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Means Testing and Retirement Choices in Europe: A Comparison of the British and Danish Systems*

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Abstract

We develop a simulation model of household behaviour in which both the consumption/saving and labour/leisure choices are endogenous. This model is used to explore the effects of the UK and Danish state tax and benefit systems on the labour supply of workers aged 50 or over. We find that, in broad terms, differences in labour force participation can be accounted for by differences in benefit structures. Furthermore, our simulations suggest that the UK system is preferred by young people while the Danish arrangement – which imposes a larger tax burden and provides larger welfare benefits – is chosen by people of 50 or older. Notably, people older than 60 are in the majority in the simulated population. The Danish system does not promote notably greater equality over the lifetime, but it does underpin a higher level of consumption for people of 50 or older.

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I. Introduction

The United Kingdom faces what is generally described as a 'pensions crisis'. The Interim Report of the Pensions Commission (2004) has drawn attention to the fact that because the population is ageing and life expectancy is increasing, the proportion of GDP devoted to providing pensions needs to rise by over 5 per cent of GDP if current commitments are to be maintained. This assumes, however, that payments to pensioners are held constant in real terms at today's levels and does not make any additional provision for pensions to increase in line with the likely increase in wages. There is a general consensus that saving is unlikely to rise enough to be able to provide this through funded pensions and it is therefore likely that there will be an additional pay-as-you-go component introduced.

One means of exploring the effects of greater reliance on pay-as-you-go pensions would be to see how the UK might look if it adopted the policy regime of one of its neighbours. Denmark is perhaps the most interesting standard for comparison because it manages to combine a seemingly generous social security system with a high level of labour force participation. The participation rate in the UK in the 55–59 age group is 67 per cent as compared with 80 per cent in Denmark.[1] In contrast, 39 per cent of 60- to 64-year-olds in the UK participate in the labour market as compared with 35 per cent in Denmark. Does the Danish scheme offer a practical solution to the UK pensions crisis or would its introduction lead to a further increase in early retirement in this country? How would people of different ages be affected?

There are a number of ways in which the different aspects of these questions can be assessed. Econometric methods can be used to fit reduced-form models of labour supply / retirement decisions either to a panel of cross-country aggregated data or more satisfactorily (Stock and Wise, 1990; Gruber and Wise, 2004) to information on individuals in the age bracket of interest, explaining their decisions to work or retire in the light of their individual pension arrangements. Bingley, Gupta and Pedersen (2002) discuss retirement behaviour in Denmark in this framework; Blundell, Meghir and Smith (2002) present a study of the UK of similar type.

This approach has, however, the disadvantage that it is not possible to explain the observed model parameters in terms of the fundamental psychological parameters that define the utility function.[2] Thus, when such models are used to try to explain how individuals might react to a change in the policy environment, they are, in effect, subject to the Lucas critique

[1]These figures are taken from OECD data.

[2]Studies typically assume that welfare is derived from income rather than consumption – which is equivalent to the assumption that all income is consumed in the year in which it is earned – and they do not give explicit recognition to the utility derived from leisure.

(Rust, 1995). It is also difficult to use reduced-form models to explore information on saving choices, mainly because of data inadequacy. And in order to explore the welfare effects on people of different ages, some sort of utility function is needed.

The approach that we follow here is therefore to use a calibrated simulation model built round the premiss that, given a particular economic environment as represented by a tax/benefit regime, individuals make optimal[3] work/leisure choices and saving decisions. We then use this structural model to explore the impact on the UK of a shift to the Danish pension system. This approach has the advantage that its findings are grounded in economic theory, making the assumption that people understand their economic environment and react rationally to it. But it has the disadvantage that calibrated models, although widely used, do not fit the data as well as estimated models. Attempts to fit optimising models to panel or even cross-section data are in their infancy (Gourinchas and Parker, 2002); as with other similar work, our model parameters are chosen to have a reasonable fit rather than to satisfy any particular econometric criterion.

While we consider the incentive effects of the Danish system on the UK population, we do not consider the question of affordability. Pension schemes with large pay-as-you-go components may, as the proportion of old people in the population rises, impose increasing fiscal burdens on those currently of working age. The very important question of whether the Danish or, indeed, the existing UK system is 'affordable' can be addressed by means of generational accounts (Cardarelli, Sefton and Kotlikoff, 2000) but is outside the scope of this paper. We make our comparison on the basis of tax and benefit structures as actually observed.

The rest of this paper proceeds as follows. Section II describes the direct tax and benefit systems of the UK and Denmark with a particular emphasis on the transfer schemes that target the elderly. The simulation model used to analyse retirement behaviour is described in Section III, and the derived analysis is reported in Section IV. Section V discusses macroeconomic implications, with conclusions in Section VI.

[3]By optimal choices, we mean that individuals derive utility from consumption and leisure and make their work/leisure and consumption/saving decisions in the light of expected future net earnings if they decide to work and in the light of benefits if they decide not to work. The optimal choices are represented as the solutions to an intertemporal optimisation problem (Sefton, 2000).

II. Two models of social welfare

1. An overview

The current UK transfer system is structured to insure individuals against the risks of extreme hardship, as advocated by the Beveridge Report (1942).[4] In broad terms, the system is comprised of a welfare safety net, which is withdrawn as a household is better placed to provide for its own needs. The Beveridgean welfare system that has been adopted in the UK is commonly described as 'liberal' because of the emphasis that it places upon independence of the individual from government intervention.[5]

The social democratic welfare system adopted in Denmark is similar to the liberal system of the UK, in that welfare benefits are withdrawn in response to the resources that are commanded by a household. In contrast to the UK transfer system, however, the Danish system provides very generous benefits that are designed to facilitate social equity and cohesion. The keystone of the social democratic model is the political objective of full employment, an objective that Denmark – from a European perspective – has successfully pursued for the last 50 years.

In the UK, the Department for Work and Pensions (DWP) reports the tax and benefit profiles for a range of household demographic types that are applicable during the working lifetime. However, these profiles are not considered here for three principal reasons. First, we have not been able to identify similar schedules for Denmark. Second, we are concerned with the practical impact of the respective tax and benefit systems rather than the impact implied by official rules and regulations. The practical impact is commonly observed to be different from the statutory impact due to imperfect take-up rates, miscalculation and misrepresentation. Third, we are principally concerned with the implications of retirement policy, rather than of transfer policy during the working lifetime, and consequently model retirement policy separately. Instead of using profiles such as those supplied by the DWP, we have therefore estimated tax/benefit functions for both countries. We did this by considering the tax/benefit systems in five parts:

1. the application of tax and benefit policy to employed individuals;

[4]The Beveridge Report recommended that the British people should be guaranteed a minimum standard of living in times of sickness, unemployment and retirement, in return for a weekly contribution during employment. The value judgements made in the Beveridge Report can, however, be traced to 1536, when English parishes were first authorised to collect money to support the 'impotent poor'. This embryonic welfare state provided a means of sustenance to the elderly, infirm, blind and insane. See Fraser (1972) on the evolution of the welfare state in Britain up to 1945. On the contemporary development of the British welfare state, see Department of Social Security (2000).

[5]Esping-Anderson (1990) distinguishes between the liberal systems that are commonly found in Anglo-Saxon countries and the social democratic regimes that are typical of Scandinavian countries.

2. the application of tax and benefit policy to individuals not employed between ages 20 and 50;
3. the application of tax and benefit policy to individuals not employed between ages 51 and 64;
4. the application of tax policy to individuals not employed over age 64;
5. an explicit consideration of state-provided pension policies.

As this list indicates, particular care has been taken to simulate the influence of pension policies, which reflects our focus on retirement behaviour. Summary tax and benefits functions were used to simulate the first four of the parts listed above. These functions are described in the following subsection. A detailed description of the pension systems that are considered by the analysis is provided in the two subsections that follow.

2. Country-specific tax and benefits functions

The functions that were used to simulate tax and benefit policy are specified at the household level and were selected to reflect the most pertinent aspects of the respective transfer systems. Each of the functions describes post-tax-and-benefits income of household i, Y_i, by a linear function of pre-tax-and-non-retirement-benefits income, X_i, where both the intercept and the marginal tax rate are specified with regard to the numbers of adults, NA_i, and children, NC_i, in the household. Specifically,

$$\text{(1a)} \qquad Y_i = \alpha_{00} + \alpha_{01} NA_i + \alpha_{02} NC_i + \alpha_{03} \left(NA_i + NC_i \right)^2 + \left(\alpha_{10} + \alpha_{11} NA_i \right) X_i$$

$$\text{(1b)} \qquad Y_i = \beta_{00} + \beta_{01} NA_i + \beta_{02} NC_i + \beta_{10} X_i$$

$$\text{(1c)} \qquad Y_i = \gamma_{00} + \gamma_{01} NA_i + \gamma_{02} D_i^{63} + \gamma_{03} D_i^{64} + \left(\gamma_{10} + \gamma_{11} D_i^{64} \right) X_i$$

$$\text{(1d)} \qquad Y_i = \theta_{00} + \theta_{10} X_i$$

where equation (1a) applies to employed households, equation (1b) applies to not employed households between ages 20 and 50, equation (1c) applies to not employed households between ages 51 and 64, and equation (1d) applies to not employed households 65 years of age and over. D_i^z is a dummy variable that equals 1 for households of age z and 0 otherwise. A household's age is defined by the age of the reference person (usually the household head), and labour status is defined with regard to all household members. Weighted least squares estimates were obtained for the tax and benefit functions using data derived from the European Community Household Panel (ECHP) for 2000–01, and these are displayed in Table 1,

TABLE 1

Post-tax-and-benefit income as a function of household age, employment status, demographics and income before taxes and non-retirement benefits in Denmark and the UK

	UK		Denmark	
Parameter	*Coefficient*	*Standard error*	*Coefficient*	*Standard error*
Employed				
c	367.64*	577.11	245.78*	512.35
na	5,599.37	346.59	5,210.22	522.65
nc	1,899.65	470.35	3,949.16	671.32
$(na+nc)^2$	–215.59	69.19	–409.37	105.81
x	0.476	0.026	0.390	0.011
na×x	–0.032	0.009	–	–
R^2	0.89		0.89	
Standard error	5,041.09		3,478.20	
Not employed, aged 20–50				
c	4,193.88	846.45	763.75*	1,281.69
na	1,689.73	584.74	6,723.97	984.85
nc	1,242.95	217.28	3,893.26	713.87
x	0.345	0.015	0.122	0.030
R^2	0.70		0.65	
Standard error	5,957.37		6,584.99	
Not employed, aged 51–64				
c	1,225.49*	1,266.65	5,489.79	1,484.04
na	4,450.48	853.92	4,357.39	924.86
d63	4,719.98	1,878.65	–	–
d64	4,203.96	1,230.44	–	–
x	0.540	0.139	0.198	0.042
d64×x	–	–	0.527	0.251
R^2	0.63		0.49	
Standard error	6,841.86		4,092.29	
Not employed, aged 65 and over				
c	2,080.76	651.92	1,950.61	976.64
x	0.774	0.059	0.779	0.087
R^2	0.85		0.88	
Standard error	3,035.54		3,165.67	

*Denotes insignificant estimate at 95 per cent significance level.

