In 1990 the employment-to-population ratio for age 55 to 64 was 29.7 percent (OECD, 2005). 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. Although population ageing is less dramatic for the Netherlands than for many other countries, and although the capital funding of the occupational pensions makes the Dutch economy less vulnerable to ageing altogether, the low participation rate before the mandatory retirement age of 65 is an important policy issue. As a broad base of tax payers is necessary to bear the financial consequences of population ageing, increasing the labour force participation of the elderly has become an important policy issue in the Netherlands – as it is in many other countries.

In the early 1990s, the Dutch social partners (unions and employer organisations) recognised the adverse incentive effects of the prevailing early retirement schemes. They decided to transform the generous and actuarially unfair pay-as-you-go (PAYG) schemes into less generous and actuarially fair capital funded schemes. The starting dates of the transitional arrangements varied by industry sector. In this study, we exploit this variation in starting dates to estimate the causal impact of the reform on early retirement behaviour. Starting April 1, 1997, the participants of the pension fund for civil servants (ABP) were the first to face new early retirement conditions. By using employees of a selection of other industry sectors as a control group we are able to estimate to which extent financial incentives affect the (early) retirement decision.

The transitional arrangements to the new actuarially fair schemes cause major changes in the individual early retirement rights. First of all, employees can retire at a much younger age under the new schemes. The actuarial adjustments in the new schemes however introduce a ‘price effect’: a retiring employee will pay the ‘fair’ price for leisure, while under the old scheme its price was virtually zero. Or stated differently, in case an employee postpones early retirement he gets rewarded with a ‘fair’ wage instead of being subject to a high implicit tax rate. Secondly, the new schemes entail lower ‘early retirement wealth’, i.e. less financial resources for the purchase of leisure. This ‘income effect’ or ‘wealth effect’ potentially leads to a postponement of early retirement.

Many studies on the labour force participation of elderly have demonstrated that financial incentives are important for individual retirement behaviour. Gruber and Wise (1999, 2004) conclude this on the basis of country studies using a discounted measure for future social security and pension incomes. Within this project, Börsch-Supan *et al.* (2004) reach the conclusion using the German Socio-Economic Panel, Blundell *et al.* (2004) using the UK Retirement Survey, and De Vos and Kapteyn (2004) using the Dutch Socio-Economic Panel. Using an alternative data source, the Dutch Retirement Survey (CERRA), Kerkhofs *et al.* (1999) conclude that financial incentives are important for early retirement and to a lesser extent for alternative early retirement routes like unemployment and disability insurance. However, on the basis of the same data, Heyma (2001) concludes that the importance of financial incentives is limited for the different early retirement routes. 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, but that not more than half of the observed variation in retirement patterns in the US can be explained from these financial incentives.

In this study we are able to estimate the causal impact of the early retirement reform by exploiting the variation in starting dates of the transitional arrangements. It is important to note that although the reform could be foreseen, it could not be evaded by the individual worker so that so-called anticipation effects do not hamper our analysis. Every age-cohort faced a pre-determined transitional arrangement in which no individual worker had the possibility to retire with the old scheme before the new scheme became relevant for this worker. The dataset we use for the empirical part of our study, 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 reform induced workers to postpone early retirement.

In section 2 we address theoretical issues with respect to the retirement decisions of individuals. Early retirement schemes in the Netherlands are reviewed in section 3. Section 4 discusses the data, while section 5 presents the estimation results. In section 6 we investigate the goodness of fit of different model specifications. Section 7 concludes.

2. Theory

2.1 Modelling the retirement decision

The ‘standard’ textbook model assumes that individuals maximise their expected lifetime utility subject to a lifetime budget constraint. Consumption (C) and leisure (L) are the choice variables in this problem, the latter including the time spent in retirement. The individual’s optimal retirement date is implicit in the leisure time path, and is thus an outcome of the optimisation process. Denote the utility function by U, the level of assets by A, the individual discount rate by ρ, wage by w (when full-time employed), and the interest rate by r. Introducing dynamics through time subscripts for age t, a basic version of the inter-temporal model is

$$\text{(2.1a)}\quad W(A_t) = \max_{C_t, L_t} E_t[U_t(C_t, L_t) + (1+\rho)^{-1} W(A_{t+1})]$$

$$\text{(2.1b)}\quad A_{t+1} = (1+r_t)A_t + w_t(1-L_t) - C_t$$

Here W is the value function, and E_t takes the expectation at time t. Taking expectations at the right hand side of (2.1a) allows for randomness in the model, e.g. stochastic future wages. The most important derivations from this dynamic programming model (DP model) are the Euler equations which determine the optimal time paths for both consumption and leisure. Explicit solutions for the time paths do not exist unless some restrictive assumptions are made about the functional form of the utility function. A common – often realistic – assumption is that L can take on only two values, corresponding with either retirement (L = 1) or continued work (L = 0), and that retirement is irreversible. As a consequence of this assumption, the *retirement age* contains sufficient information to reconstruct the optimal leisure time path $L_t,\ldots,L_T$. Denote the retirement age by R, maximum age by T, and the discount factor for age s by $\beta_{st} := (1+\rho)^{-(s-t)}$. Then (2.1) implies that immediate retirement is optimal iff

$$\text{(2.2)}\quad E_t\left[\max_{C_s(s\geq t)}\left\{\sum_{s=t}^{T}\beta_{st}U_s(C_s,1)\right\}\right] > E_t\left[\max_{\substack{C_s(s\geq t),\\ R:R>t}}\left\{U_s(C_t,0) + \sum_{s=t+1}^{R-1}\beta_{st}U_s(C_s,0) + \sum_{s=R}^{T}\beta_{st}U_s(C_s,1)\right\}\right]$$

i.e. the expected lifetime utility given immediate retirement is higher than the expected lifetime utility given at least one extra period of continued work.

