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by Sikandar Siddiqui[1]

Abstract:

In this paper, I describe a structural model of retirement behaviour, in which the multiplicity of alternative retirement ages, the possibility of unobserved heterogeneity and the "absorbing state" property of the retirement decision are accounted for. As it is based on a relatively simple utility maximization framework, the computational burden of the model's empirical implementation is only moderate although the sequential nature of the retirement decision is adequately captured by it. The model is estimated on an unbalanced panel of elderly West German males. The results reveal that a person's health status plays a key role in determining the timing of retirement, and that the relative intensity of the individual preference for leisure among public sector employees is, *ceteris paribus*, below average. Education, too, is shown to exert considerable influence on a person's tendency to retire early, but the relationship between an individual's educational status and the probability of early retirement appears to be rather complex.

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1. Introduction

Most of the industrialized countries can today be expected to undergo a dramatic process of population ageing during the next three to four decades. This tendency, which is due to both the decline in birth rates in the 1970s and the rising average life expectancy of individuals, is particularly pronounced in Germany: According to a forecast by the German Federal Bureau of Statistics ("Statistisches Bundesamt"; see SOMMER, 1992), 34.9% of the German population will be older than 60 years by the year 2030 (compared only to 20.4% in 1989). Unless appropriate policy reforms are undertaken, these developments are bound to put the financial basis of Germany's unfunded public pension system under considerable strain. As raising the average retirement age is often considered an appropriate means to cope with this problem, the expected demographic changes have spurred off an increasing interest in the factors determining the labour supply behaviour of the elderly. This becomes particularly obvious when considering the rules being laid down in the 1992 Pension Reform Act, which was enacted by the West German government in 1989: The new German pension law substantially reduces the financial incentives for early retirement which had been typical of its predecessor. Moreover, it prescribes that the minimum retirement age will be raised in quarterly steps from the year 2000 onwards until it reaches 65 by the time of the year 2012.

In this paper, I present an empirical analysis of retirement behaviour under the conditions of the German statutory pension system, using data from the Socio-Economic Panel (SOEP). Panel datasets of this kind provide a particularly useful basis for empirical studies of retirement behaviour. This is due to two main reasons: Firstly, the multi-period structure of panel data enables the researcher to take the possibility of unobserved heterogeneity among individuals into account. Secondly, it allows to treat an individual's decision about the timing of retirement as a sequence of choices among multiple discrete alternatives (defined as the remaining possible retirement ages) under the assumption that a person decides to quit the labour force as soon as the option of immediate retirement is more advantageous than any of the remaining possible choices. A difficulty inherent in structural models of retirement behaviour, however, is the fact that, unlike temporary breaks in an individual's employment history, "retirement" has to be treated as an absorbing state, which results in a problem of endogenous sample selection. A straightforward solution to this problem would be to use a continuous-time duration model, as it is done by BÖRSCH-SUPAN and SCHMIDT (1994) in their comparative analysis of retirement behaviour in East and West Germany. However, as there is no obvious way in which the multiplicity of alternatives, which is typical of the retirement decision, can be implicated in such a model, this approach is not adopted here. Another drawback of duration models in continuous time is that at least some of the explanatory variables that cannot be assumed to be time-invariant are not observed continuously. Approximating continuous time paths for variables that are observed in discrete intervals, as it was done by HAUSMAN and DIAMOND (1984), appears to be a rather arbitrary solution. Instead, the analysis presented in this paper is based on a sequential multi-period discrete choice model for multiple alternatives, in which both the possibility of unobserved heterogeneity and the problem of endogenous sample selection are accounted for.

What might give rise to some criticism is the fact that this model is set in a rather simple utility maximization framework. From a theoretical point of view, it would be more satisfactory either to employ formal dynamic programming techniques to derive optimal solutions of what appears to be a problem of intertemporal choice under uncertainty (as it was done, e.g., by RUST, 1989), or to modify the option value approach developed by STOCK and WISE (1990) in order to allow for unobserved heterogeneity and uncertainty with regard to future income levels, as has been suggested by POHLMEIER (1994). The reason why none these approaches is employed here is simply that doing so would result in inacceptably long computer runs. This problem is caused by the fact that both dynamic programming and option value models require that the optimization problem which the individuals are assumed to face is solved for every person in every iteration of the maximum likelihood algorithm anew, and aggravated by the fact that the stochastic structure of such models implies the necessity of using extremely computer-intensive simulation methods whenever the sequential nature of the retirement decision is taken into consideration adequately. However, one feature the model presented here has in common with the above-mentioned approaches is that it describes the retirement decision as a tradeoff between the gain in income which can be obtained by postponing one's exit from the labour force and the gain in leisure which is implied by early retirement. It is therefore capable of integrating possible labour (dis)incentives implied by the rules of the relevant pension system into the empirical analysis of retirement behaviour.

The outline of the paper is as follows: In section 2, the assumptions of the model employed are described in detail. Section 3 contains a brief description of the data being used and of the way in which the endogenous variable is defined. The empirical results are being discussed in section 4, and the paper ends with a couple of final remarks and a brief summary.

