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MEANS TESTING RETIREMENT BENEFITS: FOSTERING EQUITY OR DISCOURAGING SAVINGS?*

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Means testing plays an important role in the UK state pension system. We use a dynamic programming model to consider the effects of a recent policy reform that reduced the marginal tax rates on private income of means tested retirement benefits from 100% to 40%. Our analysis suggests that the policy reform will encourage the poorest third of all households to both save more and delay retirement, and have the opposite effects on richer households. The policy reform provides a reasonable compromise between the distortions associated with high marginal tax rates and the costs of universal benefits provision.

Means testing of state pensions has been criticised for discouraging individual savings and work effort, and thereby creating a dependence on the welfare state. Yet means testing does enable benefits to be targeted to poorer households, which supports greater equity of incomes in retirement. Furthermore, high taper rates (also referred to as phase-out or marginal tax rates) provide sharp disincentive effects for relatively small numbers of people, while lower taper rates imply that more people are exposed to weaker disincentive effects. These countervailing criteria imply that choosing the 'most appropriate' degree of means testing is a particularly complex problem. The problem is further complicated when applied to state pensions, in which case the evaluation should take into consideration the effects of expectations of retirement benefits on the work/leisure and consumption/saving decisions made by people of working age. Here we develop the framework needed for such an assessment. We use this framework to explore the long-run micro and macro-economic implications of a recent change to the means testing of retirement benefits in the UK, which moved from narrowly targeted benefits with a high taper rate, to more diffuse benefits with a lower taper rate.

The policy reform considered for analysis was implemented in the UK on 6 October 2003, and, for a fixed benefit, reduced the taper rate on private income (including investment income and annuitised private pensions) from 100% to 40%.[1]

Our analysis suggests that individual responses to the policy change considered will differ widely across the wealth distribution. The improved rates of return at the lower end of the distribution motivate the poorest third of households to increase their savings between ages 65 and 69 by 20–27% of average annual full-time employment income, and to work an additional 0.4–0.5 years. In contrast, the middle third of

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[1] The fixed benefit (the excess of the Pension Guarantee to the Basic State Pension), was equal to 5.6% of average gross full-time employment income for a single person (£24.65 per week) and 7.3% of average employment income for a couple (£32.00 per week) in 2003/4. Hence, the taper rate applied to the first £24.65 per week of private income for a single pensioner prior to the policy reform (at a 100% taper rate), and to the first £61.63 per week (= 24.65/0.4 or 14% of average employment income) following the reform (at a 40% taper rate). Average gross income for all full-time employees in the UK was £437 per week in winter 2003/4 (Labour Force Survey Historical Quarterly Supplement, Table 37, available from the National Statistics website: http://www.statistics.gov.uk/).

households choose to reduce their savings between ages 65 and 69 by 26–30% of average annual employment income, and to work 0.3 years less. We find that, with fixed taxes and factor prices, the behavioural responses of low income households will dominate the long-run impact on retirement, so that households will work an additional 5–8% of a year on average. In contrast, the policy change produces a small fall in aggregate savings (by between 1% and 3.4% of average annual employment income) and a reduction in the lifetime tax burden paid by households (by between 2% and 11% of average annual employment income).

Furthermore, we find that replacing means tested benefits with a universal pension that omits means testing entirely would tend to exaggerate the behavioural responses discussed above. However, a universal pension also implies a substantially larger burden on the public purse. Our analysis suggests that marginal tax rates on employed households would need to increase by 1.4% to cover the additional cost associated with provision of a universal pension. This tax rise is found to have a substantial impact on the behaviour that we identify for the policy counterfactual, discouraging employment and leading to lower disposable incomes and consumption during the working lifetime. After using a tax change on employment income to maintain budgetary neutrality, we find that households obtain lower expected lifetime utility under the universal pension than they do under *either* the Pension Credit or the Minimum Income Guarantee, which is of particular interest given the attention that the universal pension has received in the contemporary pensions debate.

The pension reforms that are considered here are best described as changes to a *means test*, as distinct from the *earnings tests* that are more commonly applied to retirement benefits outside of the UK. The distinction is important, and motivates the assumed framework of analysis. Whereas earnings tests tax returns to labour – and have been adopted to encourage exit from the labour market; means tests also tax returns to savings and are designed to limit eligibility to those who lack the capacity to provide for their own needs. The policy reforms that are considered here are described as applying to private income, although the associated pension schemes that were applied in practice also included wealth tests. This issue is discussed at length in Section 2. Consideration of the effects of means tested policy consequently requires a focus on forward-looking behavioural responses and associated distributional implications. This is distinct from the literature that considers behavioural responses to pension earnings tests, which focuses upon aggregate labour supply responses of individuals who are eligible for immediate benefits receipt: see, for example, Friedberg (2000), Gustman and Steinmeier (2004) and French (2005) for the US and Disney and Smith (2002) for the UK. Understanding how means tested pensions affect retirement behaviour is important beyond the UK context, because means testing provides a useful tool for addressing the fiscal sustainability problems that are currently associated with state pension systems throughout the developed world.

Most of the literature that has considered behavioural responses to means testing focuses on non-retirement benefits (Hubbard *et al.*, 1995; Powers, 1998; Gruber and Yelowitz, 1999; Heer, 2002 and Chou *et al.*, 2004). These studies have found that asset-tested benefits reduce saving incentives of poorer households due to two effects: a reduced precautionary savings motive (due to the insurance that is provided by the benefit against extreme financial need – this effect would exist regardless of the degree of means testing) and high implicit tax rates imposed by the means tests. In contrast to this literature, however, a focus on old age pensions de-emphasises the role played by precautionary savings, as lifetime income uncertainty diminishes close to retirement (Gourinchas and Parker, 2002). Consequently, although qualitatively similar, the quantitative effects of means testing pension and non-pension benefits are possibly quite different.

Very few studies have considered the behavioural implications of means testing retirement benefits. Neumark and Powers (1998; 2000) have, however, explored the effects of means tested Supplemental Security Income (SSI), an old age benefit provided in the US. Both of these studies focus on estimates obtained by difference-in-difference statistical methods that exploit variation in the generosity of SSI benefits between US states. They report that more generous SSI benefits reduced savings and labour supply of household heads who were approaching retirement age and were likely to be participants of the programme. Disney and Smith (2002) also adopt a difference-in-difference approach to consider behavioural responses to earnings tested pensions in the UK.

Neumark and Powers (1998) note that 1.55 million people out of 27.9 million, or just over 5% of the US population over age 64, were in receipt of SSI in 1984. SSI recipients are limited to a small proportion of the retired US population because the benefit is focused on poverty relief. In contrast, the means tested pensions considered here apply to a much broader section of the UK population – Brewer and Emmerson (2003) estimate that a third of all families containing an individual over age 65 would have been eligible for means tested benefits prior to the reform considered here, and that over half were eligible after the reform. It is interesting to consider how means testing of such an important part of the state pension system – as distinct from a poverty orientated benefit – affects retirement behaviour.

From a methodological perspective, the difference-in-difference approach considered by Neumark and Powers (1998; 2000) imposes minimal structural restrictions and is consequently useful for identifying behavioural responses to a policy experiment that are described by survey data. However, the method of analysis is not appropriate for considering behavioural responses to policy counterfactuals. Furthermore, in drawing their policy conclusions both studies focus on the behavioural responses of individuals who are identified as likely benefits recipients, and do not take into consideration associated distributional issues.

Given the emphasis on forward-looking behaviour noted above, the current study explores responses to means tested pension policy using a structural Dynamic Programming (DP) model of behaviour. Other examples of studies of retirement behaviour based on structural DP models are provided by Gustman and Steinmeier (1986), Rust and Phelan (1997) and French (2005). Households are considered to choose their consumption and labour to maximise expected lifetime utility, subject to uncertainty regarding incomes and time of death. The advantage of this approach is that it makes explicit assumptions about individual expectations and preferences that are considered important in determining retirement behaviour, but are unobserved. This can be contrasted, for example, with a study by Atkinson *et al.* (2002), who use a standard micro-simulation model (EUROMOD) to explore the effects of a minimum pension on pensioner poverty. The non-behavioural nature of EUROMOD meant that Atkinson *et al.* were limited to reporting impact effects, and were unable to explore how people on the retirement margin might react to their considered policy counterfactual.

French (2005) provides a recent example of the literature that explores retirement behaviour using DP models of savings and labour supply. In that study, the parameters of the model were estimated by Method of Simulated Moments (MSM), to match mean assets, average hours of work, mean participation and median assets described by survey data to the corresponding moments of the same variables in a simulated sample. Higher order moments were not considered 'because of problems with measurement error' French (2005, p. 401). In this study we adopt a different strategy in the selection of model parameters, as we are more interested in the distributional consequences of means testing, rather than in population aggregates. We show that in-sample variation in the real wage, the timing of retirement and consumption changes around retirement can be used to identify unobservable preference parameters. These characteristics are used to calibrate the model via a grid-search procedure.

The article is organised as follows. Section 1 describes the policy counterfactual that is considered for analysis, and provides statistical evidence of the importance of means tested retirement benefits for the UK population. Section 2 describes the structural dynamic programming model that we use to analyse behavioural responses to the considered policy counterfactual. The intuition for our analytical results is developed in the context of a simple two period model in Section 3. Model calibration is described in Section 4, and results of the analysis are presented in Section 5. The article has been structured so that the policy-focused reader may omit Sections 2 and 4 without substantial handicap. A summary of results and associated discussion are provided in a concluding section.

1. The Policy Environment and Empirical Observations

The UK pension system includes an almost universal flat rate Basic State Pension (BSP). There is also a mandatory second tier, or earnings related, pension. Individuals must either pay contributions to the state run Pay As You Go earnings related scheme, or opt out and pay contributions into a privately funded scheme. At retirement, individuals may be eligible for means tested benefits, depending upon their wealth and private income. Means-tested benefits were administered under the Minimum Income Guarantee (MIG) until October 2003, when MIG was replaced by the Pension Credit (PC). This policy reform is the focus of the current article. For further details of the system see *A Guide to State Pensions*, Department for Work and Pensions, NP46, April 2004.