Several authors have estimated a parameterisation of (2.2), including generalised versions for households, and taking into account health, and liquidity constraints (e.g., Van der Klaauw and Wolpin, 2003; Blau, 2004; French, 2005; Gustman and Steinmeier, 2005). However, this approach is computationally very demanding, and therefore simplifying assumptions are often made. Rust (1989), Rust and Phelan (1997) and Heyma (2004) assume that households cannot borrow or save. This last assumption is equivalent to assuming that consumption at any time t equals income Y_t at time t. Hence, an important simplification of (2.2) is to write it in terms of some indirect utility function V rather than the direct utility function U, so that the decision to retire at age t follows

$$(2.3)\quad E_t\left[\sum_{s=t}^{T}\beta_{st}V_s(Y_s\mid t)\right] > E_t\left[\max_{R:R>t}\left\{V_t(Y_t\mid R)+\sum_{s=t+1}^{T}\beta_{st}V_s(Y_s\mid R)\right\}\right]$$

where $V(\cdot|R)$ denotes indirect utility conditional on retirement at age R. This specification is easier to use in practice as individual income is more easily observed than consumption and savings decisions.

In the option value model (Stock and Wise, 1990a; 1990b) rather than maximising expected lifetime utility (or indirect utility) an agent chooses the retirement date for which the expected utility is at its maximum, i.e. immediate retirement is optimal iff

$$(2.4)\quad \sum_{s=t}^{T}\beta_{st}E_tV_s(Y_s\mid t) > \max_{R:R>t}\left\{V_t(Y_t\mid R)+\sum_{s=t+1}^{T}\beta_{st}E_tV_s(Y_s\mid R)\right\}$$

In comparison with (2.3) the max and expectation-operators are interchanged. Equivalence between the two equations is only achieved if $t=T$, i.e. there is only one period to make a choice for. 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, and thus the option value of continued work is necessarily smaller than would be implied by the DP rule in (2.2). An alternative version of (2.4) is

$$(2.5)\quad G(t) := \max_{R:R>t}\left\{V_t(Y_t\mid R)+\sum_{s=t+1}^{T}\beta_{st}E_tV_s(Y_s\mid R)\right\} - \sum_{s=t}^{T}\beta_{st}E_tV_s(Y_s\mid t) < 0$$

where $G(t)$ is the option value of continued work, i.e. a negative value corresponds to immediate retirement being the optimal decision of the individual. In words, the option value gives the difference between the utility from delayed optimal retirement and immediate retirement. Denote by $B_s(R)$ the amount of cash flow to or from the pension fund at age s given retirement age R. A common specification for the expected indirect utility function is

$$(2.6)\quad E_tV_s(Y_s\mid R) = \begin{cases}\sigma_{st}[w_s]^{\gamma} & \text{if } s<R\\ \sigma_{st}[kB_s(R)]^{\gamma} & \text{if } s\geq R\end{cases}$$

where σ_{st} is the conditional survival probability (of reaching age s conditional on having reached age t), γ is the risk aversion parameter and k represents the relative valuation of leisure.

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 (2.5) 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).[5] This is equivalent to estimating the full option value model with fixed parameters, and deterministic wages and retirement income (Lumsdaine et al., 1992). Several authors have questioned whether going from the full DP model to the OV model in (2.5) 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 SSDI benefits in the United States), Burkhauser et al. (2003) even conclude that the OV model outperforms the DP 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

$$(2.7)\quad H(t) := \max_{R:R>t}\left\{\sum_{s=t}^{T}\beta_{st}E_t B_s(R)\right\} - \sum_{s=t}^{T}\beta_{st}E_t B_s(t)$$

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 (γ=1), and income in retirement has the same utility value as income before retirement (k=1). The peak value is usually not applied in a decision rule such as (2.2) to (2.5). More often the peak value (with fixed discount rate) is used as an explanatory variable in a reduced

[5] 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 (γ=0.63; ρ=0.22; k=1.25) of the full option value model obtained by Stock and Wise (1990a).

form probit model, just like the option value (with fixed parameters), see e.g., Coile and Gruber (2000), Asch et al. (2005).

2.2 Early retirement schemes

From the viewpoint of the individual, early retirement schemes can be characterised by only a few parameters. In the first place, individuals fulfilling certain eligibility conditions qualify for a certain amount of 'pension wealth' P at a given age t_0. The eligibility conditions usually include an employment constraint, and often work history requirements. The latter is obviously a natural condition in the case of capital funded schemes. Secondly, 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 often close to zero in case of an actuarially fair early retirement scheme.[6]

Both 'pension wealth' P and the net increment in pension wealth p_t may be important for early retirement behaviour. The importance of these variables does not obviously follow from the models of the previous subsection. The DP model of equation (2.2) does not lead to explicit expressions for the 'wealth' and 'price' effects induced by P and p_t, respectively. The effects are more easy to understand within the option value model of equation (2.5) and the peak value model of equation (2.7). We will 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 (see section 5) the old-age pension benefits will also be taken into account.