Variable definitions: Dependent variable = household income net of tax and benefits; c = constant; na = number of adults in household; nc = number of children in household; x = income in pounds from labour, capital and retirement benefits; dyy = dummy equal to 1 at age yy.

with the weights used being those relating to the respondents in the survey.[6] All currency values reported in the table are specified in pounds. Danish figures are converted to pounds using the Purchasing Power Standard (PPS) (£1 = DKK12.55).

The coefficient estimates reported in Table 1 reflect the general properties of the respective transfer systems. In the case of Denmark, the estimates obtained for the working lifetime (under age 65) suggest that relatively high benefits (described by the coefficients that are unrelated to pre-tax income – particularly for the not employed) are offset by high effective tax rates on income. The UK transfer system, by contrast, is characterised by relatively low benefits for households that are not employed during the working lifetime, and withdrawal rates that are lower than those for the Danish system. In the case of single-adult households not employed and between ages 20 and 49, for example, the estimated coefficients suggest that the Danish (UK) transfer system provides benefits of £7,875 (£5,882), subject to a marginal tax rate on private income of 88 (66) per cent. Furthermore, the estimated marginal tax rates imposed on employed households are lower for the UK transfer system consistent with the liberal model. The estimates obtained for the impact of taxes during retirement (ages 65 and over) also reflect the fact that pensions are taxed in both countries.

3. The Danish pension system[7]

This subsection describes the simulated Danish pension system, which is based upon the specification that was applicable during 2003–04. The system is comprised of three tiers: the state-administered public pension (*Folkepension*), the Labour Market Supplementary Pension Scheme (*Arbejdsmarkedets tillægspension*), and occupational and personal pension schemes. The simulations treat all pensions as non-property income for the purposes of taxation. Krone are converted to sterling again using the PPS exchange rate of £1=DKK12.55.

(a) Public pension

The public pension is a universal benefit based upon citizenship and residency requirements, and is paid from age 65.[8] It is financed from general taxation revenues via a pay-as-you-go (PAYGO) framework, and benefits

[6]See Appendix A for details regarding the ECHP.

[7]Much of the material presented here is based upon Abrahamson and Wehner (2003).

[8]To be eligible, an individual must have been in residence in Denmark for at least three years, and for non-nationals 10 years including the five years immediately prior to receiving the pension. The simulations assume that all citizenship and residency requirements are always satisfied.

are defined with regard to the individual. The public pension is comprised of two rates:

- The basic rate, or *grundbeløb*, was equal to DKK54,204 (£4,319) in 2003. This is subject to a taper rate of 30 per cent on wages earned by the pensioner in excess of the basic-rate threshold, equal to DKK230,300 (£18,351) for a single person and DKK159,000 (£12,669) for a couple.
- The pension supplement, or *pensionstillæg*, was equal to DKK54,564 (£4,348) for a single pensioner and reduced by 30 per cent of any income earned in excess of DKK102,000 (£8,127) in 2003. For single-earner couples, the pension supplement was worth DKK25,464 (£2,029) and reduced by 30 per cent for any income received in excess of DKK102,000 (£8,127). For dual-income couples, the pension supplement was worth DKK25,464 (£2,029) and subject to a 15 per cent taper on any income earned in excess of DKK102,000 (£8,127). If a spouse does not receive a pension, then 50 per cent of his or her income is not taken into consideration when calculating the pension supplement.

(b) Labour Market Supplementary Pension Scheme (ATP)

The ATP is a state-administered defined contribution pension scheme that is partly funded and partly PAYGO. Membership of the ATP is compulsory for all employees aged between 16 and 66 working nine hours or more per week.[9] ATP contributions do not depend on income, but vary with the extent of the member's association with the labour market. The normal ATP contribution (the 'A' contribution) was DKK2,684 (£214) per year in 2003 and is paid by most wage earners and by contribution-paying recipients of social benefits.[10] ATP contributions are credited to a notional account, which pays a lifetime annuity from age 65. The annuity paid is equal to DKK100 (£8) for every DKK396 (£31.50) credited to an individual's notional account, an annuity rate of just over 25 per cent. Furthermore, the benefit can be deferred for a period of up to three years, in return for which the annuity will increase by 0.6 per cent for each month of deferral.[11] This scheme is supplemented by the *Saerlige Pensionsopsparing* (SP), which is a defined contribution pension that was introduced in 1999. Membership of SP is mandatory, and it requires all employed individuals to pay a

[9]It is also compulsory for people who receive daily allowances in case of sickness, birth, adoption or unemployment. Civil servants are administered under an alternative system. The simulations presented here do not take into consideration ATP contributions during periods when an individual chooses not to be employed.

[10]The simulations assume that all individuals who are employed accrue DKK2,684 of ATP contributions during a given year.

[11]Deferrals are not taken into consideration by the simulation model.

contribution of 1 per cent of gross income, which entitles them to a 10-year annuity at age 65.[12]

(c) Occupational and personal pensions

Occupational pensions in Denmark are defined by individual agreements between social partners. Membership is linked to employment and is compulsory. As such, occupational pensions are essentially designed as a form of collective insurance. Working members pay contributions as a percentage of their salary (between 8 and 16 per cent), and generally receive a fully funded defined contribution benefit upon retirement. Individuals can also elect to create their own pension funds, referred to as personal pensions, which are subject to similar rules and tax conditions to occupational pensions. Private and occupational pensions are simulated as a form of discretionary saving.[13]

The Danish welfare system also includes an early retirement programme (*Efterlön*) for individuals between the ages of 60 and 64 who have no part-time job or social pension, and who are eligible for unemployment benefits.[14] The Danish early retirement programme is modelled as part of the tax and benefits function defined in subsection II.2 for 50- to 64-year-olds who are not employed.

The Danish welfare system can be helpfully summarised by observing that a single person with no other income receives a state pension of at least £8,667 per annum, and a couple with no other income receives £12,796 per annum.

4. The UK pension system[15]

The simulated UK pension system is based upon the system applicable during 2003–04 and is comprised of three tiers. The first tier consists of the basic state pension (BSP), the second tier of all government-run contributory pension benefits (the State Earnings-Related Pension Scheme (SERPS) and the state second pension (S2P)) and the third tier of all private pension schemes. Furthermore, incapacity benefit is a vehicle commonly used to fund early retirement.

[12]The simulation model applies the same annuity to SP as to ATP, which extends to the full lifetime.

[13]Bingley and Lanot (2004) report econometric estimates which suggest that Danish occupational pensions have a small effect on retirement behaviour, relative to the state pension system (although the effect reported for women is statistically significant).

[14]In principle, an individual must also be a member of an *a-kassa* (a private insurance fund) for at least 25 of the preceding 30 years, although there are some exceptions.

[15]See Department for Work and Pensions (2003).

(a) Incapacity benefit

With regard to its use as a vehicle to fund early retirement, incapacity benefit is payable to individuals who have paid National Insurance contributions (NICs) and have been incapable of work because of sickness or disability for at least four days in a row. Existing legal judgements have assigned a broad interpretation to what defines an individual as 'incapable of work'. The benefit pays £54.40 per week for the first year and £72.15 per week for each succeeding year (in 2003). Early retirement typically occurs in the UK from age 50,[16] and the benefits for not working during this period are consequently modelled separately by the tax functions reported in subsection II.2. Note, however, that two parameters of the UK tax function for not employed households between 50 and 64 years of age were adjusted as part of the model calibrations: the estimates displayed in Table 1 for d63 and d64 were both reduced by twice the associated standard deviations to take into consideration the practical difficulties associated with obtaining incapacity benefit.

(b) Basic state pension

The full BSP, equal to £77.45 per week for a single person and £123.80 for a couple (in 2003), is paid to individuals who have been credited with qualifying years for approximately 90 per cent of their working lives (between age 16 and state pensionable age (SPA) – 60 for women and 65 for men). A qualifying year is defined as one in which an individual has earned an annual income that exceeds the lower earnings limit, equal to £4,004 in 2003, and also includes years of unemployment or incapacitation. This implies that most households qualify for the full BSP. For simplicity, the BSP is consequently modelled as a universal benefit. BSP is funded by PAYGO contributions of current employees. Specifically, annual income earned between £4,628 (the employees' earnings threshold (EET), as at 2003) and £30,940 (the upper earnings limit (UEL), as at 2003) is subject to NICs of 8.95 per cent to fund the BSP.[17]

(c) State second pension

The benefit payable under the second tier of the UK pension system is entirely related to an individual's average earnings over their working lifetime. Membership of the second-tier state pension is compulsory for all employees (but not the self-employed), unless the employee has contracted out into a private pension scheme. Upon reaching SPA, the wages earned by

[16]See, for example, Blundell, Meghir and Smith (2002) for empirical evidence.

[17]The total NIC charged is 11 per cent, 2.05 percentage points of which is used to fund the National Health Service (NHS). Employers are also required to pay NICs above the EET, at a rate of 12.8 per cent (10.9 percentage points of which is used to fund the BSP).

an individual during each year of their working life are rescaled by average wage growth, and the average determined. The average wages earned between £4,004 and £11,200 (in 2003) are multiplied by 0.46, wages between £11,201 and £25,600 are multiplied by 0.115 and wages between £25,601 and £30,940 are multiplied by 0.23. The aggregate of these values determines the individual's annual S2P benefit.[18] Individuals with incomes below the lower earnings threshold (£11,200 per year in 2003) earn S2P entitlements as if their income were at the lower earnings threshold. The S2P is PAYGO, funded through contributions of current workers at a rate of 1.6 per cent on income earned between the EET and the UEL.[19]

(d) Pension credit

Underlying the BSP and the S2P is the pension credit (PC), which guarantees anyone aged 60 or over an income of at least £102.10 per week, or £155.80 per week for a couple (including the BSP). The PC applies a taper rate of 40 per cent on gross private income in excess of the full BSP. The PC is also subject to an assets test. The first £6,000 of assets are ignored, but thereafter an income is imputed to any savings above this threshold at a rate of 10 per cent a year. The pension credit is modelled as part of the tax function described in subsection II.2.