The replacement of the MIG with the PC reduced the taper rate on additional income support for people over State Pension Age (SPA), currently 65 for men and 60 for women, from 100% to 40%. The practical impact of means tested pension policy under the MIG is revealed by Figure 1, which divides the retired population described by the 2001/2 Family Resource Survey into quintile groups, based upon their private income (defined as the sum of private pension income, earnings, and investment income). The bars displayed in Figure 1 indicate the average income received by each

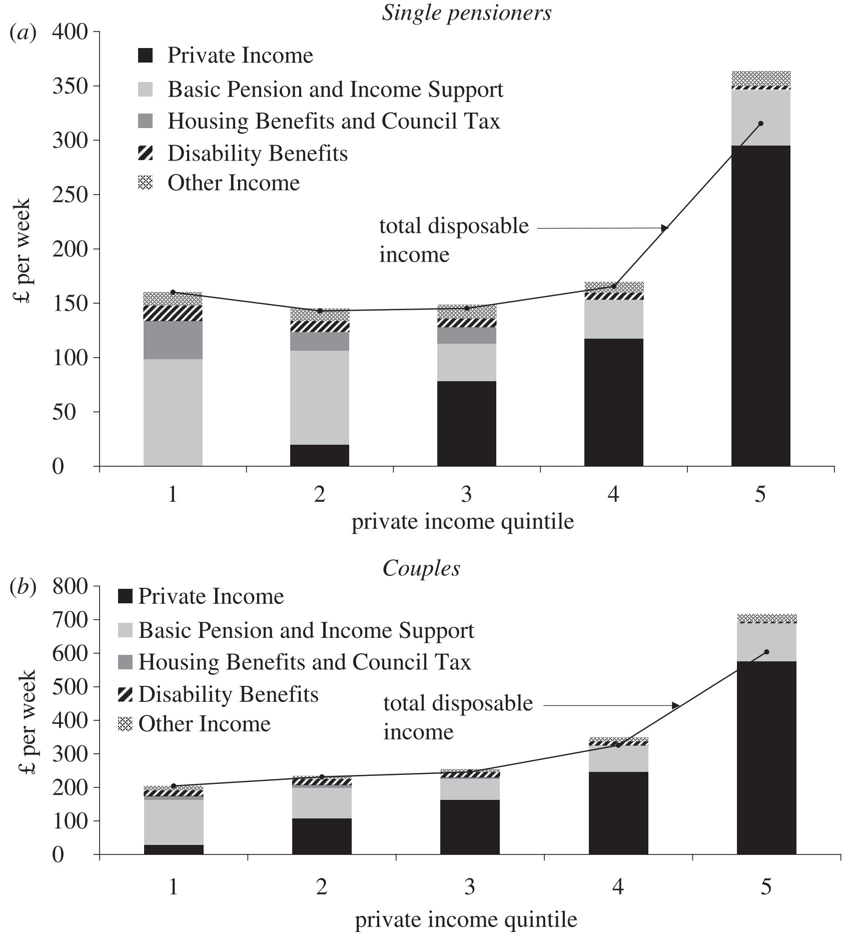

Fig. 1. *Breakdown of Total Income for Retired Households, by Private Income Quintile,* 2001/02
Source: Author's calculations using data from the Family Resources Survey 2000/01

quintile group, distinguished by income source. The aggregate of these components gives gross household income. 'Total Net Income', obtained after the deduction of associated taxes, is also reported in the Figure.

Figure 1 dramatically demonstrates the important distributional effects of means tested pensions in the UK. In particular, for single pensioners, although the fourth population quintile receives substantially more private income than the lowest quintile, it is scarcely better off in terms of total disposable income. Qualitatively similar results are also reported for retired couples in panel (*b*) of the Figure, and were obtained for single male pensioners (not reported here).

2. The Model

The model considers lifetime consumption and labour supply decisions of households in annual increments, from age 20 to the maximum potential age of 110. Households are considered to choose whether to supply labour and how much to consume in each period to maximise expected lifetime utility, subject to a wealth constraint and uncertainty regarding time of death and future labour income. We begin by defining the assumed preference relation, before describing the wealth constraint, and the Section concludes with an explanation of the approach adopted to solve the lifetime utility maximisation problem. This last subsection is more technical in nature, and the general reader may wish to skip over it.

2.1. *The Utility Function*

Expected lifetime utility of household i at age t is described by the time separable function:

$$U_{i,t} = \frac{1}{(1-1/\gamma)} \mathrm{E}_t \sum_{j=t}^{110} u\left(\frac{c_{i,j}}{\theta_{i,j}}, l_{i,j}\right)^{1-1/\gamma} \delta^{j-t} \phi_{j-t,t} \tag{1}$$

where $\gamma > 0$ is the intertemporal elasticity of substitution (of total expenditure), E_t is the expectations operator, $c_{i,t} \in R^+$ is composite nondurable consumption, $l_{i,t} \in [0,1]$ is the proportion of household time spent in leisure, and $\theta_{i,t} \in R^+$ is adult equivalent size based upon the McClements' scale (McClements, 1977). This form of adjustment for household size in the utility function is discussed by Balcer and Sadka (1986) and Muellbauer and van de Ven (2004). The McClements' scale depends upon the numbers of adults, $n^a_{i,t}$, and children, $n^c_{i,t}$ in a household, and its inclusion in the preference relation reflects the fact that household size has been found to have an important influence on the timing of consumption, e.g. Attanasio and Weber (1995) and Blundell *et al.* (1994). To simplify the analysis, we assume household size has a deterministic age profile. $\phi_{j-t,t}$ is the probability of living to age j, given survival to age t, and δ is the discount factor, which is assumed to be the same for all households and time independent.[2]

A Constant Elasticity of Substitution function was selected for within period utility,

$$u\left(\frac{c_{i,j}}{\theta_{i,j}}, l_{i,t}\right) = \left[\left(\frac{c_{i,j}}{\theta_{i,j}}\right)^{(1-1/\varepsilon)} + \alpha^{1/\varepsilon} l_{i,t}^{(1-1/\varepsilon)}\right]^{\frac{1}{1-1/\varepsilon}} \tag{2}$$

where $\varepsilon > 0$ is the (period specific) elasticity of substitution between equivalised consumption $c_{i,t}/\theta_{i,t}$ and $l_{i,t}$. The constant $\alpha > 0$ is referred to as the utility price of leisure. The specification of intertemporal preferences described by (1) and (2) is standard in the literature, despite the contention associated with the assumption of time separability (Deaton and Muellbauer, 1980, pp. 124–5; Hicks, 1939, p. 261).

The specification of (2) implicitly assumes that characteristics which affect utility, but are not explicitly stated, enter the utility function in an additive way. The division of individual expenditure into consumption and leisure focuses attention upon savings

[2] See, for example, Gustman and Steinmeier (2005) for a structural analysis of household savings and retirement decisions that allows for a varying discount factor between households.

and labour supply behaviour. It is an application of the composite commodity theorem, which is motivated in the current context by our consideration of behavioural responses to means tested pension policy that does not discriminate between alternative consumption goods (Hicks, 1939, ch. 2, § 4.)

The partial differential of (1) with respect to consumption, $c_{i,t}$, and leisure, $l_{i,t}$, is given by:

$$U_{cl} = \left(\frac{1}{\varepsilon} - \frac{1}{\gamma}\right) \frac{U_c U_l}{u^{1-1/\gamma}} \tag{3}$$

where we use the standard notation to denote partial derivatives (of within period utility, u). As within period utility and the marginal utilities of consumption and leisure are all positive, consumption and leisure are direct substitutes ($U_{cl} < 0$) when $\varepsilon > \gamma$, and direct complements ($U_{cl} > 0$) when $\varepsilon < \gamma$. Only when $\varepsilon = \gamma$ are consumption and leisure additively separable. Importantly, econometric studies have found that the assumption of additive separability is strongly rejected by the data (Ziliak and Kniesner, 2005).

2.2. *Household Labour Supply*

We consider a dichotomous model of labour supply in which households from age 20 to 64 are either employed $l_{i,t} = l_W$, or not employed $l_{i,t} = 1$. An employed household is considered to allocate 30% of the time available to its adult members to work, $l_W = 0.7$. From age 65 (the State Pensionable Age, SPA, of men), the household is forced to retire if it has not already done so, in which case $l_{i,t} = 1$ for all $t \geq t_{SPA} = 65$. The labour supply decision is considered to be made between discrete alternatives to reflect the fact that people often cannot choose their hours of work (Fagan, 2003). The discrete nature of the labour supply decision that is considered here also has the advantage that it provides a clear definition of retirement – an obvious benefit given the focus of this article; an earlier analysis which provided a third intermediate category had little impact on the overall outcomes.

It should be noted, however, that the assumption of a dichotomous labour supply decision is likely to dampen the responsiveness of labour supply behaviour implied by the simulation model. Calibration of the model is consequently likely to require a labour elasticity that overstates the practical reality. Furthermore, omitting heterogeneity in the labour supply decision is likely to imply that the calibrated income process will involve more variation than applies in practice. With regard to this last point, it is of note that we obtain a poor match to the age profile of income variation described by survey data, for reasons that are discussed at length in Section 4.3.