We 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 income[7] – does 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 benefits *times* the number of time periods until old-age pension *times* 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

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[6] Even for an actuarially fair early retirement scheme, p_t may however deviate from zero if the individual's discount rate is not equal to the discount rate employed by the pension fund. This discussion will be pursued at the end of this section.

[7] 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.

(2.8) $P_A = \sum_{s=t_A}^{t_P-1} \beta_{st_A} r_A w_{t_A-1} = \bar{\beta} r_A w_{t_A-1}$

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 loss in pension wealth. To be precise, for $t \geq t_A$ we have

$$p_t = \sum_{s=t+1}^{t_P-1} \beta_{st} r_A w_t - \sum_{s=t}^{t_P-1} \beta_{st} r_A w_{t-1} = -r_A w_{t-1} + \sum_{s=t+1}^{t_P-1} \beta_{st} r_A (w_t - w_{t-1}) \quad (2.9)$$
$$= -r_A w_{t-1} + \tilde{\beta}_t r_A (w_t - w_{t-1})$$

where again some composite individual discount factor $\tilde{\beta}$ is used. Hence for a nearly constant wage rate, i.e. $w_t \approx w_{t-1}$, we have

(2.10) $p_t \approx -r_A w_t$

This last equation clearly shows that in a flat-rate scheme the implicit tax on continued work simply equals a year's early retirement benefits. In the more general case of non-constant wages in (2.9) 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 equation (2.5) 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 equation (2.7) does not take the potential future changes in wages into account and can be directly computed from (2.9) or (2.10),

(2.11) $H(t) = \max_{\tau \in \{t,\ldots,t_P\}} \left\{ \sum_{s=t}^{\tau-1} p_s \right\},$

where we define $\sum_t^{t-1} p_s = 0.$ Clearly, for the current case of a flat-rate early retirement scheme 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

$$\text{(2.12)}\quad \sum_{s=t+1}^{t_P-1} \eta_{st} r_{t+1} w_t - \sum_{s=t}^{t_P-1} \eta_{st} r_t w_{t-1} = 0$$

which after some rearrangement gives

$$\text{(2.13)}\quad \begin{aligned} r_t w_{t-1} &= \left(\sum_{s=t+1}^{t_P-1} \eta_{st} \cdot \right) (r_{t+1} w_t - r_t w_{t-1}) \\ &= \tilde{\eta}_t (r_{t+1} w_t - r_t w_{t-1}) \end{aligned}$$

There is some empirical evidence suggesting 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

$$\text{(2.14)}\quad \begin{aligned} p_t &= \sum_{s=t+1}^{t_P-1} \beta_{st} r_{t+1} w_t - \sum_{s=t}^{t_P-1} \beta_{st} r_t w_{t-1} \\ &= -r_t w_{t-1} + \sum_{s=t+1}^{t_P-1} \beta_{st} (r_{t+1} w_t - r_t w_{t-1}) \end{aligned}$$

Finally, substituting (2.13) in (2.14) and rearranging gives

$$\text{(2.15)}\quad p_t = \left(\frac{\tilde{\beta}_t}{\tilde{\eta} t} - 1 \right) r_t w_{t-1}.$$

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 earlier mentioned criticism of Coile and Gruber (2000).

However, if the individual discount rate exceeds the discount rate of the pension fund, then generally $\tilde{\beta}_t < \tilde{\eta}_t$, so that p_t<0 and $H(t)$≤0, i.e. the peak value indicates that working longer leads to a loss in pension wealth.

3. Early retirement schemes in the Netherlands

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 all Dutch inhabitants are entitled to a state pension. In addition most employees are entitled to a supplementary occupational pension.[8] Before age 65 early retirement schemes apply.

Early retirement schemes have started since the mid-seventies of the past century. The first schemes, the so-called 'VUT schemes',[9] operated as PAYG systems in which the working population pays for the retirement of early retirees. The schemes were favourable for older workers, and the eligibility conditions were rather mild. In the 1990s concerns grew about the adverse incentive effects and the long run financial sustainability of the prevailing VUT schemes. A general agreement was reached between the *social partners* (trade unions and employer organisations) and the government to reform the system. The PAYG-based VUT schemes were gradually replaced by capital funded 'pre-pension' (PP) schemes. These new early retirement schemes introduce actuarial adjustments across different retirement ages. Moreover, the early retirement wealth is lower in the new schemes.

In the Netherlands, early retirement rules are negotiated between unions and employer organisations at the sectoral level of industry. Together with the other terms of employment, the early retirement rules are laid down in collective labour agreements. The administration of the early retirement schemes is the responsibility of pension funds, special 'early retirement funds', or insurance companies, whereby large sectors of industry as well as a number of large enterprises have their own pension fund. In most cases early retirement benefits are *conditionally indexed*, that is, ER benefits are indexed with respect to both the inflation rate and the development of contractual wages, conditional on the pension fund's financial status.[10] While computing a financial incentive measure in later sections we will assume full indexation of ER benefits, which is a realistic assumption for the period under consideration (1989–2000).

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[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'.

[10] The same applies to occupational old-age pensions.

3.1 Flat-rate early retirement schemes

From the late 1970s on, early retirement schemes were agreed upon in many collective agreements and consequently installed in many sectors of industry. A typical feature of these schemes was its flat rate, i.e. the replacement rate does not depend on retirement age. The eligibility age was decreased several times in most sectors and at the end of the eighties it was age 60 or 61 for the majority of the employees. The schemes were a shared responsibility of the social partners, 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 (Kooiman *et al.*, 2004).