2. The Theoretical Framework

Following the model set up by FIELDS and MITCHELL (1984), it is assumed that the utility level U that individual i can enjoy at time t if he (or she) chooses to retire at time $r_i \geq t$ can be expressed as a function of the expected present discounted value of all present and future income streams (which will be denoted by $Y_{it}(r_i)$ here and in the following), the expected length of his (her) retirement period, $L_{it}(r_i)$, and a disturbance term $\varepsilon_{it}(r_i)$. For the alternative-specific utility level $_{it}(r_i)$ which is associated with retirement at time r_i, the following functional form is specified:

$$(2.1.) \qquad U_{it}(r_i) \;=\; \ln Y_{it}(r_i) \;+\; \beta_{it} \ln L_{it}(r_i) \;+\; \varepsilon_{it}(r_i)\,.$$

The parameter β_{it} is a taste parameter which measures the relative intensity of an individual's preference for leisure and is allowed to vary among individuals as well as over time. It is assumed to be a linear function of a vector γ of unknown parameters and of a set of exogenous variables, which are collected in the vector x_{it} and represent certain socio-economic characteristics of the individuals observed:

$$(2.2.) \qquad \beta_{it} \;=\; x_{it}'\gamma\,.$$

If $\pi_i(s|t)$ denotes the individual-specific probability that a person who was alive at time t is still alive at time $s > t$, and if S_i is the last period in which $\pi_i(s|t)$ is positive, the expected present discounted value of present and future income levels, $Y_{it}(r_i)$, can be expressed as follows:

$$(2.3.) \qquad Y_{it}(r_i) \;:=\; \sum_{s=t}^{r_i-1} E_t(y_{is})\cdot\pi_i(s|t)\cdot(1+\rho)^{t-s} \;+\; \sum_{s=r_i}^{S_i} E_t(b_{is}(r_i))\cdot\pi_i(s|t)\cdot(1+\rho)^{t-s}.$$

In this equation, y_{is} denotes an individual's labour income at time s, the variable b_{is} stands for the amount of retirement benefits received by the respective person, E_t is the expectations operator given the information set of time t, and ρ is a discount factor, which is set to 0.03 for the sake of simplicity. (The amount of assets held by an individual is not included as an argument of the utility function within the framework of this model because the corresponding statements in the German Socio-Economic Panel, which is the data base used here, were found to be rather imprecise and incomplete). The expected length of a person's retirement period is defined as

$$(2.4.) \qquad L_{it}(r_i) \;=\; \sum_{s=r_i}^{S_i} \pi_i(s|t).$$

Let t_{i0} denote the period in which person i first has the opportunity to retire and $r_i^{\max}$ the latest possible year of retirement for the same person. (For reasons that will become obvious later, t_{i0} is assumed to be the year of the corresponding individual's 58th birthday). This implies that an individual who has not retired until the beginning of period t can either opt for immediate retirement or plan to retire at one of the $(r_{it}^{(\max.)} - t)$ remaining future years of retirement. Thus, an individual can be said to have the choice between a total number of $(r_{it}^{(\max.)} - t_{i0} + 1)$ different retirement ages at time t_{i0}. These alternatives are henceforth numbered in consecutive order beginning with zero. In order to retain relative computational simplicity while adding some stochastic flexibility to what otherwise would be a restrictive multinomial logit or independent probit model, a so-called "one-factor" decomposition (AMEMIYA, 1985, p. 323f.) is chosen as to the stochastic error terms $\varepsilon_{it}(r_i)$:

$$(2.5.) \qquad \varepsilon_{it}(r_i) \;=\; \delta_{r_{it}-t_{i0}} \cdot v_i \;+\; u_{it}(r_i)$$

The error components $u_{it}(r_i)$ and v_i are assumed to be normally distributed with mean zero; the factors δ_0 to $\delta_{r_i^{(\max)}-t_{i0}}$ are unknown parameters which have to be estimated. In order to be able to identify the elements of the parameter vector γ, however, the following arbitrary normalizations are introduced:

$$(2.6.) \qquad \begin{aligned} E\left[u_{is}(r_i)\, v_i\right] &= 0 \quad \textit{for all } r_i, \\ E\left[u_{is}(r_i)^2\right] &= 0.5, \end{aligned}$$

$$(2.7.) \qquad E\left[u_{is}(r_i)\, u_{is'}(r_i')\right] = 0 \quad \textit{for all } r_i,\ r_i' \ \textit{if } \ s \neq s',$$

$$(2.8.) \qquad E\left[v_i^2\right] = 1, \quad \text{and}$$

$$(2.9.) \qquad \delta_0 = \delta_1 = 1.$$

If the number of panel waves, *T*, falls short of the number of possible retirement ages or if not all retirement ages are observed with sufficient frequency, even further equality constraints as to the covariance structure of the error terms have to be added.