2.3. *The Wealth Constraint*

Equation (1) is considered to be maximised, subject to the constraint that net worth in any period is non-negative, $w_{i,t} \geq 0$. We define total net worth by:

$$w_{i,t} = \begin{cases} w_{i,t-1} + \tau\Big(l_{i,t-1}, rw_{i,t-1} + x_{i,t-1}, n^a_{i,t-1}, n^c_{i,t-1}, t-1\Big) - c_{i,t-1} & \text{if } t \lessgtr t_{SPA} \\ (1-\eta)\Big[w_{i,t-1} + \tau\Big(l_{i,t-1}, rw_{i,t-1} + x_{i,t-1}, n^a_{i,t-1}, n^c_{i,t-1}, t-1\Big) - c_{i,t-1}\Big] & \text{if } t = t_{SPA} \end{cases} \tag{4}$$

where r is the constant real interest rate, $x_{i,t}$ is private non-property income, and $\tau(\cdot)$ is the tax and benefit function. In practice, total net worth, $w_{i,t}$, is comprised of housing, pension wealth, safe and risky financial investments and so on. Demand for these alternative asset classes is affected by a range of considerations, including the associated transactions costs, the uncertainty of investment returns, differential tax treatment and the consumption of housing services. We simplify the current analysis by abstracting from the asset allocation problem and leave associated sensitivity analysis as an issue for further research.

At age $t = t_{SPA}$, a proportion, η, of household wealth is annuitised at an actuarially fair rate χ. During the working lifetime, $t < t_{SPA}$, $x_{i,t}$ is equal to the household wage, $h_{i,t}$, if the household works, and zero otherwise. This household wage is considered to evolve following a stochastic process. During retirement, $x_{i,t}$ is equal to the annuity income generated by private pensions.

$$x_{i,t} = \begin{cases} h_{i,t}\dfrac{(1-l_{i,t})}{(1-l_W)} & \text{if } t < t_{SPA} \\ \eta\chi\Big[w_{i,t-1} + \tau\Big(l_{i,t-1}, rw_{i,t-1} + x_{i,t-1}, n^a_{i,t-1}, n^c_{i,t-1}, t-1\Big) - c_{i,t-1}\Big] & \text{if } t = t_{SPA} \\ x_{i,t-1}\dfrac{0.5 + 0.5\big(n^a_{i,t} - 1\big)}{0.5 + 0.5\big(n^a_{i,t-1} - 1\big)} & \text{if } t > t_{SPA}. \end{cases}$$

The annuity purchased at age t_{spa} is assumed to reduce to 65% when the number of adults in a simulated household decreases to 1 in response to the mortality of a spouse. This adjustment to retirement income was necessary to capture the decline in expenditure with age observed in survey data.

2.4. *Income Dynamics*

In the first period of the simulated lifetime, age 20, each household is allocated a wage, $h_{i,20}$, via a random draw from a log-normal distribution, $\log(h_{i,20}) \sim \mathrm{N}(\mu_{20}, \sigma^2_{20})$. Thereafter, wages are generated using the stochastic process described by the equation:

$$\log h_{i,t} = \beta \log h_{i,t-1} + \kappa\frac{(1-l_{i,t-1})}{(1-l_W)} + f(t-1) + \omega_{i,t} \tag{5}$$

where $f(t)$ is an age-dependent wage growth term, β accounts for time persistence in earnings, $\omega_{i,t} \sim \mathrm{N}(0, \sigma^2_\omega)$ is a household specific disturbance term, and κ is the return to another year of experience. This model is closely related to alternatives that have been developed in the literature, discussed in Sefton and van de Ven (2004), and has the practical advantage that it depends only upon variables from the immediately preceding period ($t-1, h_{i,t-1}, l_{i,t-1}$), which simplifies the endogenous simulation of household savings and labour supply.

Although the concept of an experience term in a wage regression is not new (Mincer and Ofek, 1982), its inclusion is an innovation relative to the related literature. Most related studies omit an experience term because it complicates the utility maximisation problem by invalidating two-stage budgeting. We have, however, found that its inclusion enables us to capture labour supply better at younger ages. See Sefton *et al.* (2006) for further discussion regarding this issue.

2.5. *The Tax Function*

The age dependency assumed for the tax function divides the lifetime into three periods: the working lifetime $t < t_{IB} = 55$, early retirement $t_{IB} \leq t < t_{SPA} = 65$, and retirement $t_{SPA} \leq t$. During the working lifetime, the tax function is specified to reflect profiles reported in the April 2003 edition of the *Tax Benefit Model Tables* (TBMT) issued by the Department for Work and Pensions (http://www.dwp.gov.uk/asd/tbmt.asp). The profiles take into consideration the impact of income taxes, National Insurance Contributions, the Child Benefit, the Working Tax Credit and the Child Tax Credit. These are the principal schemes that affected healthy families with children during 2003. The focus on a single labour supply term for households raises complications for the tax function that is considered for couples. The UK tax system is based upon individual incomes – a couple cannot split their income to minimise their aggregate tax burden. The simulation of household income, as opposed to individual specific income, implies that some allowance could be made to take into account the tax effect of dual income households. Data from the 2002/3 FRS indicate that, on average, 80% of labour income earned by couples is attributable to the principal bread winner between ages 20 and 64 (the proportion is slightly lower at 76% between 20 and 30, and slightly higher after age 60 at 85%). Given this observation, we assume that all income is earned by the principal bread winner and acknowledge that this will slightly overstate the true tax burden faced by dual income households.

The simulated tax function for ages $t_{IB} \leq t < t_{spa}$ depends upon private income, employment status, age, and demographic composition. Simulated households that choose to supply labour for any t, $t_{IB} \leq t < t_{spa}$, are treated in the same way as during the working lifetime (described above). The tax treatment applied to a simulated household that chooses not to supply labour and is aged $t_{IB} \leq t < t_{MIG} = 60$, is specified to reflect the Incapacity Benefit and income taxes as they stood in 2003/4; between ages $t_{MIG} \leq t < t_{spa}$ the tax function is specified to reflect the Pension Guarantee (identical for the alternative policy counterfactuals considered here) and income taxes.

The tax function during retirement, $\tau(.)$, $t \geq t_{spa}$, is specified to reflect the effect of income taxes, and the Minimum Income Guarantee (MIG), the Pension Credit (PC) or the Universal Pension (UP), depending upon the policy scenario considered. All three policies are based upon rates and thresholds that applied during 2003, the time of the considered policy reform. The MIG is considered to provide a maximum benefit equal to the Pension Guarantee: £102.10 per week for a single pensioner and £155.80 per week for a couple. This benefit is reduced by a taper (phase-out) rate of 100% applied to any private income, including benefits received from the Basic State Pension (BSP), private pensions, annuities and investment returns. There are also asset tests, although

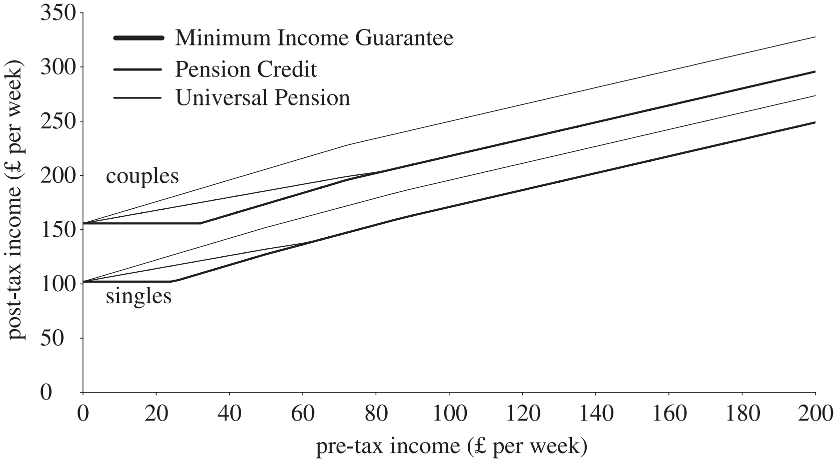

Fig. 2. *Simulated Tax Functions – Retired People.*

we do not take these into account. The PC and UP are similar to the MIG but are subject, respectively, to taper rates of 40% and 0% on any private income in excess of the full BSP. All households are considered to be eligible for the full BSP. The tax functions applied during retirement are reported in Figure 2.

2.6. *Model Solution Procedure*

This subsection provides a brief summary of the model solution procedure; see Sefton (2000) for a detailed description.

The assumption of stochastic income implies that an analytical solution to the utility maximisation problem does not exist. The procedure that we adopt consequently uses backward induction to solve the required inter-temporal Bellman equation. Starting in the last possible period of the household's life, T (= 110 in the simulations), we can solve relatively simply for the optimising consumption behaviour, given wealth w_T and annuity h_T (where we redefine h_t to denote annuity income for all $t \geq t_{SPA}$, and the household wage otherwise). The version of the model considered here does not include an explicit bequest motive (though accidental bequests are generated). Hence, in period T, households choose to consume all remaining resources. Given this level of consumption we can denote the maximum achievable utility, the value function, by $V_T(w_{T,}, h_T)$. We calculate this function at all nodes of a two dimensional grid in wealth and retirement annuity.

At time $T-1$ the problem reduces to solving the Bellman equation:

$$V_{T-1}(w_{T-1}, h_{T-1}) = \max_{c_{T-1}, l_{T-1}} \left\{ u(c_{T-1}/\theta_{T-1}, l_{T-1}) + \delta\phi_{1,T-1}\mathrm{E}_{T-1}\left[V_T(w_{T,}, h_T)\right] \right\} \tag{6}$$

$$\begin{aligned} \text{subject to } & w_T[w_{T-1}, x_{T-1}(h_{T-1}, l_{T-1}), c_{T-1}] \geq 0 \\ & h_T(h_{T-1}, l_{T-1}) \\ & l_{T-1} \in \{0.7, 1\} \\ & c_{T-1} \geq 0. \end{aligned}$$

We solve this optimisation problem for each node of the $T-1$ value function grid. Post mandatory retirement, this implies searching over feasible consumption choices only. Prior to mandatory retirement, we need to search over the feasible consumption choices for each discrete choice of labour supply and then select the particular consumption/leisure pair that achieves the maximum utility. Expectations of next period's value function are evaluated using a gaussian quadrature procedure with 5 abscissae points; a linear interpolation procedure is used to evaluate the value function at points between nodes.