The financial conditions of these 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, this clearly gave a great incentive to retire at exactly the eligibility age. This is well documented in, e.g., Lindeboom (1998) and Kapteyn and de Vos (1999).

3.2 Actuarially adjusted early retirement schemes

From the mid 1990s on, the flat-rate early retirement schemes are being replaced by actuarially adjusted 'Pre-pension' (PP) schemes. The capital funded PP schemes are collective (mandatory) savings arrangements in which workers make savings for their own early retirement. A major difference between the flat-rate and PP schemes is the funding which changed from PAYG to capital funding. From the point of view of the individual worker, the funding is however hardly relevant (except that he may be concerned about the long-run financial sustainability of the early retirement scheme), as he is mainly interested in the financial consequences of the choices he is able to make.

Under a PP scheme, an employee is eligible to receiving the maximum benefit only if he has 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*. A further difference between both schemes is that the early retirement wealth is considerably lower in the new scheme. In a sample of 105 collective labour agreements, the Labour Inspectorate (2004) finds that in most collective labour agreements the gross replacement rate at a given retirement age was decreased by at least 10%-points. Second, the old age pension rights no longer continued to increase during early retirement, as was the case under the flat-rate schemes.

An important ‘price effect’ is caused by the introduction of actuarial adjustments into the PP schemes. Compared to an old flat-rate scheme, where the price of leisure was nearly zero (compare eq. (2.10)), this implies that the price of leisure has risen substantially. Most PP schemes are actuarially fair and allow taking up early retirement benefits from the age of 55 on. Thus, compared to the eligibility age in the flat-rate schemes, actuarial adjustments are made both to higher and lower retirement ages. This aspect may induce employees to retire either before or after this former eligibility age.

3.3 Transitional arrangements

Transitional arrangements were introduced in order to smooth the transition from flat-rate schemes to actuarially adjusted schemes. These transitional arrangements were partly financed by PAYG and partly by capital funding. In practice, this meant that most older workers continued to face early retirement arrangements that were close to the old schemes. An exception was the pension fund of civil servants (ABP), which started reforming their early retirement schemes relatively early, and introduced some actuarial adjustments into their schemes from 1997 on. Civil servants who retired after April 1, 1997 and who were born before April 1, 1942 faced a replacement rate of 59% at age 60, while those who were born later receive 55%. This contrasts conditions from before April 1992, when 80% was received at this age (or, for civil servants of local governments this replacement rate was even received at age 59).

Table 3.1 shows the replacement rates in early retirement schemes in eight included industry sectors for the period 1989–2000. In four sectors, the early retirement replacement rates have not changed during this period. For some sectors the transition officially started during the period, but the transitional arrangement guaranteed the same replacement rate as in the old flat-rate scheme. None of the included sectors has a transitional arrangement which is completely actuarially fair, so that postponement of retirement until the age of 65 was still discouraged. Note that the national government and education sectors share the same early retirement schemes, and that both these sectors together with the local government have their early retirement schemes administered by the pension fund ABP. This pension fund has actuarially fair schemes, but only until the age of 61.[11]

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

Workers build up a complete old-age pension by contributing 35 or 40 years to a pension fund. Under the flat-rate schemes, early retirees continued to build up old-age pension rights. Under the PP schemes this is no longer the case, implying that most early retirees are not able to build up a complete old-age pension. Table 3.2 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 discussed in section 2. Note that the low replacement rates for the catering and cleaning industries do not necessarily imply lower pension benefits, as the franchise equals zero (see note e in table 3.2).

[insert table 3.1 here]

[insert table 3.2 here]

4. Data

4.1 The IPO dataset

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 subsample 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 permanently 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 3.1.[12] 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 3.1 and 3.2 as the industry sector codes do not allow us to differentiate between national and local government. In the empirical analysis (see section 5) we will therefore assume that a civil servant works at the national government with a given probability.

Our sample of individuals who are employed at age 55 contains mainly men, only 22% of the sample is female (table 4.1). 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. This is in line with the prevailing system of seniority wages and the principles of the life cycle model (see section 2), respectively. About 71% earns more than the Dutch median income. 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 4.1 here]

[12] The selected pension funds cover about 40% of all employees in the Netherlands aged between 25 and 65.

4.2 Sample size and measurement

For a proper measurement of the effect of the reform it is important to have sufficient numbers of observations under the different early retirement schemes. Of the 1232 observations in the government sector, 356 observations fall under the old scheme and 312 observations fall under the new scheme (table 4.2). The other 564 observations fall under both schemes as at age 55 they are not eligible to any early retirement benefit, while on April 1, 1997 they suddenly become eligible for a benefit without having reached the earlier eligibility age of 61. 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 (table 3.1).

[insert table 4.2 here]

As the regulations of the different early retirement schemes change at different points in time during our observational period, a descriptive analysis on the basis of aggregated data is not straightforward. The major change in the regulations is however on April 1, 1997, so that we may be able to see some change in early retirement behaviour for the civil servants after that date. In fact, we use the participants of the pension funds other than ABP as a control group. It should be noted that the two most important pension funds in our control group concern workers in the health sector and the post and telecom sector, which are presumably the sectors which can best be compared with workers who are subject to the 'treatment pension fund' ABP.[13] However, we will make a special effort in the next section to take account of both observed and unobserved heterogeneity of workers in different sectors.