(e) Private and occupational pensions

The third tier of the UK pension system is comprised of private pension schemes, of which there are two types: occupational pensions and personal pensions. Contributions into these schemes are made out of pre-tax income, so that contributions are effectively subsidised (at the basic tax rate) by the government. An occupational pension can usually be classified as either a 'defined benefit' scheme (where the benefits are earnings-related) or a 'defined contribution' scheme (where the benefits are related to the value of the accumulated contributions). Personal pensions are always run on a defined contribution basis. Occupational pensions play an important role in the UK pension system – forming one-half of the so-called public–private partnership, they account for approximately 50 per cent of total pension entitlements.[20] Private and occupational pensions are simulated as a form of discretionary saving.

The minimum incomes available in the UK pension system are calculated directly from the arrangements for the pension credit and amount to £5,309

[18]For example, if an individual earned the equivalent of £40,000 in one year, then they would be credited with £6,194.02 = 0.46×(11,200–4,004) + 0.115×(25,600–11,201) + 0.23×(30,940–25,601).

[19]The 'contracting-out' rebate on NICs.

[20]See, for example, Blake and Orszag (1997, table 12).

for a single person and £8,102 for a pensioner couple per annum. When comparing these with the pensions available in Denmark, it has to be remembered that, on a Purchasing Power Parity basis, GDP per capita is about 5 per cent higher in Denmark than in the UK. But pensioners are about 60 per cent better off in Denmark than in the UK.

III. The simulation model

A partial equilibrium dynamic microsimulation model is used to explore the influence of retirement policy on household saving and retirement decisions. A summary of the model is provided here – for full details, see Sefton and van de Ven (2004).

The decision unit in the model is the household. Each household is aged by annual increments, from 20 to 90 based upon the age of the household's reference person.[21] In every year, the household decides whether to work full-time or not at all (households are treated as having an aggregate labour supply),[22] and how much to consume given its economic situation, under the constraint that its net worth must remain positive. A broad definition is assumed for the economic situation of a household, which includes the household's age, its size, the wealth that it has managed to accumulate, the interest rate, the level of means-tested income support available and the wage that it can command for its labour. This (real) wage rate evolves stochastically reflecting the fact that earnings are subject to random processes.

The household is forced to retire when it reaches state pensionable age, if it has not already chosen to do so. In retirement, the household pays for its consumption out of its savings or out of income derived from pensions and investments.

Simulated households are described by seven characteristics:

- the number and age of household members;
- time of death;
- the wage rate of the household;
- the labour supply of the household;
- household consumption;
- household wealth;
- household (mandatory) defined benefit (DB) pension entitlement.

[21]See Social Survey Division, Office for National Statistics (2001, volume 1) for the definition of a household reference person.

[22]An alternative version of the model allows households to work part-time. This option is omitted here to focus attention upon the issue of retirement.

Demographic size and composition: The size of each household varies with time to reflect the coupling of individuals, and the birth and ageing of children who eventually leave home. Household size is, however, modelled in a predetermined fashion, and consequently behavioural effects are not considered in this dimension. Size is measured using the McClements scale, which reflects economies of scale in household operation and gives lower weights to children than to adults. For models of endogenous fertility, see Nerlove, Razin and Sadka (1984) and Barro and Becker (1989).

Household mortality: Each household is selected to die, based upon an exogenously defined survival function. Importantly, households do not know a priori when they will die; they know only the probability of death at any age. This means that the model is able to capture the precautionary savings that households are likely to accrue to offset the effects of uncertain life expectancy. The model treats death probabilities as exogenous and does not include any interaction between death rates and wealth or past earnings.

The wage rate: We need to distinguish the wage a household can command, or its earning power, from its actual earned income; the latter depends also on the amount of labour it chooses to supply. The wage rate of a household is simulated as a stochastic mean-reversion process. However, experience has shown that, in such models, it is very difficult to simulate a choice of full-time work. A learning-by-doing effect implies that future earning power depends on past labour market experience. This makes full-time working by young people more likely because working full-time not only generates more current income but also enhances future earnings prospects. As in the case of mortality, households are assumed to know the process by which the wage rate evolves, but are unable to predict future income perfectly due to its stochastic nature.

The parameters assumed for the number of adults, the number of children and the probability of death are displayed graphically in Appendix B as functions of the age of the household head. Details regarding the calibration of the wage rate are also reported in Appendix B. The parameters are exogenously imposed and are specified to reflect the UK as it is described by survey data for 2000. Demographic size is specified in terms of the average numbers of adults and children per household, as recorded for the UK in 2000. The mortality rates imposed are based upon World Health Organisation life tables for the UK in 2000. The wage rate is calibrated to capture distributional dynamics described by panel data for the UK up to 2000.

Labour force status, consumption and wealth: Household decisions regarding labour supply, consumption and saving are endogenous to the model, reflecting the outcome of optimising choices. As this is fundamental

to the simulation model, a detailed description of the methods involved is provided in the following subsection.

Labour force status, consumption and wealth

Households choose their labour supply and consumption in every period. These choices are made as if they are maximising their expected utility subject to a lifetime budget constraint. Sefton (2000) presents an efficient means of solving this problem. The expected lifetime utility is described by the additively separable function

$$(2) \qquad U = E\left(\sum_{i=t}^{70} u\left(\frac{c_i}{m_i}, l_i \right) \delta^{i-t} \phi_{i-t,t} \right)$$

where $c_t \in R^+$ is household consumption, $m_t \in R^+$ is the household's adult equivalent size and $l_t \in [0,1]$ is household leisure at time *t*. The parameter δ is the discount factor (which is assumed to be time-independent), and $\phi_{i-t,t}$ is the probability of surviving to age *i–t*, given survival to age *t*. From the state pensionable age, $t_P = 65$, the household is forced to retire – that is, $l_t = 1$ for all $t \geq t_P$.

A constant elasticity of substitution (CES) utility function is assumed; it is defined by

$$(3) \qquad u(C_t, l_t) = \frac{1}{(1-1/\gamma)} \left(C_t^{1-1/\rho} + \alpha^{1/\rho} l_t^{1-1/\rho} \right)^{\frac{1-1/\gamma}{1-1/\rho}}$$

where γ is the intertemporal elasticity of substitution and ρ is the elasticity of substitution between $C_t = c_t / m_t$ and l_t. The higher the value of ρ, the higher the proportional change between consumption and leisure for a given proportional change in prices. Similarly, the larger the value of γ, the higher the proportional substitution between consumption today and consumption tomorrow for a given change in interest rates. Wealth in any period, W_{it}, is constrained to be non-negative and is given by

$$(4) \qquad W_{it+1} = W_{it} - c_{it} + y_t^{DI}(W_{it}, y_{it}, m_{it})$$

where $y_t^{DI}(W_{it}, y_{it}, m_{it})$ is the disposable post-tax-and-benefit income obtained by a household of age *t* given wealth W_{it}, pre-tax-and-non-retirement-benefit income y_{it} and adult equivalent size m_{it}. Since there is a positive probability of death at any age, this constraint is justified by the

principle that people cannot become net debtors because of the risk that they may die insolvent. Pre-tax-and-non-retirement-benefit income is obtained from real returns to investment, $RW_{it} = rW_{it}$, from labour during the working lifetime, $h_{it}(1-l_{it})$, and from defined benefit pension rights during retirement, S_{it}:

$$(5) \qquad y_{it} = RW_{it} + h_{it}\left(1-l_{it}\right) + \left(S_{it} \mid t \geq t_P\right).$$

Following an extensive search, the following parameter values were found to obtain the closest approximation to observed survey data:

$$\gamma = 0.5,\ \rho = 0.3,\ \alpha = 0.00121,\ \delta = 0.96 \text{ and } r = 0.05$$

IV. Analysis of retirement behaviour

We can now simulate the model in two distinct cases. First of all, we assume that the UK tax/benefit regime is in place. This tells us how well the model, or rather the assumption that people are motivated in the manner represented by the model, fits the UK data. Second, we can ask what would happen if the UK tax/benefit scheme were replaced by the Danish one, in terms of people's work/leisure and consumption/saving decisions. We compare the simulated data for the UK with actual data from the ECHP and other relevant sources, before reporting the impact on retirement behaviour of replacing the UK transfer system with the Danish one.

1. Simulated and survey data for the UK

We would ideally compare our simulation model with the actual data for 2003, since this is the year for which we have represented the tax/benefit system. However, the most recent year for which comprehensive data are currently available is 2000; we rely mainly on the seventh wave of the ECHP (tenth wave of the British Household Panel Survey (BHPS)). This wave of data provides comprehensive information regarding household wealth in the UK.[23] However, we also show the performance of our labour force participation simulations against OECD data for 2002.

It can be argued that cross-sectional data do not describe the actual life experience of any actual cohort, and that this detracts from the practical relevance of the analysis undertaken. However, given the uncertainty that is associated with demographic trends and income growth, the assumption that expectations are based upon the current cross-section does not appear completely inappropriate. The focus on cross-sectional survey data does,

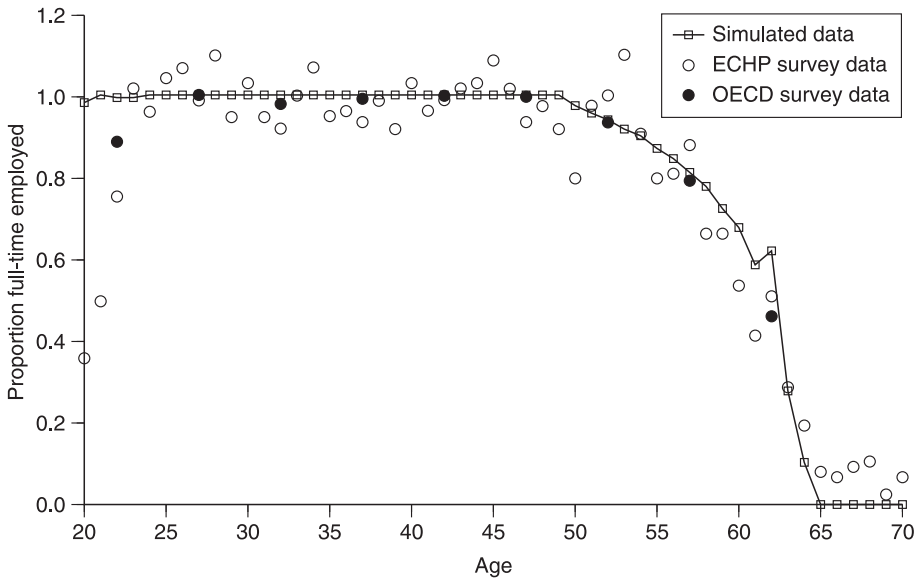
[23]See van de Ven (2004) for details.

nevertheless, imply that care should be exercised when interpreting statistics that aggregate over the simulated lifetime. Although the simulated profiles are behaviourally consistent, they do not describe the experience of any actual cohort. As such, the simulated profiles are better suited to considering broad effects of policy over the lifetime, rather than the fine detail.