With regard to computation time, there is a trade-off between the grid resolution and the order of the interpolation procedure. As the value function is not globally smooth or concave, we achieved greater accuracy by adopting a fine grid and a linear interpolation routine. Both the wealth and wage grid dimensions were specified on a log scale (to provide greater detail at the low end of the distribution) and were divided into 251 nodes after mandatory retirement and 161 nodes prior to mandatory retirement. Having solved for $T-1$ the process can be repeated for $T-2$, $T-3$, etc. This method allows a solution to be obtained for a household's entire lifetime.

The life-course of an individual household is simulated by running the household forward through the grids described above. Given the household's initial wealth and wage (w_{20}, h_{20}) we read off from the grids the household's optimal choice of consumption and leisure (c_{20}, l_{20}). Then given a random draw from the distribution $\omega_{i,t} \sim \mathrm{N}(0, \sigma_\omega^2)$ we use (4) and (5) to calculate the household's wealth and wage in the next period (w_{21}, h_{21}), a process that is repeated for $t = 21,22,\ldots T$. A cohort is built up by repeating this procedure for a sample of households.

3. Responses to Benefits Taper Rates in a Two Period Model

Before elaborating with regard to the fully-articulated model that is described above, we use a simple two period model to develop an intuition for the behavioural responses with which the study is concerned. We also use the two period model that is described here to explain our calibration approach in Section 4.

The first period of our two period model corresponds to the working life of the household, and the second period to retirement. The specification of the two period model is identical to the fully articulated model described in the preceding Section, except that we allow the labour supply decision to be continuous in the first period, and adopt a simplified tax structure throughout the considered lifetime. Our assumption of a continuous labour supply decision reflects the fact that, in the fully articulated model, households are considered to be able to vary their labour supply by choosing to work in some periods and not in others.

We assume here that wages and wealth are specified net of taxes in the first period of life. Let $a_1 (= w_1 + h_1)$ denote the total (disposable) resources available to a household at the beginning of period 1. Wealth at the beginning of retirement (the second period) is then first period savings plus the return to investment:

$$w_2 = (1 + r)(a_1 - h_1 l_1 - c_1) \geq 0$$

where the price of consumption is normalised to 1. In retirement, all households are assumed to receive the universal basic pension, p. In addition there is a means tested pension benefit, p_c, which is withdrawn at the (constant) marginal rate t_m with regard to wealth, w_2. Consumption in the second period is equal to:

$$c_2 = p + w_2 + \max(p_c - t_m w_2, 0).$$

Our two period model is similar in spirit to the one developed in Hubbard *et al.* (1995); but we focus here on consumption and labour supply responses to a change in means testing taper rates (whereas Hubbard *et al.* omit the labour decision, and focus upon a 100% taper rate). Van de Ven (2006) provides additional discussion regarding the implications for means testing drawn from a two period model, including some analytical results.

The utility maximisation problem is made analytically tractable by two important properties of the model that is described above. First, the specification of the problem permits the solution to be obtained by two-stage budgeting, with the intertemporal allocation solved in the first stage, followed by the consumption/leisure allocation (Browning *et al.*, 1985), although we lose this property in our multi-period model, because of the 'experience effect' that we assume for the household wage, as discussed in Section 2.3. And secondly, the utility function in the first period is homothetic, which implies that first period demand functions are linear in first period expenditure. Denote first period expenditure as e_1 where $e_1 = c_1 + h_1 l_1$. Then the Marshallian demand functions are:

$$l_1 = \left(\frac{\alpha}{h_1^{\varepsilon}}\right) \frac{e_1 \theta_1^{\varepsilon-1}}{\left(1 + h_1^{1-\varepsilon}\theta_1^{\varepsilon-1}\alpha\right)}, \tag{7}$$

$$c_1 = \frac{e_1}{\left(1 + h_1^{1-\varepsilon}\theta_1^{\varepsilon-1}\alpha\right)}. \tag{8}$$

Figure 3 reports the effects on incentives of a reduction in the taper rate of a means tested pension for a low ($a_1 = a^-$) and a middle ($a_1 = a^+$) income household. The line *ABDE* in the Figure is the low income household's budget line under a taper rate of 100%, $t_m = 1$. For the first $p_c/(1 + r)$ pounds saved, the low income household receives no gain in terms of second period potential consumption. The line *ACDE* is the low income household's budget line under the reduced taper rate, $t_m = 0.4$; now the low income household loses only t_m pounds of means tested benefit for every pound of savings, up to the threshold $p_c/[0.4(1 + r)]$. When $t_m = 1$, Figure 3 indicates that the low income household will maximise its welfare at point *A*, where they will consume all of their initial resources in the first period and their non-means tested pension benefit in the second. In contrast, when $t_m = 0.4$, the low income household maximises its welfare at *C*, in which case it will choose to save some of its initial resources despite the continued application of a means test.

There are a number of effects here but the largest is the substitution effect. The infinite marginal cost of second period consumption at point *A* under $t_m = 1$, is reduced to $[(1 + r)(1-0.4)]^{-1}$ when $t_m = 0.4$, so that the low income household substitutes expenditure out of the first period and into the second. Furthermore, (7) and (8) indicate that the reduced expenditure in the first period will be funded by a proportionate reduction in consumption of goods and leisure. Thus Figure 3 suggests

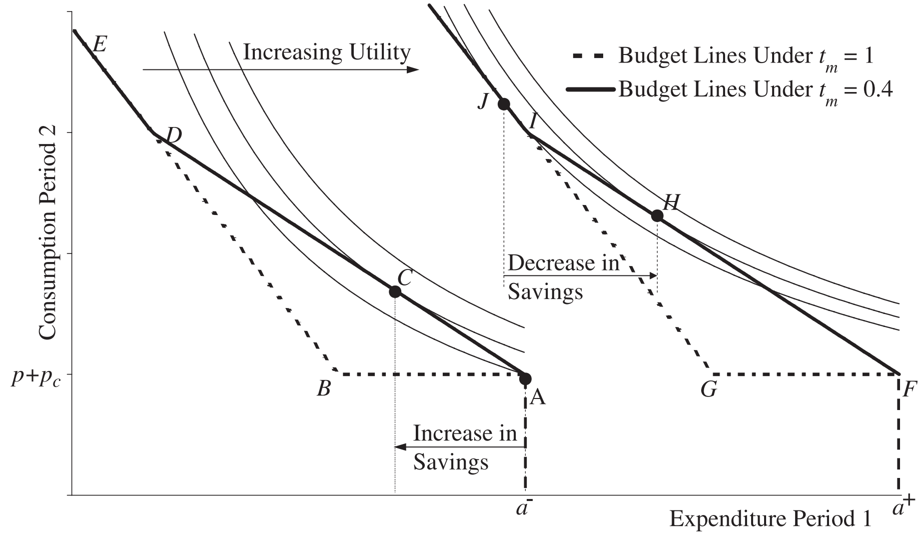

Fig. 3. *Responses of Lower and Middle Income Households to a Reduction in the Severity of Pensions Means Testing*

that the low income household will choose to save more and work longer in response to the considered reduction in the pensions taper rate.

With regard to the middle income household, *FGIJ* is the budget line under $t_m = 1$, and *FHIJ* is the budget line under $t_m = 0.4$. These are to the right of the budget lines of the low income household due to the larger first period endowment received by the middle income household. Under $t_m = 1$, the middle income household maximises their welfare at *J*. At this point the household has saved enough to be out of the means testing regime, and its marginal cost of second period consumption is $1/(1 + r)$. If the taper rate is reduced to $t_m = 0.4$, however, the middle income household will achieve its maximum welfare at point *H*. In this case the middle income household will choose to save and work less when the taper rate on means tested pension benefits falls. Again, it is the substitution effect that dominates but for the middle income household the marginal cost of second period consumption increases from $1/(1 + r)$ to $[(1 + r)(1-0.4)]^{-1}$.

This two period model consequently suggests that a reduction in the taper rate on means tested pension benefits will encourage low income households to increase their savings and delay retirement, and have the opposite effects on middle income households. These behavioural responses are borne out by the analysis based upon the fully articulated and calibrated model that is reported in Section 5.

4. Model Calibration

The parameters of the model described in Section 2 were adjusted to match the characteristics by age of a simulated population to those described by household micro-data. Calibration was undertaken using the following grid-search procedure. First, we normalised by the price of consumption so that wages and interest rates were specified in real terms. The real interest rate was fixed at 4% per annum, wealth at age 20 was set to 0 and l_W was set to 0.7 (working entails a 30% reduction in leisure). We then selected a starting value for each of the remaining model parameters, against which a solution to the lifetime optimisation problem was obtained. Monte Carlo methods were used to generate the life-history for a cohort of households, based upon the behavioural responses described by the model solution and the stochastic processes assumed for the intertemporal development of agent specific state variables. Calibration proceeded by comparing the characteristics by age of the simulated cohort with age profiles that were estimated from survey data.

The income and preference parameters of the model were adjusted to match the simulations against profiles estimated from survey data for the first and second moments of labour supply, income and consumption. Being a multidimensional problem, there was no obvious single statistic to match against and our consideration of second moments complicated the use of the econometric criteria that have been applied elsewhere (as discussed in the introduction). We therefore calculated the sum of squared errors for each model characteristic and used these in conjunction with graphical representations to guide our parameter grid-search.

The age profiles used to calibrate the model were estimated from Family Expenditure Survey (FES) data covering the period 1971Q1–2001Q1, via the procedure described by Deaton (1997) to control for time and cohort effects. Sefton *et al.* (2006) provide further details regarding the estimation procedure adopted. While this approach does address concerns regarding the representative nature of age profiles, it also raises some new problems of its own. One of the most important of these is associated with the calibration of household income.