The conditional early retirement probability, or *hazard rate,* of the participants of the pension funds other than ABP is slightly lower after April 1, 1997 for all ages except for the age of 61 (right panel of figure 4.1). The favourable economic conditions at the end of the 1990s may have caused a slight change in early retirement behaviour. The hazard rate for the education sector (ABP) hardly changes after April 1, 1997. We may conclude that the transitional arrangement hardly induced workers to retire before the age of 61 (left panel of figure 4.1), although the new system explicitly allows for this. We may also conclude that workers of the education sector hardly postponed early retirement, which is unsurprising as the transition scheme is not actuarially fair after age 61 (table 3.1). The hazard rate for government workers (ABP) did change. Under the old flat-rate scheme some employees retired at the ages of 59 and 60, and these

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

employees are likely to have been working for the local government (see table 3.1). After April 1, 1997, very few participants retired before the age of 61. This may be an indication of the policy reform being effective.

[insert figure 4.1 here]

5. Empirical strategy and results

The purpose of this section is to estimate the impact of the policy reform on early retirement behaviour. Our identification and estimation strategy is based on the variation in the starting dates of the transitional arrangements. We use a mixed proportional hazard rate model to explain the duration of employment after age 55. We use one specification with dummy variables to estimate the average impact of the reform, and we use two specifications with measures of the financial incentives to estimate the price and wealth effects more precisely (section 2). In the next section, we will use goodness-of-fit measures to check the accuracy of the different model specifications.

We are able to estimate the causal impact of the reform by exploiting the variation in starting dates of the transitional arrangements. We compare the early retirement behaviour of civil servants before and after the reform, 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. It is important to note that the reform could not be evaded by the individual worker so that so-called anticipation effects do not hamper our analysis: every age-cohort faced pre-determined transitional arrangement and alternative early retirement options hardly existed. [14] Nevertheless, for our identification and estimation strategy we need to assume the impact of the macro-economic conditions on early retirement behaviour to be the same for all sectors of industry included in the analysis. However, as was seen in the previous section, our selection of sectors of industry into the control group makes this assumption more plausible.

5.1 Mixed proportional hazard rate model

We use a mixed proportional hazard rate model to describe the time working since the age of 55. The advantage of a hazard rate model over probit regressions per age from 55 to 64 (which are often used in

[14] 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 options is however 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 our period of investigation.

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. A second point is that probit regressions per age allow for a different impact of the financial incentives at different ages. In our hazard rate model, we restrict the impact of a given financial incentive to be the same over different early retirement ages.

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) $\lambda_i(t \mid x_{it}, \varepsilon_i)$ 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

$$(5.1)\quad \lambda_i(t \mid x_{it}, \varepsilon_i) = \lambda_0(t)\exp(x_{it}'\beta + \varepsilon_i).$$

In this equation $\lambda_0(t)$ is the baseline hazard, and ε_i is a random term representing unobserved heterogeneity between individuals. Following Meyer (1990) we will estimate the baseline hazard semi-parametrically: we consider a model with observations on a yearly basis to get parameters for t = 0, ..., 9 with one parameter for each age. The probability that a spell lasts until time t+1 given that it has lasted until t now reads as:

[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.

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

where

(5.3) $\bar{\lambda}_0(t) = \int_t^{t+1} \lambda_0(u)du.$

The vector of parameters $\bar{\lambda}_0 = [\bar{\lambda}_0(t)]_{t=0}^{9}$ can be estimated along with the other parameters in β. Next, we assume that unobserved heterogeneity can be characterised by a mixture of two mass points:

(5.4) $P(\varepsilon_i = \eta) = \alpha,$

with the second mass point chosen such that E[exp(ε_i)]=1, i.e. P(ε_i=η_2)=1-α, with η_2=(1-αexp(η))/(1-α).[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 (5.2), after taking the expectation with respect to the unobserved heterogeneity term using (5.4). Thus, summing over individual workers indexed by *i*, the likelihood function reads as:

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

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.

[16] As noted by Heckman and Singer (1984), results may be very sensitive to the choice of a particular functional form for the distribution of ε_i. 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.

5.2 Specification with dummy variables

Our first specification makes a distinction between actuarially unfair and actuarially fair schemes using dummy variables. We estimate the impact of the reform 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, making the specification robust for possible misspecification of the financial incentives. 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 of section 2.

In general, a worker can fall under three regimes: (1) a worker may be *not yet eligible* to an early retirement benefit. In this case, early retirement is unattractive as the worker will loose all early retirement rights. (2) A worker may be *eligible to a flat-rate early retirement benefit*. As was seen in section 2.2, early retirement is then attractive as continuing to work hardly leads to a higher life-time income. (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* (see table 5.1 for exact definitions). The latter dummy implies that the worker will become eligible at some moment in the future if he postpones early retirement, leading to an incentive to wait. Because of the reform, the value of the dummies changes over time for the civil servants (participants of the pension fund ABP). The dummies for the other industry sectors do not change over time, which makes an interpretation as 'control group' possible.

[insert table 5.1 here]

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. This hints at 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 as the incentive to retire at exactly that age may in reality be stronger than expressed by the dummy variables for the reform. As such explanations relate to misspecification, we will address this issue in more depth in section 6.

The early retirement behaviour differs significantly between participants of different industry sectors. Even after correction for individual characteristics, the workers of the industry sectors government, education, Post, Telecom and Agriculture retire significantly earlier than the workers of the other sectors. As could be expected, individuals with children have a lower hazard rate than those without. The dummy variable *high income* has a positive sign, while the variable *house value* has a significantly negative sign. Interpretation of these outcomes may be hampered by omitted variable bias, as these variables may be correlated with for example education. 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 result 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. Theoretically one would expect that not having reached the eligibility age gives a strong incentive to postpone early retirement. But as we could see from the left panel of figure 4.1 already, 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, i.e. on average 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.