Figure 1 displays average labour force participation rates by age, as derived from simulated data and as described by ECHP and OECD data.[24] Figure 2 shows the geometric mean of full-time pre-tax wages for individuals classified by age. Take-home pay, shown in Figure 3, includes benefits but is net of taxes and is calculated on a household basis. Data reported in Figure 1 reveal that simulated early retirement begins at age 50 and progresses so that approximately one-third of the population (32.6 per cent) have departed the workforce by age 60 and 28 per cent are identified as working by age 63. This trend of departure from the labour force is broadly consistent with both the ECHP and OECD data displayed in Figure 1.

FIGURE 1

Labour force participation for the UK in 2000–01: simulated and survey data



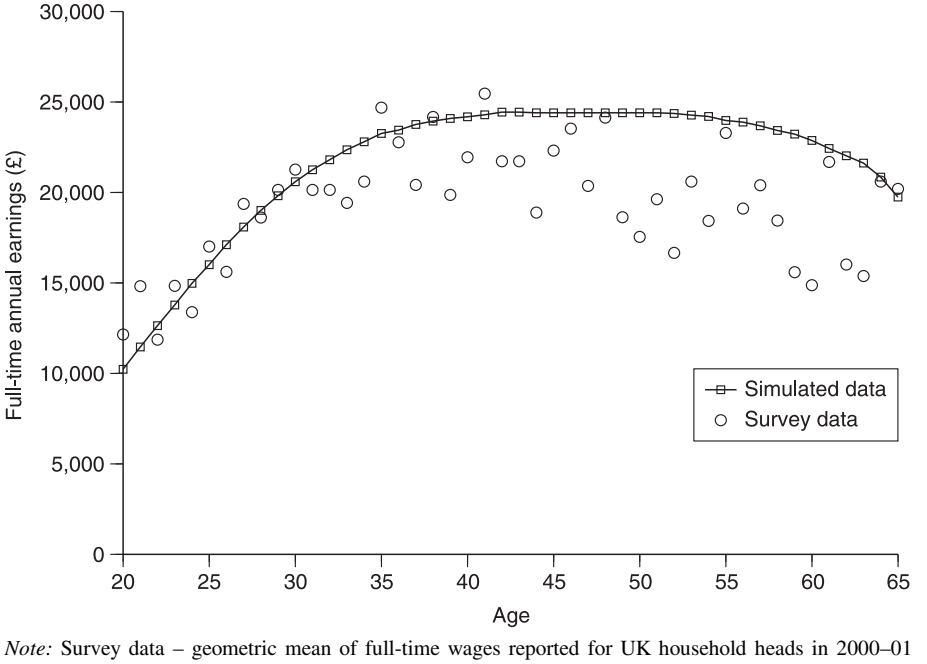
Notes:
ECHP survey data – average employment status reported for UK household heads in 2000–01 wave of European Community Household Panel; adjusted to full employment for 25- to 45-year-olds.
OECD survey data – activity rates for UK men and women in 2002; five-year age groups allocated to midpoints; adjusted to ensure full participation for 40- to 44-year-olds.

[24]Data from the ECHP and OECD are adjusted to reflect the fact that involuntary unemployment is not included in the simulations presented here.

Figures 2 and 3 suggest that the simulation model reflects the relationship between household income and age described by cross-sectional data fairly closely, although the model does depart from the data when representing the employment income of full-time employees over about 45. Since take-home pay fits better, the problem might be resolved in future work by means of more detailed tax functions allowing the wedge between earnings and pay to be better modelled. The observed disparity between the simulated household take-home pay and the associated survey data over age 64 is attributable to the fact that households are forced to retire by age 65 in the simulation model, but may continue to draw upon labour income at higher ages in practice.[25]

FIGURE 2

Average full-time employee income (human capital) for the UK in 2000–01: simulated and survey data

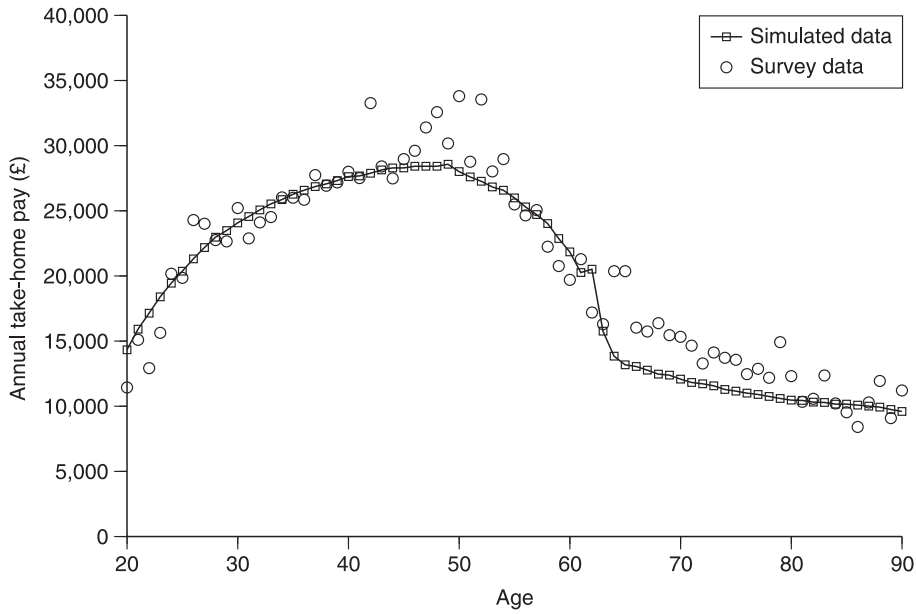


Note: Survey data – geometric mean of full-time wages reported for UK household heads in 2000–01 wave of European Community Household Panel.

[25]The associated survey data were obtained from the Family Expenditure Survey (FES) due to the finer detail that that survey provides regarding the definition of household income. See Appendix A for details regarding the FES.

FIGURE 3

Average household take-home pay for the UK in 2000–01: simulated and survey data



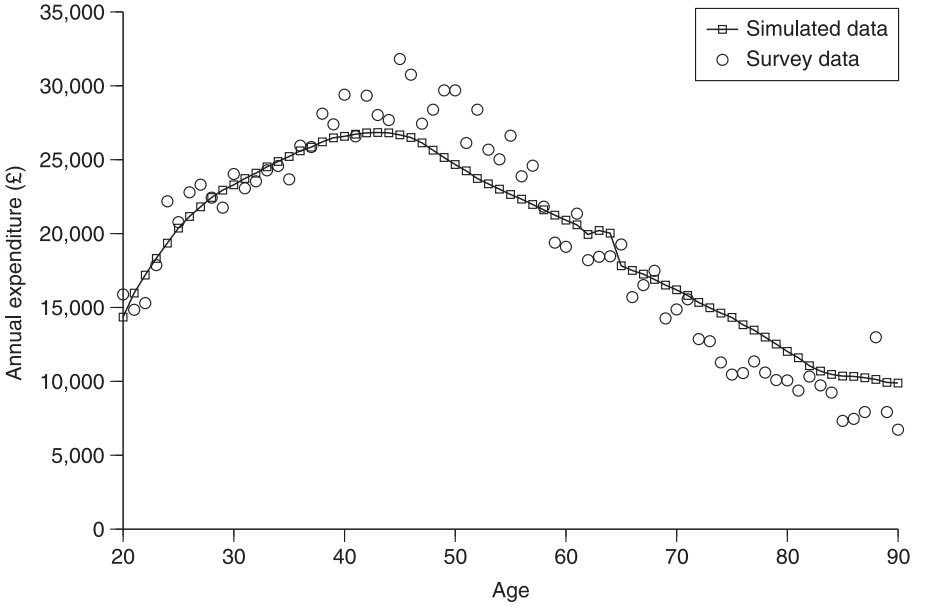
Note: Survey data – average post-tax-and-benefit income reported for UK households in 2000–01 Family Expenditure Survey.

Figure 4 reports simulated household expenditure and expenditure data described by the 2000–01 Family Expenditure Survey (FES). Survey data were taken from the FES in response to the fact that the measures of household expenditure recorded by the ECHP (BHPS) are incomplete. Figure 4 indicates that the hump-shaped profile of household expenditure described by survey data is approximately reflected by the simulation model, although expenditure appears to be underpredicted systematically between ages 38 and 57 and to be overpredicted for ages above 71. This latter observation can be explained by the fact that simulated households are assumed to die with certainty by age 90.

Household wealth as generated by the simulation model is defined to include all financial and housing assets, and accrued rights to the S2P, personal and occupational pensions. The methods used to impute these data from the ECHP (BHPS) are described in van de Ven (2004). Figure 5 reports the simulated data and the wealth data derived from the ECHP. This graph suggests that the simulation model captures the hump-shaped profile that can be inferred from survey data. In the case of wealth, however, the simulations systematically underpredict observations drawn from survey data for almost all ages, an observation that warrants extended comment.