When calibrating the model against cross-sectional data, it is natural to consider data for the year in which the tax policy under consideration was applied, which enables simulations to be matched against distributions of both private and disposable income, and provides a useful validation of the procedures used to model tax and benefits policy. This is not possible when profiles are estimated using Deaton's method, as the estimated distributions of private and disposable income are not related by any tax and benefits system that applied at a point in time, but rather they depend on an average of the transfer systems that were applied during the period of estimation. Consequently, it was not possible to calibrate *both* gross labour income and disposable income in the current context. As savings and labour supply decisions depend crucially upon income net of tax and benefit payments, the wage generating process was calibrated to match the model against estimated age profiles for disposable household income, subject to the assumed tax system.

A further complication arises if one is concerned about the profile for wealth as well as that for income. The most comprehensive source of microdata for household wealth in the UK is the British Household Panel Survey, which provides relevant data for 1995 and 2000. As this survey provides data for only two years, it cannot be used to obtain age profiles using Deaton's method. Hence, the model was not calibrated to match wealth data in the current context. Nevertheless, our experience (Sefton *et al.*, 2005) is that the analytical results with which this study is principally concerned are qualitatively the same, whether the profiles against which the model is calibrated are those provided by cross-sectional survey data, or those estimated using Deaton's method.

We now discuss specific issues relating to the calibration of preference parameters and the income process, before presenting statistics regarding our match to survey data.

4.1. *Calibration of Preference Parameters*

There are four preference parameters to calibrate, γ, ε, δ and α. In Section 3 on the simplified model, we discussed how the household decision problem can be solved by two-stage budgeting. As households near retirement, the separation of the intertemporal allocation problem from the intratemporal allocation broadly carries over into the fully articulated model, with the parameter pair (γ, δ) determining household preferences over feasible intertemporal expenditure paths and the parameter pair (ε,α) determining preferences over feasible intratemporal consumption/leisure choices. This is because the influence of the experience effect on the dynamic programming problem diminishes as age tends toward mandatory retirement (and disappears in the year prior to mandatory retirement). For given values of the elasticity parameters γ and ε, we chose the discount rate, δ, to achieve the 'closest' match between the simulated and estimated age profiles for mean household consumption; and we chose the parameter α to match average retirement rates. Effectively this process defines the parameters (δ,α) as a function of (γ, ε). The second stage was to calibrate the parameter ε to fit the household cross-sectional distribution of retirement age and the parameter γ to fit the cross-sectional distribution of consumption at the mandatory retirement age, 65. The criteria for selecting γ and ε warrant further comment.

We discuss the calibration of ε first. Equations (7) and (8) from Section 3 indicate that the consumption to leisure ratio about retirement is (approximately) given by:

$$\frac{l_1}{c_1} = \left(\frac{\alpha}{h_1^{\varepsilon}}\right)\theta_1^{\varepsilon-1}. \tag{9}$$

For a given ε, the parameter α is calibrated so that average simulated participation rates by age match those estimated from survey data; or in the language of the two-period model the average simulated labour supply equals the average observed labour supply. Denote the normalised average household labour supply by $\overline{l_1}/\overline{c_1}$ and the wage of the average household by $\overline{h}_1$, so that

$$\alpha = \left(\frac{\overline{h}_1}{\theta_1}\right)^{\varepsilon}\left(\frac{\overline{l}_1}{\overline{c}_1/\theta_1}\right). \tag{10}$$

Substituting this value of α into (9) implies that the labour supply of any household is given by

$$\frac{l_1}{c_1} = \left(\frac{\overline{h}_1}{h_1}\right)^{\varepsilon}\left(\frac{\overline{l}_1}{\overline{c}_1}\right). \tag{11}$$

Thus for high income households $(\overline{h}_1/h_1) < 1$, increasing the intratemporal elasticity decreases the demand for leisure relative to consumption (equivalent to later retirement in the fully articulated model) but for low income households $(\overline{h}_1/h_1) > 1$ it increases the demand (equivalent to earlier retirement). The cross-sectional demand for leisure (or the timing of retirement) can consequently be adjusted by varying ε. We effectively use the in-sample variation in wages to calibrate ε.

With regard to γ, the empirical literature (Attanasio and Weber, 1993; Blundell *et al.*, 1994) has documented that consumption tends to track income across the life-cycle, falling substantially at retirement. Heckman (1974) was the first to draw attention to the fact that this can be explained by the life-cycle hypothesis if leisure and consumption are direct substitutes in utility. Discussion in Section 2.1 reveals that a smaller value of γ, *ceteris paribus*, implies greater substitutability between leisure and consumption, and hence more pronounced income tracking. We therefore adjusted γ to fit the distribution of consumption about the mandatory retirement age, when labour changes most substantially.

4.2. *Calibration of the Income Process*

Three aspects of the wage generating process were subject to detailed calibration: the initial distribution of wages $(\mu_{20}, \sigma_{20}^2)$ were selected to reflect statistics of the distribution for disposable non-property income at age 20; the experience effect (κ) and the intertemporal persistence term (β) were increased to motivate higher labour supply by the young; and age specific dummy variables (one for each year) and the variance of the household specific disturbance term (σ_{ω}^2) were adjusted to match the age profile of the distribution of disposable non-property income to the profiles estimated from survey data.

Finally, the model was calibrated for an assumed proportion of annuitised wealth at retirement, η. This parameter is important in the current context because the proportion of wealth that is not annuitised is considered to be exempt from means testing. Of the various holdings that are included in the composite asset, $w_{i,t_{spa}}$, two principal classes are omitted from the eligibility (income and wealth) tests that were actually applied by the Minimum Income Guarantee and Pension Credit: owner occupied housing and the first £6,000 of additional wealth. In the first instance we assume that these exempt assets account for 50% of $w_{i,t_{spa}}$, $\eta = 0.5$, and conduct associated sensitivity analysis by also considering $\eta = 0.7$ (30% of wealth is exempt from means tests). Non-annuitised assets are assumed to revert to the government on death.

4.3. *The Fit Between Simulated and Estimated Age Profiles*

Following an extensive search, the parameter values that were found to obtain the closest approximations to age profiles estimated from survey data are reported in Table 1. The Table is divided into three panels. The top panel reports preference parameters and other exogenously assumed population characteristics; the middle panel reports parameters for the wage generating process; and the bottom panel provides age specific dummy variables that are used as exogenous input for the model.

The first row in the top panel of Table 1 displays the parameter combination that provides the best overall fit that we identified to the age profiles estimated from survey data, assuming $\eta = 0.5$. This parameter combination implies that consumption and leisure are direct substitutes. The resulting intertemporal elasticity of consumption depends on the point of calculation. However, at population averages for consumption

Table 1

Calibrated Model Parameters

	γ	ϵ	α	δ	η	w_{20}	r	lw
base case	0.200	0.580	1.630	0.970	0.5	0	0.04	0.7
$\gamma = 0.5$	0.500	0.580	1.620	0.956	0.5	0	0.04	0.7
$\gamma = 0.1$	0.100	0.580	1.605	0.980	0.5	0	0.04	0.7
$\epsilon = 0.7$	0.345	0.700	1.690	0.967	0.5	0	0.04	0.7
$\epsilon = 0.45$	0.080	0.450	1.460	0.980	0.5	0	0.04	0.7
$\eta = 0.7$	0.200	0.580	1.630	0.970	0.7	0	0.04	0.7

Wage Generating Parameters

$\mu_{20} = 5.443$ $\sigma_{20} = 0.160$ $\kappa = 0.050$ $\beta = 0.990$ $\sigma_{\omega} = 0.032$

Age Specific Dummy Variables

age	$f(t)$	eqv scale	na	nc	age	eqv scale	na	mort prob	cum (survival)
20	–	1.617	1.647	0.950	65	1.201	1.454	0.005	0.975
21	0.226	1.670	1.713	0.992	66	1.193	1.446	0.006	0.970
22	0.288	1.724	1.775	1.051	67	1.199	1.456	0.007	0.964
23	0.221	1.724	1.774	1.016	68	1.183	1.428	0.009	0.957
24	0.156	1.753	1.813	1.037	69	1.173	1.412	0.010	0.948
25	0.101	1.775	1.805	1.122	70	1.175	1.413	0.012	0.939
26	0.079	1.811	1.818	1.210	71	1.171	1.408	0.014	0.927
27	0.068	1.841	1.822	1.291	72	1.150	1.373	0.017	0.914
28	0.071	1.877	1.820	1.389	73	1.144	1.364	0.020	0.898
29	0.036	1.921	1.824	1.500	74	1.133	1.343	0.023	0.881
30	0.064	1.958	1.822	1.592	75	1.134	1.345	0.027	0.861
31	0.051	2.011	1.829	1.713	76	1.120	1.319	0.031	0.838
32	0.031	2.032	1.809	1.780	77	1.109	1.296	0.035	0.812
33	0.058	2.081	1.829	1.842	78	1.106	1.293	0.041	0.783
34	0.046	2.114	1.815	1.918	79	1.108	1.292	0.047	0.751
35	0.037	2.127	1.798	1.929	80	1.096	1.268	0.054	0.716
36	0.057	2.153	1.791	1.947	81	1.088	1.256	0.061	0.678
37	0.040	2.176	1.796	1.961	82	1.064	1.215	0.070	0.637
38	0.051	2.203	1.793	1.992	83	1.062	1.211	0.079	0.592
39	0.027	2.197	1.789	1.938	84	1.074	1.224	0.090	0.545
40	0.024	2.179	1.775	1.857	85	1.060	1.192	0.101	0.496
41	0.044	2.175	1.771	1.813	86	1.050	1.161	0.113	0.446
42	0.034	2.152	1.765	1.743	87	1.040	1.129	0.126	0.396
43	0.028	2.085	1.762	1.556	88	1.030	1.097	0.139	0.346
44	0.026	2.045	1.739	1.462	89	1.020	1.066	0.154	0.298
45	0.024	2.007	1.740	1.361	90	1.000	1.000	0.168	0.252
46	0.021	1.930	1.715	1.207	91	1.000	1.000	0.183	0.210
47	0.021	1.855	1.693	1.059	92	1.000	1.000	0.202	0.171
48	0.019	1.791	1.693	0.891	93	1.000	1.000	0.221	0.137
49	0.019	1.708	1.669	0.727	94	1.000	1.000	0.239	0.106
50	0.022	1.673	1.677	0.626	95	1.000	1.000	0.258	0.081
51	0.021	1.581	1.645	0.454	96	1.000	1.000	0.278	0.060
52	0.018	1.547	1.648	0.373	97	1.000	1.000	0.295	0.043
53	0.016	1.494	1.631	0.268	98	1.000	1.000	0.310	0.031
54	0.013	1.459	1.633	0.194	99	1.000	1.000	0.328	0.021
55	0.011	1.424	1.617	0.133	100	1.000	1.000	0.350	0.014
56	0.010	1.399	1.619	0.064	101	1.000	1.000	0.389	0.009
57	0.006	1.373	1.610	0.026	102	1.000	1.000	0.422	0.006
58	0.000	1.354	1.607	0.000	103	1.000	1.000	0.474	0.003
59	−0.005	1.329	1.595	0.000	104	1.000	1.000	0.525	0.002
60	−0.009	1.294	1.559	0.000	105	1.000	1.000	0.584	0.001
61	−0.012	1.275	1.544	0.000	106	1.000	1.000	0.651	0.000