Following a suggestion made by PUDNEY (1989, p. 127-131), an individual is assumed to retire at time *t* if this is the period in which the utility level associated with the option of immediate retirement exceeds the maximum utility level that can be achieved by postponing retirement for the first time. Let $\bar{r}_i$ denote the year of retirement that has actually been chosen by individual *i* (which is observable for the econometrician if it lies within the sampling period) and r_i^* be the corresponding person's optimal year of retirement (which is a discrete random variable from the econometrician's point of view because it is a function of the unknown parameters and the stochastic components of the individual's utility function). Then, the probability that this individual retires at time *t* given he/she has not retired until *t-1* and conditional on *v*, can be expressed as follows:

(2.10.) $$\Pr(r_i^* = t \mid r_i^* > t-1;\ v)$$
$$= \prod_{r=t+1}^{r_i^{(\max)}} \Phi\left[\ln Y_{it}(t) - \ln Y_{it}(r) + x_{it}'\gamma \cdot \left[\ln L_{it}(t) - \ln L_{it}(r)\right] + \left[\delta_{t-t_{i0}} - \delta_{r-t_{i0}}\right] \cdot v\right]$$

Here and in the following, $\Phi(\cdot)$ denotes the cumulative distribution function and $\phi(\cdot)$ the probability density function of the standard normal distribution. (By definition, the probability of a person retiring before t_{i0} is zero). The right-hand side of equation (2.10.) can be understood as a "hazard rate" with regrard to the transition from work to retirement. It follows from this equation that the unconditional probability of individual i retiring at time t is

(2.11.) $$\Pr(r_i^* = t) = \int_{-\infty}^{\infty} \Pr(r_i^* = t \mid r_i^* > t-1; v) \cdot \prod_{s=t_{i0}}^{t-1} \left[1 - \Pr(r_i^* = s \mid r_i^* > s-1; v)\right] \phi(v)\, dv$$

It thus becomes obvious that the unknown parameters of the decision model described here can be estimated by the method of maximum likelihood. Suppose that the individuals in the sample are observed during a period of T consecutive years. In this case, there will be some persons who did not choose to retire during the sampling period although they were already entitled to retire. Taking this phenomenon (which can be thought of as a kind of right-hand-side censoring if this model is understood as a duration model in discrete time) into account, the contribution of individual i to the sample likelihood function (Λ_i) can be expressed as follows:

(2.12.) $$\Lambda_i = \begin{cases} \Pr(r_i^* = \bar{r}_i) & \text{if } \bar{r}_i \le T \quad (\Leftrightarrow \textit{observed}) \\ \int_{-\infty}^{\infty} \prod_{s=t_{i0}}^{T} \left[1 - \Pr(r_i^* = s \mid r_i^* > s-1; v)\right] \phi(v)\, dv & \text{if } \bar{r}_i > T \quad (\Leftrightarrow \textit{unobserved}) \end{cases}$$

Then, the log-likelihood function for an entire sample of N individuals simply is

(2.13.) $$\ln \Lambda = \sum_{i=1}^{N} \ln \Lambda_i$$

and can be maximized by means of conventional numerical optimization techniques.

3. The Data

The definition of "retirement"

In previous micro-econometric studies of retirement behaviour, a variety of different definitions of the endogenous variable have been used. To a certain extent, this is due to the fact that the questions of main interest within this field vary considerably among researchers. Another reason is that the informational content of the datasets in use differs from case to case. The striking differences among the results of previous empirical investigations concerning the labour force exit behaviour of elderly Americans can, in part, be attributed to these factors. HURD and BOSKIN (1984), for instance, who use the "Retirement History Survey" (RHS) as a data base, only consider a person as retired if he or she has left the labour force finally and irrevocably. Contrary to that, in a study by BURTLESS and MOFFITT (1984), which is based on PSID data, an elderly employee's retirement age is defined as the age in which a sudden and pronounced decline in the individual's number of working hours occurs. If the incentive effects of firm pension plans are being analyzed, it is most appropriate to equate a person's date of retirement with the period when he or she first receives pension benefits, as it is done by STOCK and WISE (1990).

In an empirical study of retirement behaviour in West Germany conducted by BÖRSCH-SUPAN (1992) using the 1984 cross-section of the SOEP, the period of retirement is defined as the year in which the number of a person's working hours per week first falls short of fifteen. However, as "retirement" is understood as an absorbing state in the model described in section 2, it seems more reasonable in this context to equate a person's date of retirement to the moment in which he/she first declares himself/herself retired. This is possible with data from SOEP because it contains a very detailed set of information on a person's present and past labour force status in which "retirement" is a seperate category.

One of the main goals of the empirical study described here is to explain the effect of Germany's pension system on retirement behaviour. Nevertheless, it is assumed here that individuals can opt for retirement up to two years before they reach the age of 60, which is the minimum age for the receipt of old-age pension benefits in this system. The reason for this assumption is that, under the rules of the German system of unemployment insurance, unemployed individuals who are older than 58 can receive full unemployment benefits without having to declare explicitly that they are willing to work as long as they are ready to apply for the receipt of pension benefits at the earliest possible age (see BUNDESMINISTER FÜR ARBEIT UND SOZIALORDNUNG, 1993, p. 111). As an evaluation of the labour force histories of all male SOEP respondents born between 1915 and 1925 reveals, less then 3% of all persons in this category who were either unemployed or out of the labour force at the age of 58 returned to employment afterwards. This indicates that setting the minimum retirement age ("retirement" being defined as a state in which a person does not intend to return to paid employment) to 58 is a reasonable choice.