5.3 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 (section 2). An advantage over the previous specification is that we can now make use of different sources of variation in financial incentives in order to identify the effects separately. Thus, in theory, this specification should give the best results. On the other hand, one should keep in mind that the specification is built on assumptions which may not hold true. For this reason, the specification may be less robust to misspecification (see section 6).

Table 5.2 presents results with the peak value measure (equation (2.7)), while table 5.3 discusses the results for the option value measure (equation (2.5)). For the option value measure we assume the marginal utility of income to fall with consumption, to be precise $\gamma = 0.75$ (see equation 2.6). The relative valuation of leisure parameter (k) is set equal to 1.7, and the individual discount rate (ρ) equals 4%.[17] Furthermore, both model specifications use the variable *pension wealth* in order to estimate the wealth effect resulting from the early retirement schemes.

Both specifications of the model yield a clear wealth effect as the parameter of the variable *pension wealth* is significantly larger than zero. So, a larger pension wealth induces workers to retire at younger age. Furthermore, both specifications yield a clear price effect as well. Both parameters for the *option value* and the *peak value* are significantly negative, which is consistent with theory. A financial reward to postpone early retirement, in the form of a higher benefit level in case of postponement, induces workers to continue working. Most parameters have changed only little compared to the estimates of the preceding section. A remarkable change is however 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.

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

$$(5.5)\ \xi_k = \frac{\partial \xi}{\partial x_k} = \frac{\partial (10 - E[T])}{\partial x_k} = -\frac{\partial E[T]}{\partial x_k},$$

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 the appendix. 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, respectively. Thus, increasing the *peak value* with 100,000 euros[18] would induce the average worker to extend his career by about 8 months (≈0,67·12). 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. Increasing *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 career 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 his pension wealth. Again, this is in line with theory, as wealth changes may equally affect the demands for other goods than leisure.

[17] We experimented with different parameter values. Within the ranges mentioned in footnote 5 there was not much variation in the results.

[18] Note that the peak value is measured in terms of net future cash flows, viz. equation (2.7). An additional incentive of 100,000 euros thus equals about 3 to 4 net year salaries of the average worker (compare table 4.1 which reports average gross salaries).

[insert table 5.2 here]

[insert table 5.3 here]

6. Goodness of fit

Although the parameter estimates of the previous sections look plausible, it is an open question how well the models perform in reproducing the observed early retirement patterns. As the models are not nested, a formal likelihood ratio test to compare the models is theoretically incorrect. Therefore we use other, less formal measures for the goodness of fit.

According to Akaike's Information Criterion (Akaike, 1973) and Schwarz's Information Criterion (Schwarz, 1978), the model on the basis of the dummy variables outperforms the two other models. The criteria are based on the likelihood, and are often used in practice to compare non-nested models. The criteria correct the log-likelihood for the number of observations and the number of parameters. As these latter figures are however the same for our three model specifications, the criteria boil down to a simple comparison of the log-likelihoods. The model on the basis of the dummy variables clearly performs best, while the two other models perform about equally well.

As the different pension funds of the industry sectors offer rather different incentives to retire, it is informative to see how the models perform in terms of predictions of the conditional early retirement probabilities (hazard rates) at different ages. In particular, some early retirement schemes show strong incentives to retire at one particular age, i.e. education (ABP) , Post/telecom (TPG/KPN) at age 61 and the health care sector (PGGM) at age 60.[19] The non-parametric Kaplan-Meier hazard rates clearly show the existence of these incentives: the hazards of education (ABP) and Post/telecom (TPG/KPN) reach a clear peak of 56% and 77% at age 61, while the hazard of the health care sector (PGGM) reaches a peak of 59% at age 60 (table 6.1).

The models perform reasonably well in the sense that the predicted hazard rates reproduce the age patterns of the different industry sectors (table 6.1). Nevertheless, the models have difficulties in reproducing the level of the peaks for some sectors. This is particularly true for the health care sector (PGGM). Recall that the baseline hazard of the three models shows a peak or a clear jump at age 61, leading to excess retirement at that age. As the pension fund of the health care sector (PGGM) gives an incentive to retire at

[19] The ABP(gov) includes workers of the national and the local government, who face different early retirement schemes.

age 60, it is rather obvious that the model has difficulties in reproducing an age pattern with a peak at age 60. In the literature, some models perform better in terms of predicted hazard rates, for example, Gustman and Steinmeier (2005). Note, however, that they need to explain only two peaks in the hazard rates for workers who all face the same early retirement scheme. We need to explain hazard rates for workers that face many more different schemes (table 3.1).

[insert table 6.1 here]

On the basis of simple goodness-of-fit measures for the hit rate per industry sector, we again conclude that our model on the basis of dummy variables for the reform is the best performing model. As our interest is in predicting the hazard rates per sector, we construct a simple goodness-of-fit measure which can be calculated easily per sector:[20]

$$(6.1)\quad GF = 1 - \sqrt{\frac{1}{W}\sum_{t=55}^{63} w_t \left(p_t - \hat{p}_t\right)^2} \quad with\ \ W = \sum_{t=55}^{63} w_t$$

with weights w_t and the observed and predicted conditional early retirement probabilities p_t and $\hat{p}_t$. A natural choice for the weights may be the number of observations.