FIGURE 4

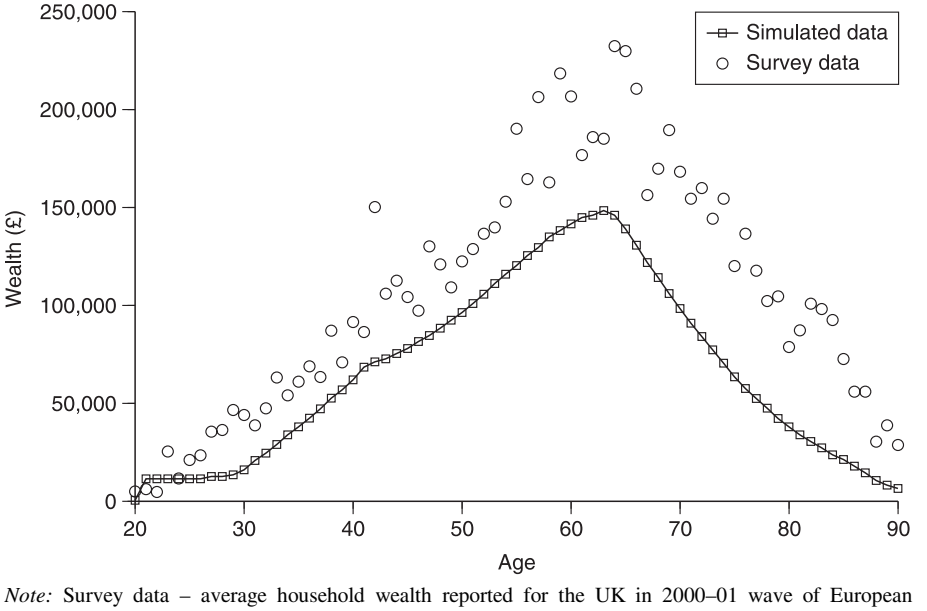
Average household expenditure for the UK in 2000–01: simulated and survey data



Note: Survey data – average household expenditure reported for the UK in 2000–01 Family Expenditure Survey.

FIGURE 5

Average household wealth for the UK in 2000–01: simulated and survey data



Note: Survey data – average household wealth reported for the UK in 2000–01 wave of European Community Household Panel.

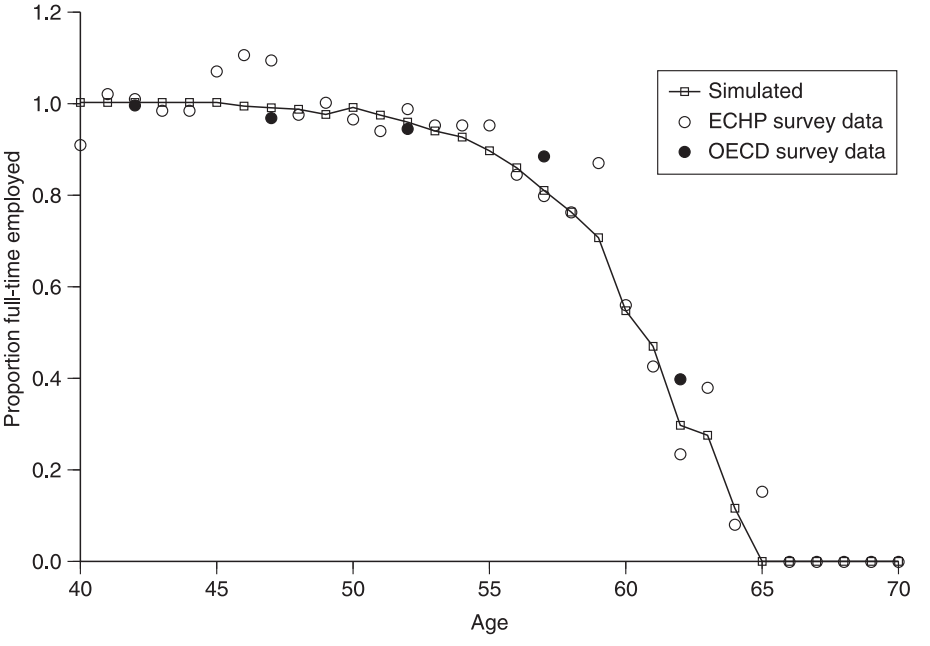
The wealth comparisons between the simulated and survey data referred to above are, in a sense, inconsistent with the associated income and expenditure comparisons – if the simulated income (inflow of wealth) and expenditure (outflow of wealth) profiles with age match survey data reasonably well throughout the lifetime, then the same should be approximately true for (the stock of) wealth. It is clear something is missing from the system. Two considerations are of particular note here. First, the survey data against which the simulation model is compared are drawn from a single cross-section, and hence do not describe the experience of any one cohort (as discussed above). Second, the cross-section used for calibration had experienced a particularly high real rate of return as a result of the stock market boom of the 1980s and 1990s. Given that this high rate of return is unlikely to persist over the longer run, the simulation model is based upon a more realistic return of 5 per cent.

2. Incentive effects for retirement behaviour of the Danish benefit system

The preceding subsection reveals that the simulation model generates a close reflection of UK survey data when the UK tax and benefit system as described in Section II is applied. We address first how far retirement behaviour in Denmark and the UK is affected by the benefit environment by exploring what choices UK households would make if subject to the Danish transfer system. Given the current focus on retirement behaviour, discussion of this question begins with associated figures that display the impact on labour supply. Analysis based upon the parameter estimates reported in Table 1 for the Danish transfer system suggested very low labour participation rates for people of all ages. This is consistent with the particularly generous transfer benefits implied by the Danish estimates and with the relatively high tax rates. To mitigate the difficulties associated with this issue, the intercept terms of the tax and benefit functions for individuals not employed and between ages 20 and 65 were multiplied by a factor of 0.75. This adjustment is rejected by an F-test at any reasonable confidence interval. Nevertheless, the adjustment can be rationalised by assuming that it reflects the impact of measures taken by the Danish government to discourage benefit receipt, or an associated social stigma. Denmark has created an environment where benefits appear generous but are not available indefinitely. The write-down assumed here reflects this aspect, which makes the benefit system 'not as good as it looks'. It follows immediately from this that if the UK were to adopt the Danish welfare system without also taking on board additional measures designed to discourage people of working age from 'living on welfare', then labour market participation would be much lower than current levels.

FIGURE 6

Simulated UK labour supply rates when subject to the Danish transfer system vs. observed Danish labour supply rates



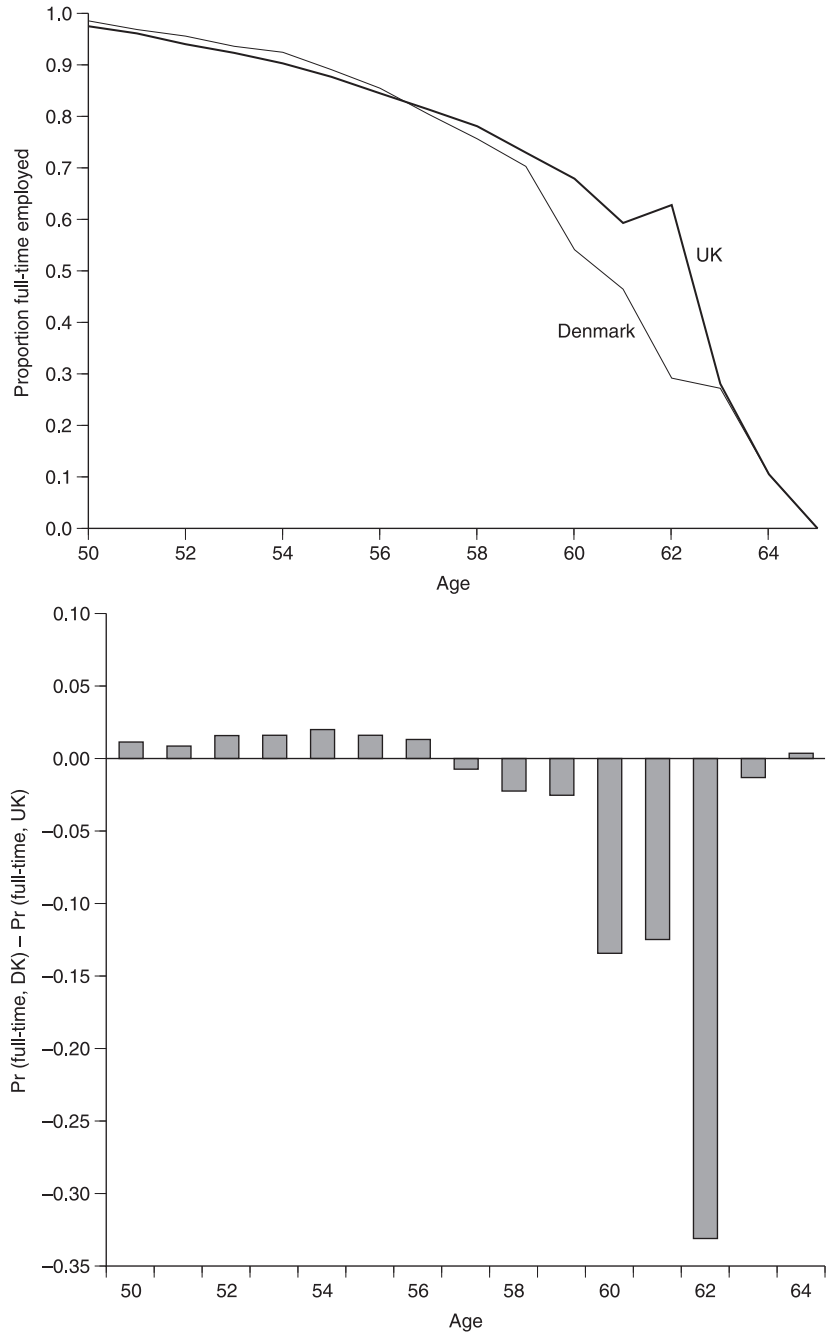
Notes:
ECHP survey data – average employment status reported for household heads in 2000–01 wave of European Community Household Panel; adjusted to full employment for 29- to 48-year-olds.
OECD survey data – activity rates for men and women in 2002; five-year age groups allocated to midpoints; activity rates adjusted to ensure full participation for 30- to 34-year-olds.

Figure 6 displays simulated data regarding labour supply by age for the Danish transfer system, and associated ECHP and OECD survey data. The graph shows that, despite its obvious simplicity, the model does a reasonable job of capturing the incidence of early retirement in Denmark.