Exogenous variables

The intensity of an individual's preference for leisure, which is measured by the parameter β within the framework of the model described in chapter 2, is assumed to be influenced mainly by the person's current health status and educational background. In addition to these variables, the dummy variable PUBLIC, which indicates whether a person is or was a public sector empoyee, is included in order to control for the influence of possible differences between the pension systems applying to public and private sector employees, respectively. From a psychological point of view, it might be interesting to find out whether married persons exhibit a higher preference for leisure than others; therefore, a corresponding dummy variable (MARRIED) is taken account of. Finally, in order to examine in how far macroeconomic conditions on the labour market influence retirement behaviour, the gender-specific unemployment rate in the corresponding age group, UR, is included in the set of regressors. Definitions and descriptive statistics of the explanatory variables used are described in tables 3.1. and 3.2.

Table 3.1.: Definitions of explanatory variables in β_{it}

D_DISAB	Degree of disability with regard to the requirements of the corresponding person's job. $0 \leq$ D_DISAB ≤ 1.
PUBLIC	Dummy variable; PUBLIC = 1 if a person is or was formerly employed in the public sector.
CH_MAL	Dummy variable; CH_MAL = 1 if a person suffers from a chronic malady.
UR	Gender-specific unemployment rate in the age group a person belongs to.
FOREIGN	Dummy variable; FOREIGN = 1 if a person is not a German citizen.
MARRIED	Dummy variable indicating whether a person is married.
HAUPTS REALS ABI	Dummy variables for the highest grade in general education achieved; HAUPTS = 1 corresponds to 9 years, REALS to 10 years, and ABI to 13 years of schooling.
UNI	Dummy variable; UNI = 1 if a person has a university degree.

Table 3.2. : Descriptive statistics of the exogenous variables in β_{it}

Variable	Mean	Standard Deviation	Minimum	Maximum
D_DISAB	0.2832	0.2404	0.0000	1.0000
PUBLIC	0.1203	0.3254	0.0000	1.0000
CH_MAL	0.3839	0.4864	0.0000	1.0000
UR /100	0.1055	0.0080	0.0823	0.1173
FOREIGN	0.2832	0.4506	0.0000	1.0000
MARRIED	0.6888	0.4630	0.0000	1.0000
HAUPTS	0.3533	0.4780	0.0000	1.0000
REALS	0.0745	0.2625	0.0000	1.0000
ABI	0.0599	0.2372	0.0000	1.0000
UNI	0.0409	0.1980	0.0000	1.0000

Selection of Sample

In order to implement the model described in section 2, it is necessary to confine the sample to the persons whose earliest possible year of retirement lies within the sampling period. This implies that in case described here only individuals born between 1926 and 1933 were included in the dataset used for estimation. As the pension systems that apply to most of the self-employed in Germany differ significantly from the one which is relevant for employees, persons who report to have been self-employed in one of the years of the the sampling period were excluded from the sample. The same applies to a total of twelve individuals whose statements about their labour force status were found to be self-contradictory or incomplete. Women were not included in the sample because the significant differences between the labour force participation patterns of males and females make it an unrealistic assumption that the factors influencing their respective job exit behaviour can be reasonably examined with the same type of model.

Income forecasts

Individual-specific forecasts of net labour income levels were computed on the basis of a classical, MINCER (1974)-type earnings function. In order to avoid the problem of a possible selectivity bias in the earnings estimates, the model was extended to a "type-two-Tobit" model (see AMEMIYA, 1985, p. 385-389) by including a separate selection equation. Let y_{it}^* denote a person's market wage (in DM per annum) net of taxes, d_{it} a dummy variable indicating whether individual i is employed at time t ($\Leftrightarrow$ $d_{it} = 1$) or not ($\Leftrightarrow$ $d_{it} = 0$), and d_{it}^* the latent variable determining a person's employment situation. Then, this model can be summarized by the following system of equations:

$$\text{(3.1.)} \qquad \ln y_{it}^* = z_{it}^{(1)\,\prime} \alpha^{(1)} + \omega_{it}^{(1)} ,$$

$$\text{(3.2.)} \qquad d_{it}^* = z_{it}^{(2)\,\prime} \alpha^{(2)} + \omega_{it}^{(2)} ,$$

$$\text{(3.3.)} \qquad d_{it} := I\left(d_{it}^* > 0\right),$$

$$\text{(3.4.)} \qquad y_{it} = \begin{cases} y_{it}^* & \text{if } d_{it} = 1 , \\ 0 & \text{if } d_{it} = 0 , \end{cases}$$

$$\text{(3.5.)} \qquad \left[\omega^{(1)},\ \omega^{(2)}\right]' \sim N(0, \Sigma),$$

$$\Sigma \equiv A A' \ ; \quad A := \begin{bmatrix} a_{11} & 0 \\ a_{21} & 1 \end{bmatrix} .$$