According to our simple goodness-of-fit measures, the model on the basis of the dummy variables is the best performing model for all industry sectors; see the last two columns in table 6.1. The models on the basis of the financial variables seem to do about equally well. The fact that the measures are close to one does not necessarily mean that the models are doing very well: the models are able to reproduce the small hazard rates at age 55 to 59. Most of the action however takes place at ages 60 and 61. In particular our first measure gives little weight to these ages as the numbers of observations are low at these ages. Therefore we construct a second measure which does not weigh with the number of observations (last column). But according to this measure the first model is the best performing model as well.

Why do our models have difficulties in reproducing the peaks in the hazard rates? In particular, our model with dummy variables seems to do rather well, and nevertheless the peak remains a problem. We can think of two explanations: measurement error and misspecification. We discuss two special cases of

[20] Heckman and Walker (1987) discuss formal tests for the goodness-of-fit, but in practice these are seldom used.

misspecification that are often mentioned in the literature: interdependent preferences and irregularities in intertemporal optimisation behaviour:

Measurement error: although our dataset allows us to observe early retirement incentives of individual workers in more detail than datasets of previous studies, it does not allow us to observe the exact early retirement and pension rights. In particular, for the construction of the financial variables we need to make assumptions. Note that for the model with dummy variables, we only need to assume a worker to be working in a firm or a sector for the last 10 years. This assumption is less strong than the assumption on complete contribution histories we have to make in the models with financial incentive measures. For this reason, our first model with dummy variables is likely to be less seriously affected by measurement error.

Interdependent preferences: our estimation results show excess retirement at age 61 (table 5.1), or a jump in the early retirement probability at this age (tables 5.2 and 5.3). This may be the result of interdependent preferences. The baseline hazard will pick up interdependent preferences as long as it is the same over all industry sectors. As the workers in the health care sector do not show excess retirement at age 61, interdependent preferences may however vary by industry sector. Allowing for different baseline hazards per industry sector may correct for this kind of misspecification. But it may lead to overfitting of the model as well. A better strategy would be to explain interdependent preferences, but this is beyond the scope of this paper. Examples of empirical applications in consumption and labour supply are Kapteyn *et al.* (1997) and Woittiez and Kapteyn (1998).

Irregularities in intertemporal optimisation behaviour: more and more evidence is becoming available that people do not behave according to the standard life cycle model with rational expectations and time-consistent planning behaviour. This may be a serious threat to the option value model, but also to the peak value model which discounts future early retirement benefits. The question how non-standard optimisation behaviour affects early retirement behaviour is beyond the scope of this paper as well. Frederick *et al.* (2002) provide a recent overview of issues in time discounting and time preferences.

7. Conclusion

In this study, we estimate the causal impact of an early retirement reform on early retirement behaviour. We exploit the variation in starting dates of transitional arrangements from actuarially unfair schemes to more actuarially fair schemes. It is important to note hat the reform could not be evaded by the individual worker so that so-called anticipation effects do not hamper our analysis: every age-cohort faced pre-determined transitional arrangement in which no individual worker had the possibility to retire with the old scheme before the new scheme became relevant for this worker. 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 reform induces 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’. Secondly, 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,[21] while a decrease in his early retirement wealth by the same amount would induce a career extension of 5 months. Although the estimation results look quite reasonable, simulations show that the models with the financial incentives have a harder job in predicting the peaks in early retirement at certain ages than the model with robust dummy variables for the reform. Measurement error and misspecification due to interdependent preferences and irregularities in individual intertemporal optimisation behaviour may play a role here.

As early retirement will remain important 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 to the administrative data from the Dutch National Tax Office will largely rule out the problems with 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 will be a major challenge for the future.

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[21] The peak value is defined as a worker’s increase in lifetime wealth if he decides to continue working for one year (see section 2).

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Appendix A. 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 (5.1)) 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 by[22]

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

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

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 (A.1) then generalises to

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

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

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

so that the expected period spent in early retirement equals

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

Although not shown explicitly in the current notation, λ and f are still conditional on a vector of exogenous variables x (compare equation (5.1)). Hence, the change in ξ resulting from a marginal change in the variable x_k equals

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

Using equation (A.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 (A.2) are obtained from aggregate statistics.

Tables and figures

Table 3.1 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 3.2 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 4.1 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 (≤18y)	0.12	0.23	0.16	0.16	0.31	0.25	0.31	0.17
Financial characteristics								
Gross wage (×€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

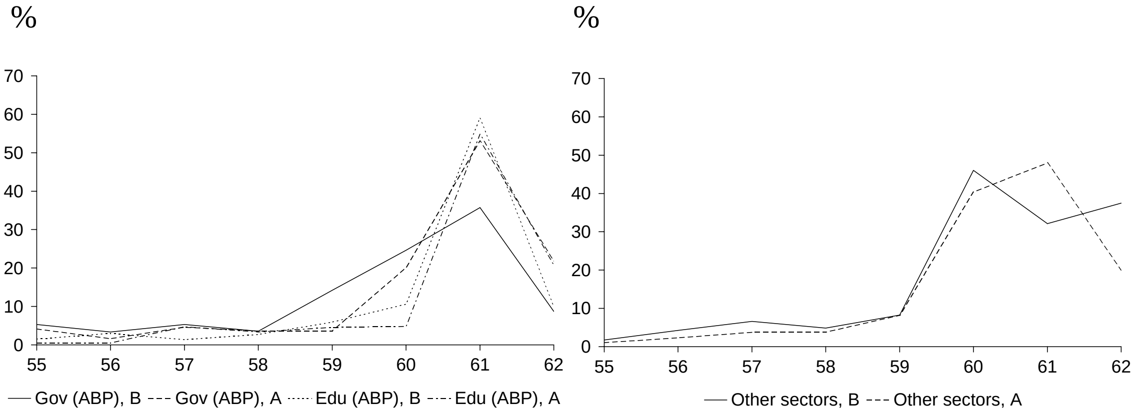
[a] Dummy which equals 1 if income is higher than the Dutch median income.
[b] Relative to yearly income.
Source: Dutch Income Panel (Statistics Netherlands), 1989–2000, own calculations.