Table 1

(Continued)

Wage Generating Parameters									
$\mu_{20} = 5.443$ $\sigma_{20} = 0.160$ $\kappa = 0.050$ $\beta = 0.990$ $\sigma_{\omega} = 0.032$									
Age Specific Dummy Variables									
age	*f*(*t*)	eqv scale	*na*	*nc*	age	eqv scale	*na*	mort prob	cum(survival)
62	−0.014	1.274	1.540	0.000	107	1.000	1.000	0.730	0.000
63	−0.009	1.255	1.519	0.000	108	1.000	1.000	0.813	0.000
64	−0.002	1.239	1.505	0.000	109	1.000	1.000	0.900	0.000
					110	1.000	1.000	1.000	0.000

γ = intertemporal elasticity of substitution of total expenditure in preference relation
ϵ = intratemporal elasticity of substitution in preference relation
α = utility price of leisure in preference relation; delta = discount rate in preference relation
η = proportion of wealth annuitised at retirement (and subject to pensions means test)
w_{20} = wealth endowment at age 20; r = real interest rate; *lw* = proportion of time spent in leisure when employed
μ_{20} = mean log wage at age 20; σ_{20} = variance of log wage at age 20
σ_{ω} = variance of stochastic wage innovation at age t
κ = experience effect in wage generating process; β = intertemporal persistence in wage generating process
f(t) = age specific dummy variables in wage generating process
eqv scale = McClements' equivalence scale by age; *na* = number of adults in the household; *nc* = number of children in the household
mort prob = age specific (period) mortality rate; cum(survival) = age specific cumulative survival probability (from age 20)

(£522 per week), leisure (0.7142), and the equivalence scale (1.837×300) between ages 25 and 60, weighting each age equally we find a value of 0.367 which is within the range suggested by the literature. The next two rows of the Table report parameter combinations that provide the closest fit to survey data for alternative assumptions regarding γ and the following two rows do the same for alternative assumptions regarding ε. These alternative specifications (all of which are based upon the same wage generating process) are provided to highlight the sensitivity of simulated behaviour to γ and ε. The last row in the top panel of Table 1 provides the parameters assumed for the alternative assumption made for η.

The parameters assumed for the wage generating process imply strong intertemporal persistence and a 5% annual wage premium in return for employment. These statistics reflect the difficulties that are commonly experienced in capturing labour participation rates at young ages. The age profiles for household size that were estimated from FRS survey data were exogenously assumed for the model and are reported in the bottom panel of Table 1. These data reflect the standard hump-shaped age profile for household need that has been found to have an important influence on the profile for consumption. The survival probabilities assumed for the analysis are based upon the probability that at least one member of a couple survives from age 20 and were calculated from the UK Government Actuary's life tables averaging probabilities over the available data from 1980 to 2002.

The relations between simulated data obtained using the calibrated parameter values and the age profiles estimated from survey data are displayed in Figures 4 to 6. All

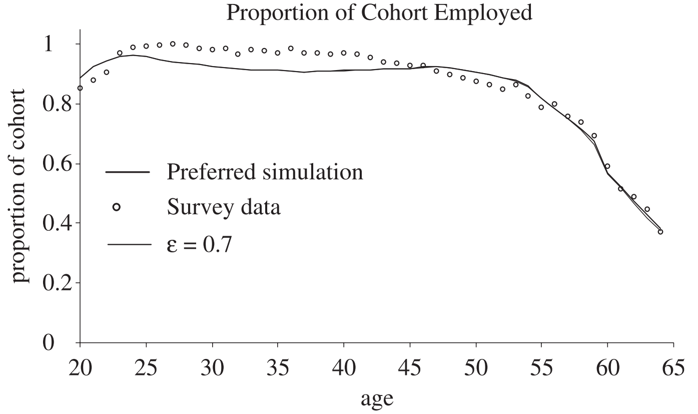

Fig. 4. *Labour Force Participation – Simulated Versus Survey Data*
Source: Survey data – Estimated age profiles, controlled for time and cohort effects. Survey data arithmetically adjusted to 100% employment at age 27.

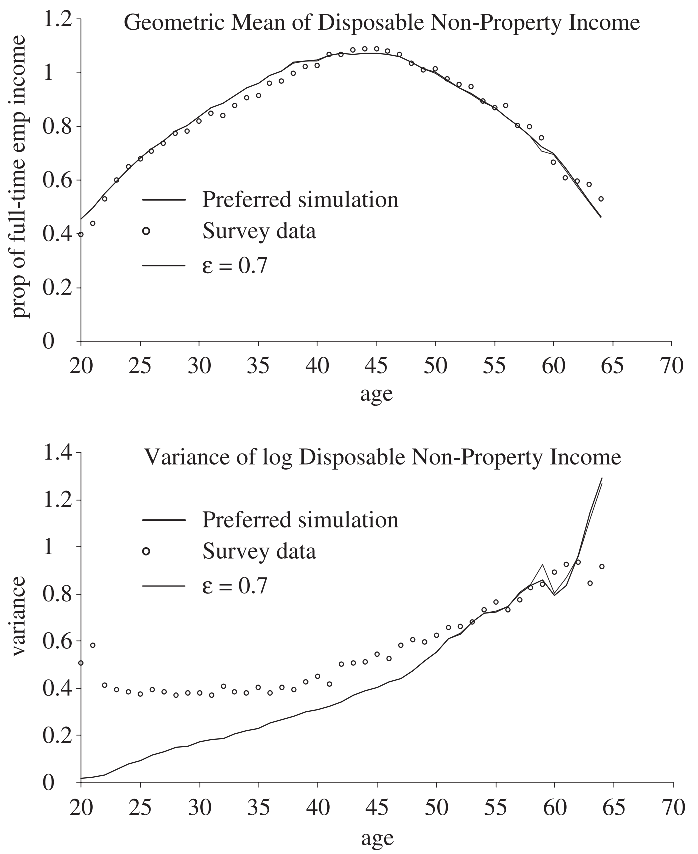

Fig. 5. *Disposable Non-Property Income Profiles by Age – Simulated Versus Survey Data*
Source: Survey data – Estimated age profiles, controlled for time and cohort effects. Monetary values reported as proportions of average annual full-time employment income.

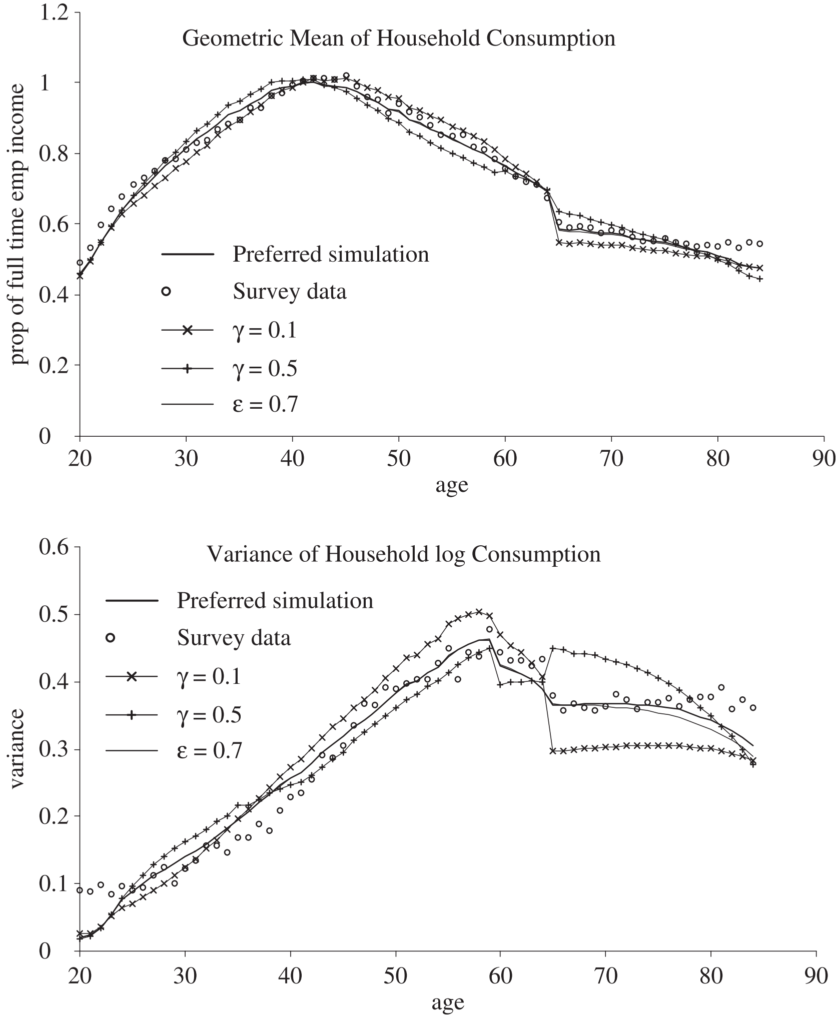

Fig. 6. *Consumption Profiles by Age – Simulated Versus Survey Data*
Source: Survey data – Estimated age profiles, controlled for time and cohort effects. Monetary values reported as proportions of average ammual full-time employment income.