A total of T consistent cross-sectional estimates of this system's unknown parameters can be obtained by maximizing the within-period quasi-log-likelihood function

$$\text{(3.6.)} \qquad l_t\left(\tilde{\alpha}_t^{(1)}, \tilde{\alpha}_t^{(2)}, \tilde{a}_{11,t}, \tilde{a}_{21,t}\right) = \sum_{i=1}^{N} (1 - d_{it}) \cdot \ln\Phi\left(\frac{-z_{it}^{(2)\,\prime}\tilde{\alpha}_t^{(2)}}{\left(1 + \tilde{a}_{21,t}^2\right)^{1/2}}\right)$$
$$+ \ d_{it} \cdot \ln\left[\frac{1}{\tilde{a}_{11,t}} \phi\left(\frac{y_{it} - z_{it}^{(1)\,\prime}\tilde{\alpha}_t^{(1)}}{\tilde{a}_{11,t}}\right) \cdot \Phi\left(z_{it}^{(2)\,\prime}\tilde{\alpha}_t^{(2)} - \frac{\tilde{a}_{21,t}}{\tilde{a}_{11,t}}\left(y_{it} - z_{it}^{(1)\,\prime}\tilde{\alpha}_t^{(1)}\right)\right)\right]$$

with respect to all of its arguments. The results, in turn, can be combined to panel estimates of $\alpha^{(1)}$, $\alpha^{(2)}$, a_{11} and a_{21} by means of a minimum distance method described by GOURIÉROUX and MONFORT (1989, pp. 385-387). In the particular case discussed here, this was done for a balanced panel of 1.633 male SOEP respondents born between 1925 and 1959. Descriptive statistics of the explanatory variables of this model are given in table A.1. and the estimation results in tables A.3. and A.4. of the appendix.

If the normality assumption (3.5.) concerning the random variates $\omega^{(1)}$ and $\omega^{(2)}$ is true, the following equality holds (cf. RONNING, 1991, p. 213) :

$$(3.7.) \qquad E(y_{it}) = exp\,(z_{it}^{(1)'}\alpha^{(1)} + a_{11}^{2})\,.$$

Replacement of the unknown quantities $\alpha^{(1)}$ and a_{11} in (3.7.) by their estimated values makes it possible to use the right-hand side of that equation as a basis for income forecasts. According to LAISNEY et. al. (1993), it is reasonable to assume that a German employee's annual labour income (including regular voluntary bonuses paid by the employer) can be approximated by thirteen times the monthly labour income with sufficient accuracy, as it is done here.

Because of the complexity of the German pension law, the computation of hypothetical pension benefits (b_{it}) for persons who did not retire during the sampling period proved to be a rather difficult task. In Germany, an individual's pension level is a function of both the person's number of years of service and of all past and present labour income streams. (For details, see CASMIR, 1990, and DÖRING, 1980). Fortunately, the SOEP contains rather detailed information on the labour force histories of the individuals, so that at least the number of years in which a person paid social security contributions could be computed with adequate accuracy. Together with the estimation results from the earnings equation, these estimates made it possible to evaluate a person's claims on the pension system at least in an approximate manner. (The mean absolute forecast error of this approximation with regard to the monthly pension income levels of persons already retired proved to be less than DM 100, which corresponds to roughly 9%).

4. Empirical Results

The model described in section 2 was estimated on two samples. Sample I consists only of German citizens, whereas in sample II, foreigners are included, as well. It is difficult to assess which one of these two datasets leads to more reliable results when being used for estimation: On one hand, including foreigners raises the sample size by almost one third, which is due to the fact that immigrants are deliberately oversampled in the SOEP database. But on the other hand, many immigrants can be expected to have claims on the pension systems of their home countries, which are likely to differ enormously among nations as well as individuals. STEINER and VELLING (1993) argue that the desire to re-migrate to one's country of origin might produce a tendency towards early retirement among elderly foreigners. The estimation results for sample II (see table 4.1.) support this hypothesis, as the estimated coefficient referring to the dummy variable FOREIGN is statistically significant at the 95% level.

Furthermore, the estimation results reveal that an individual's health status has considerable influence on the timing of retirement. The coefficients belonging to both of the health-related variables in this model, D_DISAB (= degree of job-related disability) and CH_MAL (dummy variable indicating the presence of a chronic malady) bear the expected positive sign, indicating that, on average, a bad health status leads to a higher probability of early retirement.

It cannot be told unequivocally from the estimation results whether married men have a significantly higher preference for leisure than others. The related parameter estimate for sample II suggests that they do, but for sample I it is statistically insignificant and bears the opposite sign. A similar ambivalence can be verified with regard to the effect of the actual unemployment rate on the probability of early retirement. A possible explanation for this phenomenon is that, on one hand, untimely retirement due to layoffs probably occurs more frequently in times of high unemployment, whereas on the other, people still employed might tend to feel more pessimistic as to their future income prospects and are therefore inclined to postpone their retirement. The fact that, for both samples, the estimated coefficient belonging to the variable "UR" is not statistically significant at conventional significance levels might indicate that the two above-mentioned effects of the unemployment rate on the mean retirement age cancel out on average.