Figure 7 presents data that are useful for considering the predicted answer of the simulation model to the question 'What would be the effect on the timing of retirement if the elements of the UK transfer system described in subsection II.4 were replaced by the analogous elements of the Danish transfer system as described in subsection II.3?'. The top panel of Figure 7 reports the proportion of the simulated cohort that was identified as full-time employed, by age and simulated transfer system. The bottom panel is obtained from the top panel by subtracting the age-specific proportion of the population identified as full-time employed under the UK transfer system, from the associated proportion identified when subject to the Danish transfer system. The bottom panel of the figure consequently highlights the

FIGURE 7

Impact on timing of retirement of alternative transfer systems: simulated data



Note: pr(full-time, XX) = proportion of population full-time employed by age for country XX; simulated data.

simulated effect on early retirement of replacing the UK transfer system by elements of the Danish transfer system. Data are presented here for the 50–65 age band to focus upon the issue of early retirement.[26]

Figure 7 indicates that replacing the UK transfer system by that of Denmark increased simulated labour supply slightly between ages 50 and 56, and resulted in accelerated early retirement between ages 57 and 63. These observations are approximately consistent with the associated ECHP and OECD survey data, which suggest that the UK has slightly lower labour market participation at the earliest ages of retirement, but has higher participation for the 60–64 age group. In the case of OECD data, for example, the unadjusted activity rate of 45- to 49-year-old men and women in 2000 was 85 per cent for the UK and slightly higher at 88 per cent for Denmark. Furthermore, the participation rate of 50- to 54-year-old men and women was substantially lower for the UK (80 per cent) than the same data for Denmark (85 per cent). By the 55–59 age group, the OECD data indicate that the UK has a lower participation rate (67 per cent) than Denmark (80 per cent). However, the participation rate for 60- to 64-year-olds is 39 per cent in the UK as compared with 35 per cent in Denmark. We replicate the higher UK participation among this age group but are unable also to replicate the higher labour force participation in Denmark among 55- to 59-year-olds. This may be an aspect of the fact we have observed above that participation in Denmark is generally higher than would be expected given the structure of the tax/benefit system.

It is useful to consider how the respective transfer systems affect post-tax income, household wealth and expenditure to gain some insight into the labour market effects discussed above. In this respect, Figure 8 is particularly interesting. The top panel of the figure indicates that pre-tax-and-benefit incomes simulated under the two alternative policy regimes are very similar, which is a fundamental aspect of the analytical framework adopted. We explore the implications of applying the Danish system to the UK; in consequence, pre-tax incomes differ only because of differences in employment rates induced by differences in the tax/benefit system. The bottom panel of Figure 8 suggests that, compared with the Danish transfer system, the UK transfer system imposes a lower average tax burden on working households and provides a smaller pension during retirement. These two effects of transfer policy act to encourage continued labour force participation in old age in the UK, as observed.

An additional implication of the income data displayed in Figure 8 is that the UK transfer system places a greater emphasis on self-provision for

[26]It should be noted that the limited calibrations undertaken for the tax function of the working lifetime mean that the model fails to capture important labour supply effects at the time of labour market entry (to age 29 for Denmark).

retirement than the Danish transfer system. The impact that this has upon simulated behaviour is displayed in Figure 9; by contrast to Figure 5, this shows only holdings of *financial* wealth. Figure 9 indicates that households save more under the UK transfer system than under the Danish transfer system. This reflects the substantial role played by private and occupational pensions in the UK relative to Denmark.

FIGURE 8

Simulated household pre-tax income and take-home pay by age and transfer system: population averages

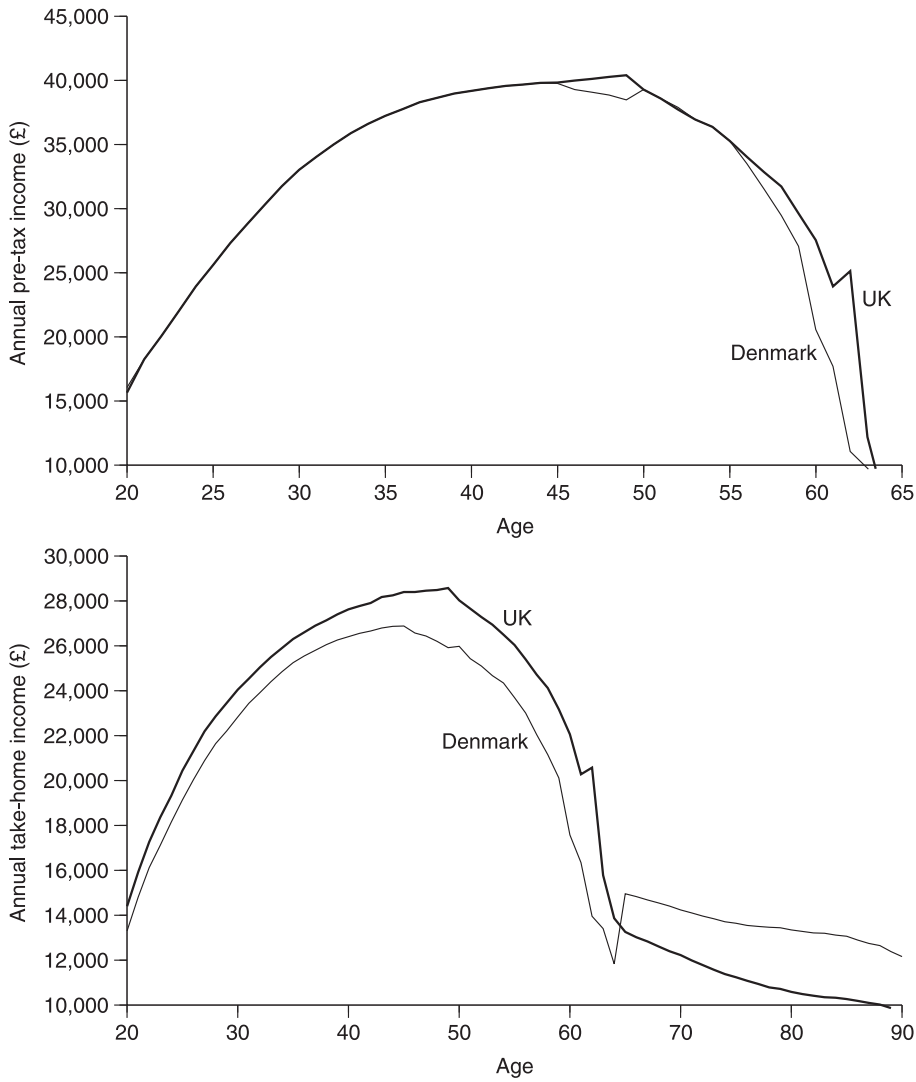
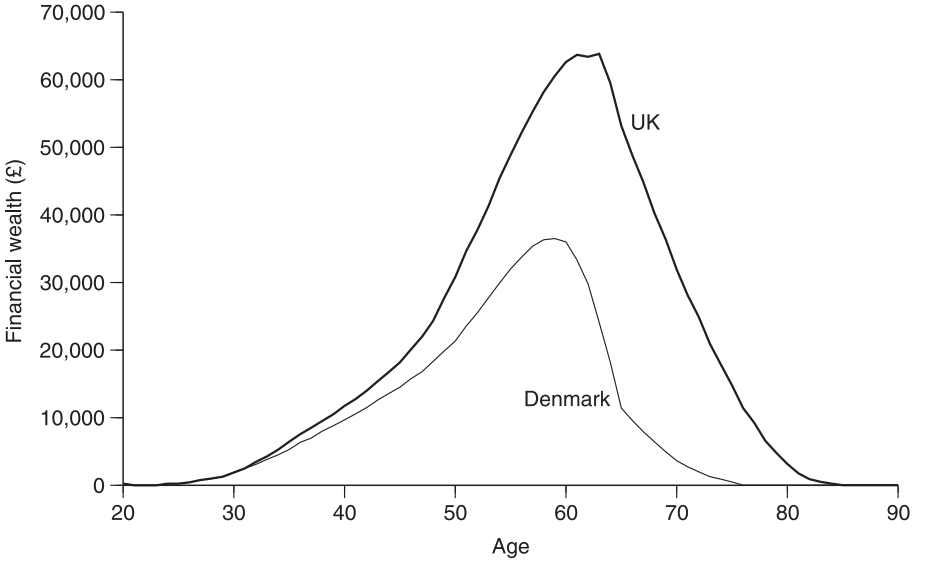


FIGURE 9

Simulated average household financial wealth holdings under the Danish and UK transfer systems

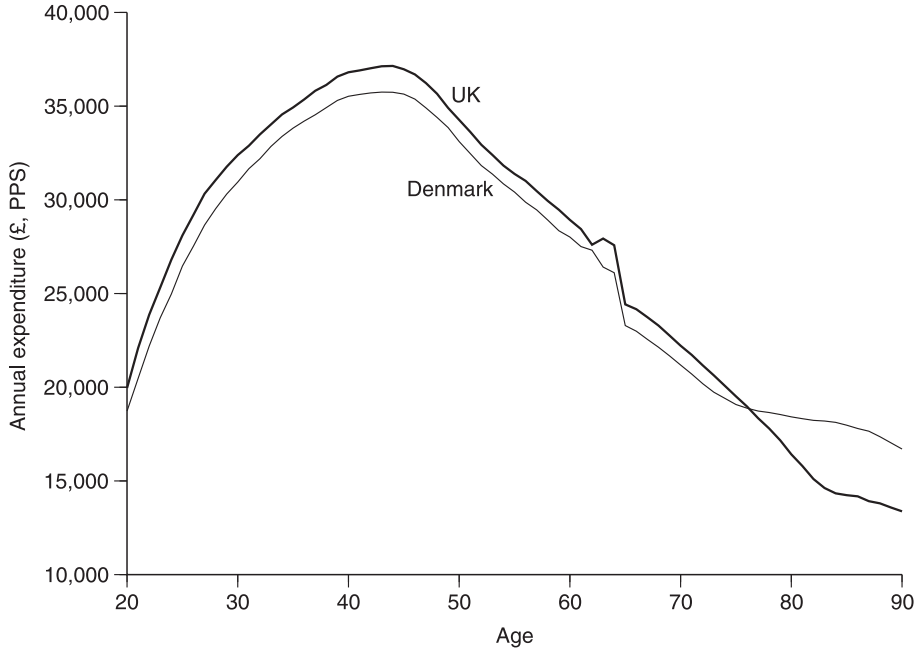


In summary, the simulated behavioural responses to tax and benefit policy imply that replacing the UK transfer system by the Danish transfer system would accelerate earlier retirement. The most important effect of the policy experiment considered here is on household savings, which adjust to compensate for the alternative generosity of the respective pension policies considered. This result serves to underscore the potential importance of including savings and household wealth in an analysis of retirement behaviour.

The smoothing effect of household savings is revealed by measures of average annual expenditure calculated under the two policy regimes, displayed in Figure 10. This graph indicates that the simulated profiles of household expenditure are very similar for both policy regimes, where the most important difference is attributable to the simulated wealth constraint. The simulation procedure adopted implies that households face a less binding wealth constraint following retirement under the UK transfer system, due to the lower proportion of their savings that are annuitised. At the same time, the system of means testing discourages spending late in life and encourages consumers to bring forward their spending. For both these reasons, households choose to shift some of their consumption from retirement to their working lifetime under the UK transfer system, relative to the Danish transfer system.