monetary values are reported relative to average gross annual income for all full-time employees in the UK during 2003/4, equal to £22,724.[3]

Figures 4 to 6 indicate that the simulation model based upon the preferred parameter calibration does a good job of capturing the age profiles estimated from survey data. The top panel of Figure 4 reveals that, although the simulation model under-predicts the proportion employed between ages 23 and 46, the age profile of employment matches the survey data particularly closely for the period of early retirement (from age 45), consistent with the focus of the current study. Furthermore, Table 2 suggests that the

[3] £437 per week. Figure based on average gross weekly earnings of all full-time employees, winter 03/04, Labour Force Survey Historical Quarterly Supplement, Table 37. Available from the National Statistics website: http://www.statistics.gov.uk/.

Table 2

Proportion of People aged 55–59 not Working

	lowest quintile	2nd quintile	3rd quintile	4th quintile	highest quintile
preferred simulation	71.89	17.90	2.02	2.83	30.91
$\gamma = 0.5$	69.77	16.94	3.21	2.28	29.88
$\gamma = 0.1$	73.83	17.51	1.50	2.39	27.92
$\varepsilon = 0.7$	88.69	28.17	3.41	0.56	6.97
$\varepsilon = 0.45$	41.37	6.11	1.04	12.95	66.87
$\eta = 0.7$	71.85	19.77	1.27	3.12	30.84
ELSA	49.60	26.60	14.30	20.80	25.60

Note. Simulated quintiles defined with respect to wealth at age 65, ELSA quintiles defined with respect to wealth Authors' calculations and Marmot *et al.* (2003)

simulation model does a reasonable job of capturing the pattern of distribution in retirement, with earlier departure from the labour force observed at the distributional extremes, and later departure for the 3rd and 4th quintiles. The two profiles obtained for alternative parameter values of ε indicate that the preferred parameter combination achieves a reasonable compromise between the alternative extremes.

Figure 5 reveals a close relationship between the geometric mean of simulated disposable income and the associated age profile estimated from survey data. However, one of the most conspicuous disparities between the analytical model and the age profiles estimated from survey data is the degree to which the analytical model understates the inequality of disposable incomes between ages 20 and 40. This disparity is attributable to the assumptions made regarding the tax function, the age profile for household size and the age profile for geometric mean disposable income. At age 20, for example, the simulations are based upon an average household size of 1.65 adults and 0.95 children, and the distribution of wages has been calibrated to match the geometric mean of disposable income to £174 per week (40% of average full-time employment income). In this context, it is of note that the tax function provides a minimum disposable income of £145 per week to a household based upon the assumed demographics. The small difference between this minimum and the associated geometric mean gives rise to the small measure of inequality obtained for simulated disposable incomes. This is a clear example of the complications that can arise when attempting to calibrate the simulation model to age profiles of statistics that have been independently estimated to control for time and cohort effects. It is noteworthy that the small difference between the minimum income provided by the tax and benefits system and the geometric mean also implies that there is little direct benefit to working at early ages with the incentive to work being provided by the experience effect.

In terms of consumption, Figure 6 reveals that the simulation model based upon the preferred parameter combination delivers a close reflection of the estimated age profiles for both the geometric mean and variance. The Figure also reveals that the preferred parameter combination provides a closer approximation to the reduction observed for both the geometric mean and variance of consumption at retirement than either of calibrations based upon alternative assumptions for γ.

Furthermore, in all of the Figures above the profiles for the preferred specification and for $\eta = 0.7$ are very nearly identical. Although the proportion of wealth that is assumed to be annuitised at retirement does not substantially alter the calibrated statistics reported here, it does influence the behavioural responses of households, as is discussed in Section 5.

5. Rational Responses to Means Tested Pension Policy

This Section reports the responses to means tested pension policy that are implied by the model of behaviour that is described above. We begin by presenting the effects on household labour supply and consumption decisions of a shift from the Minimum Income Guarantee (MIG) to the Pension Credit (PC), both considered in the absence of second tier pensions; this policy reform reduces the taper rate on pension benefits from 100% to 40%. Sefton *et al.* (2005) provide extended discussion of, and sensitivity analysis to the omission of the current second tier pension, the State Second Pension introduced in 2003. Sensitivity of the behavioural responses is explored here with regard to the degree of exemption (as discussed in the preceding section) and to a Universal Pension (UP), which is considered to do away with means testing all together.

The analysis is based upon a simulated cohort of 10,000 households, where the only variable between simulations is the considered policy environment; each simulated household is subject to the same age specific innovations between alternative policy simulations. The simulations assume that households (accurately) expect throughout their lifetimes that they will be subject to a single policy environment. Behavioural responses to policy are identified by comparing the household decisions made under one policy environment with those made under another. Hence the analysis is concerned with the long-term effects of policy change, and not with transitional period effects. We begin with the household behavioural responses to means testing, before presenting implications for associated population aggregates, and conclude with a discussion of the welfare effects.

5.1. *Household Responses to Means Tested Pension Benefits*

The extent of means testing associated with a welfare benefit is described by three characteristics: the maximum benefit to which an agent is potentially eligible, the value of permitted exemptions and the rate at which benefits are withdrawn in response to non-exempt personal circumstances. The current analysis focuses upon behavioural responses to the latter two of these, consistent with the focus of the contemporary pensions debate in the UK. Specifically, simulated behavioural responses to the following four policy counterfactuals are explored:

1 *Partial Equilibrium Pension Credit reform* (*Partial PC reform*) replacing the Minimum Income Guarantee (MIG) with the Pension Credit (PC), where 50% of household wealth is exempt from means testing and interest rates, wage rates and taxes are unchanged.
2 *General Equilibrium Pension Credit reform* (*GE PC reform*) replacing the Minimum Income Guarantee (MIG) with the Pension Credit (PC), where 50% of household wealth is exempt from means testing, interest rates are increased from 4% to 4.108%, wage rates are increased by 0.020% and marginal tax rates are

increased by 0.101% for employed households to clear labour and capital markets on the assumption that the economy is closed and to maintain budget neutrality.

3 *General Equilibrium Universal Pension reform* (*GE UP reform*) replacing the Minimum Income Guarantee (MIG) with the Universal Pension (UP), where 50% of household wealth is exempt from means testing, interest rates are increased from 4% to 4.727%, wage rates are decreased by 0.108% and marginal tax rates are increased by 1.376% for employed households. Again, these changes clear factor markets and maintain budget neutrality.

4 *Exemption sensitivity analysis* replacing the Minimum Income Guarantee (MIG) with the Pension Credit (PC), where 30% of household wealth is exempt from means testing, and no change is applied to interest rates, wage rates, or taxes during the working lifetime.

Each of the four policy scenarios described above explores behavioural responses to replacing the MIG. The four scenarios are distinguished by three aspects of the policy counterfactual against which the MIG is compared: the size of the considered taper rate (which varies from 0% to 40%), the size of exemption (which varies from 30% to 50% of personal wealth), and the economic environment (which is either a general equilibrium that assumes factor prices adjust to clear markets and taxes adjust to maintain budget neutrality, or a partial equilibrium that ignores such adjustments).

The first policy counterfactual listed above is the principal policy scenario with which the current study is concerned, and is referred to as the 'Partial PC reform' in the discussion that follows. The second policy counterfactual (GE PC reform in what follows) repeats the Partial PC reform, subject to altered tax rates and factor prices. Factor prices were adjusted to reflect a General Equilibrium in a closed economy, based upon a Cobb-Douglas production function with a 30% capital share and 10% annual depreciation of capital. Qualitatively similar results to those reported here were also obtained under the assumption of a small open economy (fixed factor prices) and are available from the authors upon request. In much the same way, tax rates were adjusted to ensure budget neutrality over the life-course of the simulated cohort. Details of the tax adjustments are also available on request. This counterfactual was undertaken to enable associated sensitivity analysis and provides an appropriate comparator for welfare analysis.

The third policy counterfactual listed above (GE UP reform) repeats the second counterfactual but replaces the Pension Credit with the Universal Pension to provide sensitivity analysis with regard to the imposed taper rate. And the fourth counterfactual (Exemption sensitivity analysis) restates the Partial PC reform but with 30% of wealth exempt from means tests. As qualitatively similar results were obtained for all four policy counterfactuals, we focus primarily on describing the behavioural responses observed for the Partial PC reform, statistics for which are reported in Table 3. Sensitivity analysis to the policy environment is undertaken by comparing selected statistics for the alternative policy scenarios reported in Table 4. All monetary values reported here are expressed as proportions of average gross income for all full-time employees in the UK in 2003/4, equal to £22,724 per year.