Interpreting the coefficients referring to the impact of education on retirement behaviour is rather difficult. A person's educational status can reasonably be expected to be positively correlated with wealth, which, seen from a life-cycle point of view, would imply that highly educated people tend to quit the labour force earlier than others. However, persons with rather low educational status are probably more likely to be laid off immediately when or even before reaching the minimum retirement age. The estimation results presented here do not permit an unequivocal conclusion as to which one of these two factors dominates the other.

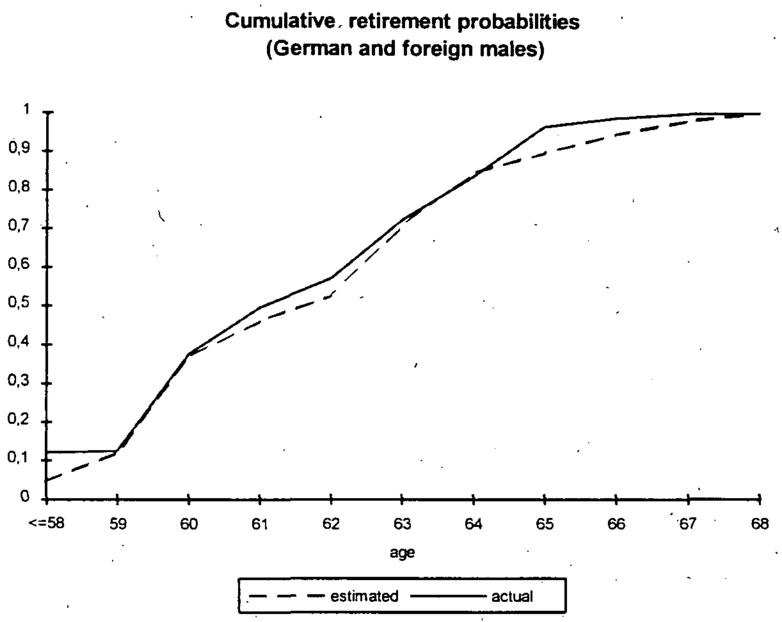
Unobserved wealth effects might also be one of the reasons why the preference for early retirement appears to be significantly lower than average among public sector employees. Another possible explanation for this phenomenon is that some of the differences between the pension systems applying to public and private sector personnel could not be taken into consideration within framework of the model presented here because of a lack of appropriate data. But also people who simply believe that public sector employees are, on average, overpaid and underworked compared to their private sector colleagues might regard the above-mentioned result as a confirmation of their verdict.

Table 4.1: Parameter Estimates

Variable	Sample I: German citizens only		Sample II: Germans and foreigners	
	Estimate	t-statistic	Estimate	t-statistic
CONSTANT	2.3975	0.856	-1.5596	-0.729
D_DISAB	4.8436	4.232	4.4203	4.912
HAUPTS	2.1553	5.122	1.6587	4.115
REALS	2.8181	4.882	2.0863	3.655
ABI	1.2155	1.158	0.7307	0.702
UNI	2.2651	1.771	1.5887	1.328
MARRIED	-0.4826	-1.193	0.5803	1.911
PUBLIC	-1.7346	-3.246	-1.4168	-3.756
CH_MAL	1.2083	3.233	1.0620	3.137
UR	-0.0619	-0.243	0.2959	1.535
FOREIGN	-	-	0.9819	2.772
δ_2	-2.8447	-1.351	-1.5456	-1.370
δ_3	-2.2364	-1.104	1.3586	13.769
δ_4	1.1895	7.474	-0.7519	-0.717
δ_5	1.4450	8.029	1.4268	9.376
δ_6	-2.6571	-1.162	-1.4604	-1.132
Mean $\hat{\beta}$	5.0754		4.5659	
Mean Log Likelihood	-1.1165		-1.0658	
# of cases	419		586	

The estimation results displayed in table 4.1. can be used as a basis for estimation of age-specific retirement probabilities. In figure 4.1., the estimated cumulative retirement probabilities are compared to the observed cumulative frequency distribution (as it can be computed from the observed age-specific hazard rates with regard to retirement) of the retirement ages of a group of male SOEP respondents born between 1917 and 1932, of which the persons whose data were actually used for estimation simply constitute an adequately selected sub-sample.

Figure 4.1.



Apparently, the model underestimates the probability of immediate retirement at the earliest possible retirement age, while otherwise „fitting“ the data rather well. The fact that the probability of retirement at 65 is also underestimated is probably due to the problem of right-hand-side censoring mentioned above. The inclusion of macroeconomic information in the estimation procedure might help to circumvent this difficulty, as recent work by IMBENS and LANCASTER (1991) suggests. Whether this is the case in the context of the particular subject studied here is, however, still an open question at this stage.

5. Summary and Conclusions

In this paper, the retirement behaviour of male employees in West Germany was analyzed empirically using a sequential multi-period decision model for multiple discrete alternatives. The estimation results reveal that health-related factors play a key role in determining the age a person chooses for the transition from work to retirement. Education, too, does matter; yet the influence a person's educational status has on the probability of an early exit from the labour force seems to follow a rather complicated, non-linear pattern. The hypothesis that the tendency toward early retirement is significantly higher in times of high unemployment could neither be supported nor refuted from the data.