FIGURE 10

Simulated average household expenditure by age and transfer system



V. Macroeconomic implications and voter preferences

In this section, we explore the effects of the different schemes on people's welfare at different points in their lives. These figures, unlike comparisons of disposable income, take account of discounted welfare over the whole of the remaining life span and allow for the fact that people respond to the tax/benefit environment by varying both labour supply and saving decisions. The implications of the statistics that reflect lifetime behavioural responses cannot be properly reflected in models subject to the Lucas critique.

Both the differences in the underlying costs of the schemes and the differences in the participation rates they induce affect the budgetary implications of the schemes. Table 2 shows the net budgetary contribution made by households in quinquennial age groups and also the total lifetime contribution. The figures are calculated for each age group and weighted by the size of the age group in a steady-state population with death rates as implied in official life tables. The Danish figures are corrected for the fact that, in order to generate employment rates in Denmark close to those observed, we had to write down the value of the Danish benefits; thus here

TABLE 2

Net taxes and transfers paid by households under the Danish and UK systems

Pounds per annum

	Transfer system	
Age group	*UK*	*Denmark*
20–24	2,917	4,211
25–29	6,753	8,058
30–34	9,878	11,031
35–39	11,330	12,361
40–44	11,545	12,732
45–49	11,639	12,638
50–54	10,403	12,612
55–59	7,935	9,311
60–64	567	–1,900
65–69	–10,565	–14,282
70–74	–10,485	–13,838
75+	–10,275	–13,109
Total lifetime payment	5,612	5,620
Discounted lifetime payment	3,208	3,651

the calculations are performed with the true budgetary cost. The total contributions are shown both discounted back to the beginning of the working life assuming a real discount rate of 5 per cent per annum and without discounting. These figures are all positive, reflecting the fact that only a part of taxation is used to pay for benefits; the surplus goes to pay for the other services governments provide. The table shows that the total net payment over a lifetime is much the same in the two countries. However, discounted back to the start of the working life, the net payment is appreciably higher in Denmark. Thus the Danish system takes money from people when they are young in order to return it when they are old, but offers a rate of return lower than the assumed 5 per cent interest rate in the process. Indeed, the discount rate that equates the present value of the two systems to a 20-year-old is very close to zero, as the near equality between the two undiscounted lifetime figures implies. With a target rate of return higher than this, the UK offers a better deal to its representative subject starting out on working life.

Our model also allows us to identify who gains and who loses with each of the systems in place. Since we are able to construct a measure of welfare from equation (2), we can work out, for a household with any particular wage trajectory, whether its lifetime welfare is higher with the Danish or with the UK welfare system. The result of such a poll may be history-dependent; thus someone who reaches a given age having planned on the

basis of the UK system in place may prefer the UK system to remain in place, while someone who reaches the same age expecting the Danish system to persist may prefer the Danish system. The question we focus on is whether a household that has lived with the UK system up to a given age and planned on the basis of that would prefer to experience the UK or the Danish system for the remainder of its life. Thus we can explore the preferences of the median voter in each age group and also in the economy as a whole.

The message from this exercise is clear. Households prefer the UK system up to the age of 49 but after that the median voter would vote for a switch to the Danish system. The demographic structure of the country is such that, in the population as a whole, a majority would prefer a switch to the Danish system. Voters prefer the UK system when they are young and the Danish system when they are old. The reason for this is quite straightforward. Young voters favour the low tax rates in the UK while old voters favour the generous benefits offered by the Danish system.

Nevertheless, if we look at the welfare of a voter starting his or her working life at the age of 20, welfare is higher with the UK than with the Danish system, and a benevolent social planner would therefore adopt the UK rather than the Danish system. The difference between the two choices arises because children under 20, including those not yet born, are affected by the choice of regime. A fortiori, they should be expected to prefer the UK system. Their preferences do not, however, enter into the median voter analysis. These calculations are performed for a stable population. As the post-war population bulge passes the age of 45, the Danish system is likely to become harder and harder to reform and the UK may experience increased pressure to move towards something similar to the Danish structure.

It might be thought that this finding is a consequence of our earlier observation that the discounted budgetary cost of the Danish system is higher to a young person whereas without discounting the UK system is dearer; this obviously implies that as people age, the attractions of the UK system decline relative to those of the Danish scheme. However, Sefton and Weale (2003) find that, in a stylised example with budget balance maintained in each period, young voters typically prefer low labour taxes and means testing, while, as people approach retirement, they prefer a regime of higher benefits and higher taxes to go with them.

VI. Conclusions

The results of this paper present stark findings. The lower labour force participation of people aged 60–64 in Denmark can be substantially

attributed to the nature of the state pension scheme in Denmark. Thus its introduction in the United Kingdom would not be in line with UK government policy to reduce the incidence of early retirement. But the findings are stronger than that. The high level of labour force participation in Denmark by both young and old workers is something of a surprise, given the generosity of the tax/benefit system. In recent years, Denmark has taken steps to discourage people from living on welfare; without such arrangements here, the introduction of the Danish tax/benefit system would be likely to lead to a sharp fall in labour market participation at all ages. Thus the Danish model does not offer a solution to the UK pensions crisis even if, which we have not discussed, the population structure is such as to make the system affordable.

The Danish and UK systems impose much the same net payments by the average household to the exchequer. However, this masks higher payments early in life and larger benefits later in life, leading to a situation where, at any positive discount rate, the discounted burden on a young household is higher with the Danish system than with the UK system. Nor is this preference of the 'average' household simply an outcome of a skewed distribution. We also find that in each age group up to people in their late 40s, the median voter prefers the UK system to the Danish system. However, voters over 49 typically prefer the Danish system, and the degree of longevity is such that, even for a steady-state population, such voters will be in the majority. This draws attention to obvious political problems which countries with generous pension systems may find difficult to resolve.

Appendix A. Survey data

1. European Community Household Panel and the British Household Panel Survey

The European Community Household Panel (ECHP) is 'the most closely co-ordinated component of the European system of social surveys' that are collected by Eurostat (the statistical office of the European Union). The ECHP provides detailed panel data for households that are drawn from 15 EU countries, spanning the period between 1994 and 2000 (the most recent year for which data have been made available). The data are collected at annual intervals, and so build up an historical record of 60,500 nationally representative households.[27]

The ECHP data that are considered in this paper have been sourced by Eurostat from the British Household Panel Survey (BHPS) for the UK and from a National Data Collection Unit commissioned by Eurostat for Denmark.

[27]See Eurostat (2003) for further details regarding the ECHP.

The BHPS is a panel survey of households that were originally selected to provide a nationally representative sample of the UK population.[28] The first wave of the survey was undertaken in 1990 and includes information for 13,840 individuals drawn from 5,511 households. Subsequent waves have been undertaken annually, to provide a survey history for individuals who were approached in the original wave (and their subsequent households). The most recent wave released by the Office for National Statistics (ONS) supplies data for the year 2000–01 (the tenth consecutive wave) and is of particular interest because it includes a suite of questions that are designed specifically to describe household wealth. When combined with the time-series aspect of the survey, these questions provide a valuable source of wealth data for the UK.[29]

The variables used to undertake the analysis presented in this paper were extracted from the ECHP using SPSS programs. The authors may be contacted for further details.

2. Family Expenditure Survey

The Family Expenditure Survey (FES) is a cross-sectional survey that provides a detailed description of household expenditure, income and demographic characteristics. The model calibrations are based upon expenditure data derived from the 2000–01 FES, which records information for a nationally representative sample of 6,115 households that were randomly selected from the Small Users file of the Post Office's list of addresses.[30] Expenditure data are obtained for the FES from a diary that is kept by each responding adult during a two-week period. Data on some expenditures are based on individual recall or the most recent bill.

[28]Due to the repeated survey methods employed, the most recent wave of the BHPS no longer provides a representative sample of the UK population. See Taylor (2001) for further details regarding the BHPS.

[29]There are currently three main sources of wealth data for the UK: the General Household Survey (primarily for housing wealth), the Family Resources Survey and the British Household Panel Survey. An alternative source that will provide detailed information for the English population over the age of 50 is the English Longitudinal Study of Ageing, the first wave of which has yet to be released. Following a review of these alternative data-sets, the BHPS was identified as the most comprehensive source of wealth data currently available for the UK.

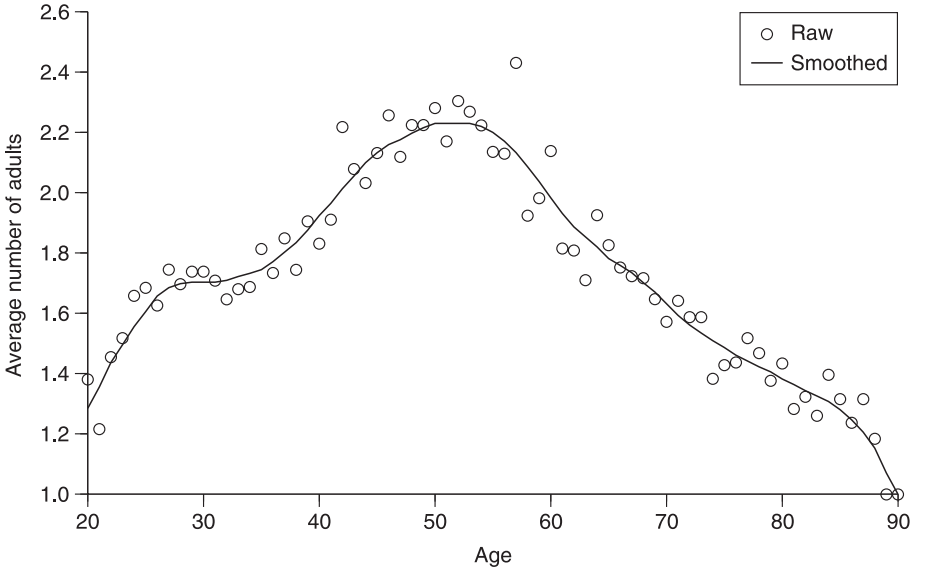
[30]For further information, see Social Survey Division, Office for National Statistics (2001).