Table 4.2 Number of observations per regime, workers in 7 selected industry sectors, 1989–2000

Industry sector	Start of transition	VUT[a]	Both	Transition[b]	Total
Government (ABP)	April 1997	356	564	312	1232
Education (ABP)	April 1997	116	412	213	741
Health care (PGGM)[c]	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 3.1)
[b] Transitional arrangement to less generous and actuarially fair early retirement scheme (see section 3.3)
[c] Note that the transitional arrangement of the health care sector is highly actuarially unfair (table 3.1).
Source: Dutch Income Panel (Statistics Netherlands), 1989–2000, own calculations.

Figure 4.1 Conditional early retirement probabilities (hazard rates) before (B) and after (A) April 1, 1997[a]



[a] Conditional early retirement probabilities according to the Kaplan-Meier method. The conditional early retirement probability is the probability to retire at a certain age, conditional on working at the date of turning that age (the birthday).
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 (2.7)).
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 (2.5)). We assume k = 1.7 and γ = 0.75 (equation 2.6).
Source: Dutch Income Panel (Statistics Netherlands), 1989–2000, own calculations

Table 6.1 Observed and predicted conditional early retirement probabilities (hazard rates) by age, in %[a,b]

	Retirement age 55	56	57	58	59	60	61	62	63	GF1[c]	GF2[c]
Government (ABP)											
# obs.	1232	937	709	532	366	253	139	55	20		
hazard	5.0	2.9	5.1	3.6	10.1	22.5	46.0	16.4	5.0		
M_IV	2.9	2.9	4.7	3.4	8.9	25.4	47.7	18.9	14.2	0.984	0.983
M_PV	2.7	2.8	4.4	3.4	8.5	24.2	51.3	18.3	13.0	0.982	0.977
M_OV	2.7	2.8	4.4	3.5	8.6	24.1	51.1	18.4	13.2	0.982	0.978
Education (ABP)											
# obs.	741	592	462	372	284	189	123	34	18		
hazard	1.2	2.2	2.6	3.0	5.3	7.4	56.1	17.6	16.7		
M_IV	2.7	2.8	4.5	3.2	5.6	16.4	52.6	15.6	11.6	0.978	0.964
M_PV	2.7	2.7	4.4	3.5	7.3	19.2	54.2	19.3	10.5	0.973	0.956
M_OV	2.5	2.6	4.2	3.4	7.3	19.8	54.1	19.1	10.6	0.972	0.954
Health care (PGGM)											
# obs.	445	335	258	178	116	68	17	7	4		
hazard	0.7	0.0	0.8	1.1	0.9	58.8	23.5	28.6	0.0		
M_IV	0.8	0.9	1.5	2.9	4.3	31.7	37.2	13.6	6.8	0.963	0.879
M_PV	1.6	1.7	2.6	2.3	4.3	24.3	53.4	23.3	10.9	0.951	0.837
M_OV	1.7	1.7	2.6	2.3	4.6	23.3	53.2	23.8	10.9	0.950	0.835
Post/telecom (TPG/KPN)											
# obs.	224	175	122	83	57	33	17	3	0		
hazard	4.5	14.3	9.8	8.4	15.8	24.2	76.5	33.3			
M_IV	8.8	8.2	12.1	8.2	11.3	22.3	68.3	52.8		0.981	0.879
M_PV	7.3	6.8	10.3	7.7	13.2	27.1	43.6	12.1		0.973	0.837
M_OV	7.4	6.9	10.3	7.7	13.4	28.1	42.8	12.9		0.972	0.835
Other industry sectors (BPL/PHC/BPSG)											
# obs.	295	219	165	106	70	37	19	13	7		
hazard	0.7	0.5	9.7	6.6	14.3	32.4	21.1	23.1	14.3		
M_IV	2.0	2.1	3.2	4.3	17.1	32.6	30.9	15.9	14.3	0.983	0.949
M_PV	2.6	2.6	3.8	4.1	12.4	29.5	41.4	22.4	18.6	0.980	0.923
M_OV	2.8	2.8	4.0	4.2	11.9	28.3	41.6	22.4	18.2	0.980	0.922

[a] The conditional early retirement probabilities (hazard rates) observed in the data are according to the Kaplan-Meier method.
[b] M_IV is model with indictor variables, M_PV is model with peak value, and M_OV is model with option value.
[c] Goodness-of-fit measures, see equation (6.1). As weights, GF1 uses the number of observations while GF2 uses unity. We do not use the inverse of the observed hazard rate as weights as for some cells they are equal to zero. For age 64 the number of observation per industry sector is very small and we did not include this age in the table.
Source: Dutch Income Panel, 1989–2000, own calculations