The main advantage of the approach presented here is that it adequately reflects the sequential nature of the retirement decision and allows for unobserved heterogeneity among individuals.

One major point of criticism, of course, is that its relative computational simplicity necessitates the introduction of rather restrictive assumptions concerning the utility maximization framework it is based on. Whether further progress with regard to simulation methods and optimization algorithms might help to circumvent this difficulty, however, is still an open question at this stage.

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Appendix:

Table A.1.: Definitions of explanatory variables used for the earnings forecasts

PEXP	Potential labour experience; defined as age - years of schooling - 6
SM_FIRM	Dummy variable. SM_FIRM = 1 if a person works in a small firm (less than 200 employees)
LG_FIRM	Dummy variable. LG_FIRM = 1 if a person works in a large firm (more than 2 000 employees).
AGFF	Binary variable indicating whether an individual works in the agrarian sector, in forestry or in fishery
TRADE	Dummy variable. TRADE = 1 if a person is employed in the trade sector.
AGEG50, -55, -60	Dummy variables for the age groups 50 to 54, 55 to 59, and ≥ 60, respectively
UNM	Dummy variable indicating whether an individual is unmarried
M_WS	Dummy variable. M_WS = 1 if someone is married and living with his/her spouse.
VOC_D	Dummy variable pointing out whether the corresponding person holds a vocational degree
TT_SCHOOL	Binary variable indicating whether a person holds a degree from a trade school or technical school.
D85, ..., D90	Dummy variables for the years 1985 to 1990. (1984 is the reference period).
TIME	Time trend

Table A.2.: Descriptive statistics of explanatory variables in the earnings equation

Variable	Mean	Standard Deviation	Minimum	Maximum
PEXP /10	2.8019	0.9964	0.6000	4.9000
$PEXP^2$ /100	8.8434	5.7015	0.3600	24.0100
SM_FIRM	0.2282	0.4197	0.0000	1.0000
LG_FIRM	0.3009	0.4587	0.0000	1.0000
UNI	0.0808	0.2726	0.0000	1.0000
TT_SCHOOL	0.0793	0.2702	0.0000	1.0000
VOC_D	0.0688	0.2532	0.0000	1.0000
MARRIED	0.8484	0.3587	0.0000	1.0000
ABI	0.1133	0.3170	0.0000	1.0000
HAUPTS	0.4764	0.4995	0.0000	1.0000
PUBLIC	0.2005	0.4004	0.0000	1.0000
AGFF	0.0048	0.0692	0.0000	1.0000
TRADE	0.0344	0.1822	0.0000	1.0000
FOREIGN	0.2394	0.4268	0.0000	1.0000
AGEG50	0.1755	0.3804	0.0000	1.0000
AGEG55	0.1478	0.3550	0.0000	1.0000
AGEG60	0.0848	0.2786	0.0000	1.0000
UNM	0.0962	0.2949	0.0000	1.0000