Appendix B. Parameters used for simulations

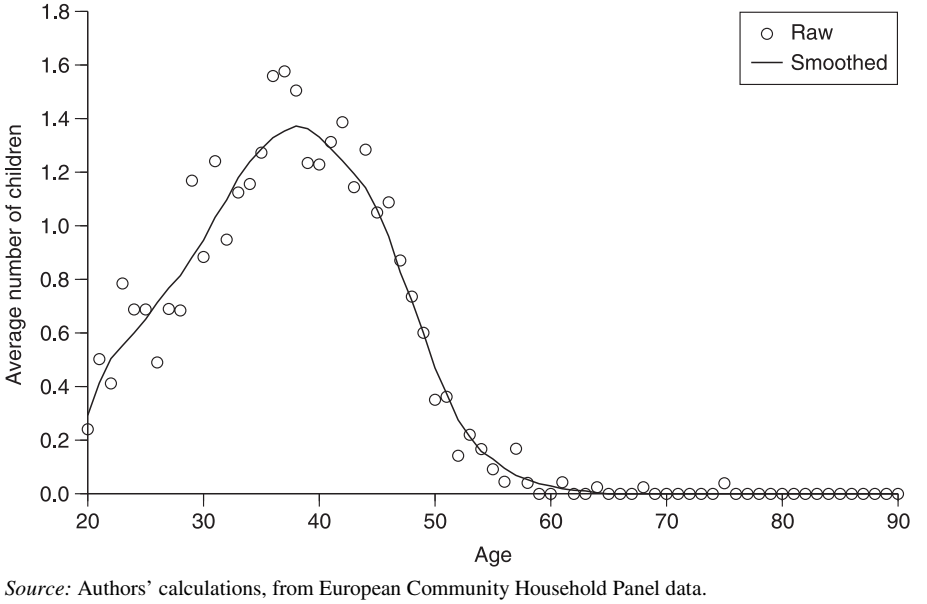
FIGURE 11

Household size by age of reference person

Number of adults



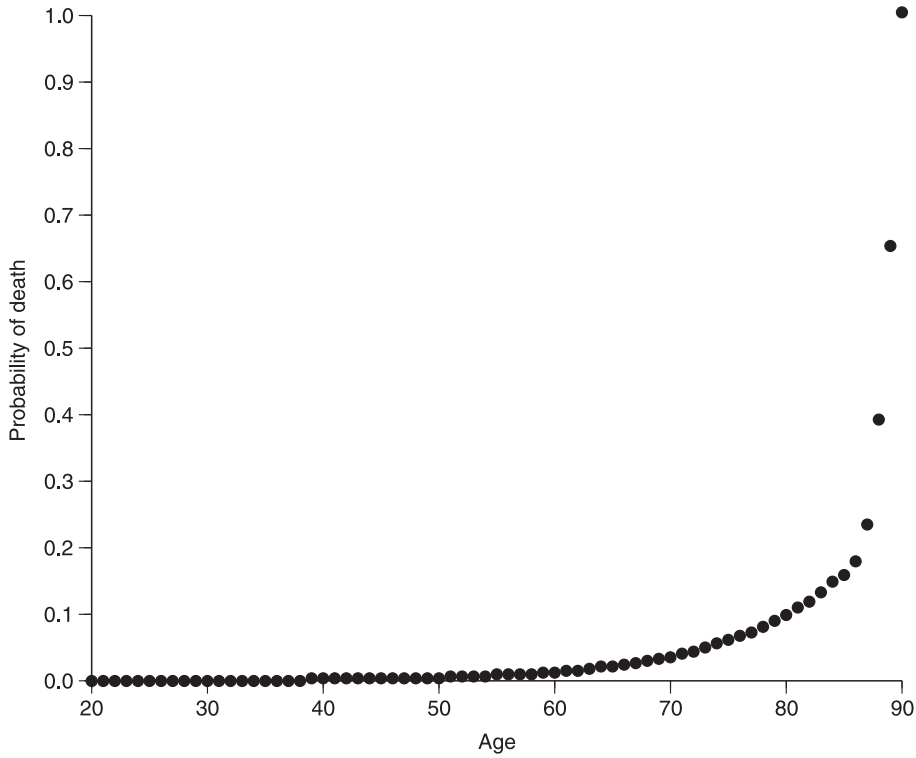
Number of children



Source: Authors' calculations, from European Community Household Panel data.

FIGURE 12

Mortality probabilities by age



Note: Probabilities after age 85 subject to manual adjustment to ensure death by age 90.
Source: World Health Organisation Life Tables for the UK, 2000.

The wage rate

The model used to generate the wage rate, as discussed at length by Sefton and van de Ven (2004), is defined by

$$h_{it} = \beta^R h_{it-R} + \sum_{s=1}^{R} \beta^{s-1} \left(\theta w_{it-s} + f\left(t+1-s\right) + \varepsilon_{it+1-s} \right) \quad (6)$$

where h_{it} is the (log) full-time annual wage of household i at age t, w_{it} is a dummy variable that takes a value of 1 if the reference person of household i is full-time employed at age t and 0 otherwise, and $f(.)$ is a cubic polynomial of age.

Equation (6) was estimated using a sample selection model of individual full-time employment wages.[31] This model takes into consideration the facts

[31]The regression was undertaken using the 'Sampsel' procedure in TSP, full details of which can be obtained from the *TSP 4.4 User's Guide* (see elsa.berkeley.edu/wp/tsp_user/tspugpdf.htm).

that wages are only observed for individuals who are working and that there is likely to be a relationship between the probability of working and the wage rate.

The sample selection model involves estimating two equations – a probit to identify individuals who are employed and a (log) wage equation. The probit equation predicts the probability that an individual is employed, given various demographic, health and economic variables. Estimates for a probit model that was arrived at after trialling various alternatives are reported in Table 3. Two sets of regression estimates for equation (6) are reported in Table 4, one in which $R = 3$ and another in which $R = 6$. Both of these regressions use observations for the UK drawn from the ECHP for 2000–01 to describe h_{it} for household reference people. Table 4 also includes 'restricted estimates', which are used for the simulation analysis. The relationship between the various regression models for which estimates are reported in Table 4 is discussed at length by Sefton and van de Ven (2004).[32] The relationship between the income profile implied by the restricted estimates reported in Table 4 and the ECHP survey data is displayed in Figure 13.

TABLE 3

Probit regression of full-time employment

Parameter	*Estimate*	*Standard error*
c	–12.176	3.47
age	0.991	0.348
age^2	–0.032	0.013
age^3	4.60×10^{-4}	1.95×10^{-4}
age^4	-2.69×10^{-6}	1.10×10^{-6}
nc	–0.339	0.032
male	1.017	0.058
couple	0.038	0.068
car	0.487	0.085
roomst	0.039	0.019
bad health	–1.439	0.228
good health	0.232	0.057
Correct predictions	0.788	

Notes:
nc = number of children; roomst = number of rooms in principal residence
The following dummy variables take the value 1 when true and 0 when false:
male – household reference person is male
couple – reference person is part of a couple
car – household owns a car
bad health – reference person reports bad or very bad health in period *t*–3
good health – reference person reports good or very good health in period *t*–3

[32]All currencies are specified in terms of Purchasing Power Standards (PPS), obtained by dividing the national currency by the relevant Purchasing Power Parity (PPP). The PPPs used were calculated by Eurostat and are provided with the ECHP.

The geometric mean assumed for the wage rate at age 20 is £9,426 and the standard deviation of log wage rates is 0.40, both of which are derived

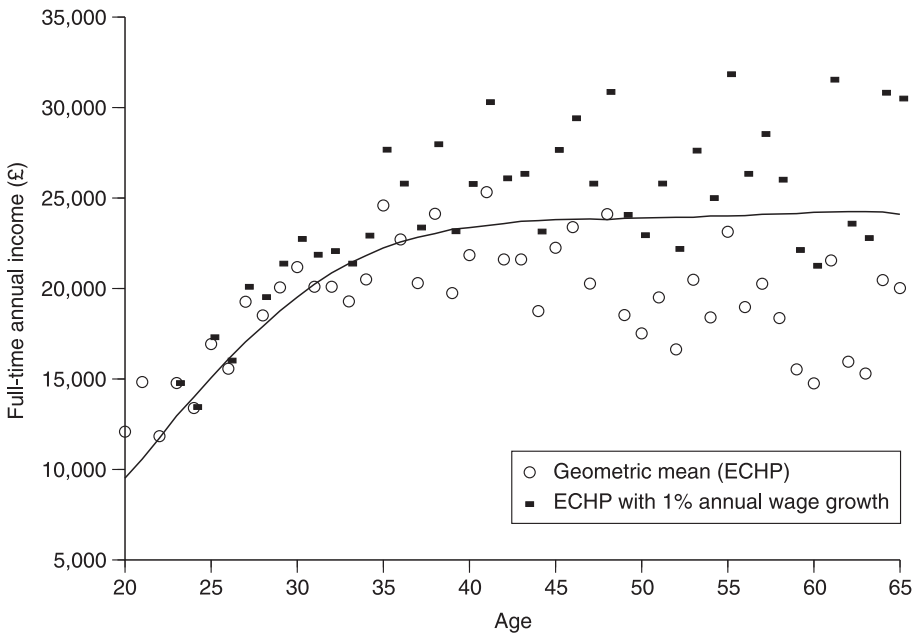
TABLE 4

Econometric estimates of human capital equation

	$R = 3$		$R = 6$		Restricted estimates	
	Estimate	*Std error*	*Estimate*	*Std error*	*Estimate*	*Std error*
beta	0.829	0.008	0.882	0.006	0.975	NA
theta	0.081	0.034	0.108	0.022	0.057	0.021
c	1.549	0.180	1.062	0.119	0.631	0.097
age	0.020	0.013	0.005	0.009	–0.024	0.007
age^2	-5.41×10^{-4}	3.26×10^{-4}	-2.26×10^{-4}	2.24×10^{-4}	4.64×10^{-4}	1.88×10^{-4}
age^3	4.42×10^{-6}	2.59×10^{-6}	2.30×10^{-6}	1.80×10^{-6}	-2.91×10^{-6}	1.53×10^{-6}
inverse mills	–0.143	0.030	–0.158	0.038	–0.029	0.042
R^2	0.510		0.384		0.363	
Std error	0.333		0.373		0.425	
Adj. std error	0.154		0.106		0.149	

FIGURE 13

Estimates of full-time earnings by age



Source: ECHP and authors' calculations.

from ECHP data. The standard deviation of the temporal variation term, ε_{it}, is assumed to equal 0.1489, which was calculated from the econometric estimate for the standard deviation of the restricted regression reported in Table 4.

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