Table A.3.: Cross-sectional Estimates of Earnings Equation

Variable	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 6	Wave 7
			Income Equation				
CONST	6.7998	6.8628	6.8506	6.8481	6.8496	6.8566	6.9946
	(72.989)	(68.969)	(60.795)	(63.605)	(56.037)	(1.219)	(43.078)
PEXP	0.6589	0.6164	0.6879	0.6678	0.7570	0.7576	0.7155
	(8.287)	(7.715)	(8.067)	(8.301)	(8.237)	(0.197)	(6.369)
PEXP ^{2}	-0.1202	-0.1102	-0.1238	-0.1179	-0.1343	-0.1315	-0.1261
	(-7.933)	(-7.318)	(-7.907)	(-8.179)	(-8.353)	(-0.208)	(-6.812)
ABI	0.0484	0.0319	0.0435	0.1419	0.0689	0.1101	0.0102
	(0.898)	(0.615)	(0.626)	(1.987)	(1.218)	(0.046)	(0.199)
REALS	-0.0159	0.0032	-0.0516	0.0048	-0.0279	0.0182	-0.0327
	(-0.339)	(0.069)	(-1.016)	(0.102)	(-0.574)	(0.009)	(-0.631)
HAUPTS	-0.1483	-0.1590	-0.1936	-0.1491	-0.1668	-0.1395	-0.1636
	(-3.628)	(-3.988)	(-4.452)	(-3.668)	(-3.903)	(-0.085)	(-3.547)
TT_SCHOOL	0.1040	0.1161	0.1097	0.1059	0.0750	0.1073	0.1382
	(1.769)	(2.243)	(2.113)	(1.957)	(1.800)	(0.059)	(2.980)
UNI	0.2857	0.3160	0.2883	0.2608	0.2902	0.3329	0.4347
	(5.862)	(5.795)	(4.540)	(4.159)	(5.588)	(0.146)	(7.654)
MARRIED	0.2046	0.1806	0.1675	0.1897	0.1546	0.1576	0.1491
	(4.730)	(4.467)	(3.922)	(4.532)	(3.368)	(0.088)	(3.056)
FOREIGN	-0.2455	-0.2598	-0.2915	-0.2819	-0.3029	-0.2437	-0.2610
	(-5.572)	(-5.815)	(-6.026)	(-6.965)	(-6.785)	(-0.141)	(-5.881)
VOC_D	0.1628	0.1299	0.0854	0.1107	0.1006	0.1221	0.1666
	(2.629)	(2.588)	(1.517)	(1.823)	(1.493)	(0.047)	(2.232)
PUBLIC	-0.0743	-0.0653	-0.0382	-0.0500	-0.0509	-0.0791	-0.0809
	(-2.302)	(-2.019)	(-0.996)	(-1.301)	(-1.249)	(-0.050)	(-2.200)
TRADE	-0.0065	-0.0124	-0.0425	-0.0371	-0.0338	-0.0011	-0.0415
	(-0.078)	(-0.157)	(-0.509)	(-0.384)	(-0.389)	(-0.000)	(-0.678)
AGFF	-0.0530	-0.2502	-0.1977	-0.2253	-0.1774	-0.0736	-0.1360
	(-0.351)	(-1.821)	(-1.035)	(-1.446)	(-1.029)	(-0.008)	(-0.643)
SM_FIRM	0.0130	0.0040	0.0078	-0.0089	0.0079	-0.0196	0.0139
	(0.419)	(0.121)	(0.244)	(-0.268)	(0.243)	(-0.016)	(0.410)
LG_FIRM	0.0541	0.0473	0.0767	0.0740	0.0878	0.0778	0.0928
	(1.602)	(1.474)	(2.299)	(2.397)	(2.654)	(0.062)	(2.783)
			Selection Equation				
CONST	0.9986	0.9422	0.7977	0.7470	0.7067	0.7289	0.5624
	(6.891)	(8.064)	(5.704)	(5.949)	(5.905)	(0.143)	(4.873)
AGEG50	-0.0359	-0.1304	-0.0617	-0.1037	-0.1306	-0.1001	-0.0855
	(0.297)	(-1.191)	(-0.597)	(-0.876)	(-1.076)	(-0.022)	(-0.896)
AGEG55	-0.3595	-0.1969	-0.3083	-0.1225	-0.1006	-0.0651	-0.0330
	(-3.020)	(-1.961)	(-3.388)	(-1.359)	(-1.269)	(-0.021)	(-0.437)
AGEG60	-0.4577	-0.5200	-0.6680	-0.6611	-0.7818	-0.8685	-0.8780
	(-1.955)	(-3.646)	(-6.277)	(-6.743)	(-8.810)	(-0.244)	(-10.898)
M_WS	-0.0302	0.0276	0.2489	0.2118	0.2566	0.2390	0.2784
	(-0.194)	(0.232)	(1.723)	(1.622)	(2.148)	(0.047)	(2.383)
UNM	-0.0163	-0.0286	0.1413	0.3855	0.2833	0.3415	0.2710
	(-0.120)	(-0.220)	(0.828)	(2.560)	(1.708)	(0.043)	(1.718)
a_{11}	0.1712	0.2017	0.2062	0.1757	0.1825	0.1520	0.2035
	(7.702)	(11.270)	(10.732)	(11.260)	(9.694)	(0.204)	(11.346)
a_{21}	0.6036	0.6037	0.6091	0.6181	0.6186	0.6148	0.6359
	(49.510)	(38.987)	(36.206)	(45.009)	(40.361)	(1.192)	(36.266)
Mean Log-Likelihood	-0.809942	-0.847198	-0.832625	-0.855222	-0.845093	-0.836828	-0.906481

Table A.4.: Minimum Distance Estimate of the Earnings Equation

Dependent variable: Log of monthly labour income in DM

	Income Equation	
Variable	Coefficient	t-Statistic
CONST	6.886	169.734
PEXP	0.606	20.381
PEXP2	-0.107	-20.077
ABI	0.011	0.604
REALS	-0.008	-0.519
HAUPTS	-0.153	-10.067
TT_SCHOOL	0.102	5.846
UNI	0.378	19.786
MARRIED	0.177	11.097
FOREIGN	-0.280	-16.361
VOC_D	0.133	6.537
PUBLIC	-0.064	-5.311
TRADE	-0.015	-0.547
AGFF	-0.174	-2.778
SM_FIRM	$-1.6*10^{-4}$	-0.013
LG_FIRM	0.072	6.294
CH_MAL	-0.075	-5.811
D85	0.003	0.125
D86	0.032	1.519
D87	0.089	4.285
D88	0.140	6.629
D89	0.212	10.266
D90	0.237	10.581

Selection equation

Variable	Coefficient	t-statistic
CONST.	0.823	14.205
AGEG50	-0.068	-1.687
AGEG55	-0.088	-2.755
ALTG60	-0.074	-19.940
M_WS	0.218	4.872
UNM	0.161	3.180
FOREIGN	-0.086	-2.413
CH_MAL	-0.350	-11.064
D85	0.036	0.624
D86	0.117	2.019
D87	0.061	1.074
D88	0.104	1.819
D89	-0.050	-0.882
D90	0.011	0.202
a_{11}	0.219	39.493
a_{21}	0.582	117.508

$$\chi^2\,(\,d.f.\ = 152\,)\ =\ 1668.41$$