Table 3

Predicted Long-term Effects on Behaviour of Replacing the Minimum Income Guarantee with the Pensions Credit, where 50% of Wealth is Exempt from Means Test

Age Group	$x^* = £0$	£0 < x < £3.20	£3.20 < x < £32	£32 < x < £80	£80 < x < £100	£100 < x < £200	£200 < x < £300	£300 < x
				Proportion of Population (%)				
	17.22	6.93	7.43	6.35	4.53	22.80	14.78	19.96
				change in wealth (%**)				
50–54	1.01	3.54	3.89	2.86	0.98	−4.03	−7.60	−6.78
55–59	1.20	9.76	12.08	5.31	−2.71	−11.49	−12.06	−7.44
60–64	0.67	18.22	41.54	4.02	−25.62	−24.34	−12.89	−6.47
65–69	1.33	26.26	58.82	−0.39	−54.51	−34.93	−11.20	−5.11
70–74	1.44	18.72	47.87	−0.17	−61.80	−36.44	−9.45	−3.97
				change in employment (%***)				
50–54	0.29	0.40	0.30	0.06	0.04	−0.05	0.00	0.04
55–59	−0.29	1.59	5.06	−0.28	−1.59	−0.41	−0.05	0.06
60–64	0.39	6.84	18.12	−3.91	−12.67	−3.57	0.34	0.17
All ages	5.84	45.95	117.74	−18.89	−70.05	−19.75	1.60	1.34
				change in consumption (%**)				
50–54	−0.01	−0.58	−0.65	−0.32	0.20	0.97	0.81	0.18
55–59	0.07	−1.37	−1.56	−0.22	1.70	1.64	0.29	−0.03
60–64	0.08	−0.68	−1.32	0.37	2.65	0.87	−0.02	−0.02
65–69	−0.11	1.86	4.18	3.99	1.61	−0.51	−0.62	−0.35
70–74	0.16	1.73	5.00	4.10	0.54	−0.72	−0.64	−0.33
All ages	1.52	12.12	62.40	76.97	27.50	−0.06	−1.15	0.21
				change in net taxes paid by households (%**)				
50–54	0.08	0.17	0.14	0.07	0.02	−0.08	−0.12	−0.02
55–59	−0.04	0.70	1.68	0.02	−0.41	−0.27	−0.19	−0.02
60–64	0.20	3.68	8.81	−1.33	−5.21	−1.73	0.20	0.25
65–69	0.02	0.63	−0.31	−4.03	−1.77	−0.48	−0.14	−0.07
70–74	0.02	0.55	−0.06	−4.18	−2.44	−0.61	−0.13	−0.06
All ages	2.36	33.07	49.64	−85.31	−95.41	−30.68	−3.56	−0.69

Behavioural responses to the Pension Credit, 50% of wealth exempt, and no change in factor prices or tax treatment of employed households
Changes measure subgroup arithmetic means under the Pension Credit, less arithmetic means under the Minimum Income Guarantee
Statistics for 'All ages' aggregated over lifetime, weighted by age specific survival rates
All other statistics reported as (unweighted) annual averages
*x denotes pre-tax and benefit (private) income in £ per week at age 65 under MIG
** percentage of average gross annual income
*** percentage of population subgroup

The statistics reported in Tables 3 and 4 relate to population groups distinguished by private income received at age 65 under the MIG. This disaggregation of the population implies that the same households are identified in each population subgroup when undertaking comparisons between policy counterfactuals. The limits used to generate the population groups are a product of the policy counterfactuals that are considered for analysis. The simulations focus upon means testing of private income – asset tests are omitted from the analysis. This helps to identify the households that are affected by means testing of pensions. Two income thresholds are important for identifying the extent to which households are subject to means testing. The first is the difference between the MIG and the Basic State Pension (BSP), equal to £32 per week for a couple in the analysis. A household that receives an income in retirement beyond this threshold is subject to the full extent of means testing under the MIG. Similarly, the second threshold is equal to the difference between the MIG and the BSP divided by the taper rate of the PC (32/0.4 = £80 per week for a couple). Households with private retirement incomes in excess of this second threshold are subject to the full extent of means testing under the PC. The other thresholds were selected to divide the remaining population into subgroups that are convenient for exploring the distributional effects of the policy reforms.

Table 4

Predicted Long-term Effects on Behaviour of Replacing the Minimum Income Guarantee with Alternative Policy Counterfactuals

Policy Scenario	$x^* = £0$	$£0 < x < £3.20$	$£3.20 < x < £32$	$£32 < x < £80$	$£80 < x < £100$	$£100 < x < £200$	$£200 < x < £300$	$£300 < x$
Proportion of Population (%)								
Partial PC reform	17.22	6.93	7.43	6.35	4.53	22.80	14.78	19.96
GE PC reform	17.22	6.93	7.43	6.35	4.53	22.80	14.78	19.96
GE UP reform	17.22	6.93	7.43	6.35	4.53	22.80	14.78	19.96
Exemption Sensitivity	21.38	6.00	4.43	3.53	3.86	21.76	15.09	23.95
change in wealth – ages 65–69 (%**)								
Partial PC reform	1.33	26.26	58.82	−0.39	−54.51	−34.93	−11.20	−5.11
GE PC reform	1.29	26.31	58.81	−0.47	−54.32	−35.87	−15.48	−11.89
GE UP reform	4.48	40.48	68.52	−6.03	−79.23	−110.10	−128.03	−179.47
Exemption Sensitivity	4.03	63.32	89.63	−11.87	−54.03	−28.72	−5.76	−2.52
change in employment – ages 60–64 (%***)								
Partial PC reform	0.39	6.84	18.12	−3.91	−12.67	−3.57	0.34	0.17
GE PC reform	0.31	6.84	18.03	−3.87	−12.67	−3.65	−0.78	−0.42
GE UP reform	0.52	7.59	19.27	−4.31	−16.29	−8.71	−6.83	−5.31
Exemption Sensitivity	1.23	18.90	25.96	−6.86	−15.34	−3.74	0.38	0.19
change in employment – all ages (%***)								
Partial PC reform	5.84	45.95	117.74	−18.89	−70.05	−19.75	1.60	1.34
GE PC reform	4.74	45.09	116.81	−19.68	−69.61	−20.62	−6.01	−6.71
GE UP reform	−135.66	−41.01	69.62	−58.06	−115.44	−65.27	−59.32	−62.99
Exemption Sensitivity	5.07	130.09	159.47	−37.42	−82.41	−20.52	2.16	1.28
change in consumption – ages 60–64 (%**)								
Partial PC reform	0.08	−0.68	−1.32	0.37	2.65	0.87	−0.02	−0.02
GE PC reform	0.07	−0.68	−1.33	0.37	2.71	0.97	−0.33	−0.39
GE UP reform	−0.16	−2.33	−2.82	−0.46	2.22	1.46	−1.65	−4.50
Exemption Sensitivity	0.09	−1.62	−3.73	1.88	3.44	0.79	−0.30	−0.03
change in consumption – ages 65–69 (%**)								
Partial PC reform	−0.11	1.86	4.18	3.99	1.61	−0.51	−0.62	−0.35
GE PC reform	−0.12	1.85	4.19	4.01	1.67	−0.41	−0.57	−0.29
GE UP reform	−0.59	2.53	5.64	6.24	3.95	1.34	−0.03	−1.40
Exemption Sensitivity	0.05	3.88	6.03	4.12	0.86	−0.87	−0.39	−0.16
change in consumption – all ages (%**)								
Partial PC reform	1.52	12.12	62.40	76.97	27.50	−0.06	−1.15	0.21
GE PC reform	−0.26	8.62	58.71	73.54	25.14	−2.63	−9.73	−13.94
GE UP reform	−42.84	−45.97	32.61	75.09	30.58	−16.25	−74.75	−173.41
Exemption Sensitivity	1.67	34.16	77.82	74.18	15.90	−5.38	−0.38	1.01
change in net tax burden paid by households – ages 60–64 (%**)								
Partial PC reform	0.20	3.68	8.81	−1.33	−5.21	−1.73	0.20	0.25
GE PC reform	0.16	3.73	8.94	−1.08	−4.88	−1.29	0.04	−0.08
GE UP reform	0.29	4.73	10.57	0.21	−4.70	−0.75	−0.33	−4.90
Exemption Sensitivity	0.64	9.80	12.87	−2.40	−6.01	−1.75	0.15	0.23
change in net tax burden paid by households – ages 65–69 (%**)								
Partial PC reform	0.02	0.63	−0.31	−4.03	−1.77	−0.48	−0.14	−0.07
GE PC reform	0.02	0.64	−0.28	−3.98	−1.71	−0.41	−0.04	0.18
GE UP reform	−0.02	−0.03	−3.02	−8.93	−7.89	−7.39	−7.11	−6.78
Exemption Sensitivity	0.11	1.75	0.71	−3.61	−1.79	−0.46	−0.08	−0.04

Table 4

(Continued)

Policy Scenario	$x^* = £0$	$£0 < x < £3.20$	$£3.20 < x < £32$	$£32 < x < £80$	$£80 < x < £100$	$£100 < x < £200$	$£200 < x < £300$	$£300 < x$
	change in net tax burden paid by households – all ages (%**)							
Partial PC reform	2.36	33.07	49.64	−85.31	−95.41	−30.68	−3.56	−0.69
GE PC reform	4.44	37.79	56.21	−77.24	−84.79	−16.52	11.98	15.92
GE UP reform	0.37	56.08	67.05	−93.73	−113.46	−37.67	21.35	37.95
Exemption Sensitivity	5.44	90.57	87.00	−95.09	−89.31	−24.84	−1.75	0.08

Partial PC reform: behavioural responses to Pension Credit, 50% of wealth exempt and no change to factor prices or taxes
GE PC reform behavioural responses to Pension Credit, 50% of wealth exempt, GE adjustment to factor prices, and budgetary neutral adjustment to taxes
GE UP reform behavioural responses to Universal Pension, 50% of wealth exempt, GE adjustment to factor prices, and budgetary neutral adjustment to taxes
Exemption Sensitivity: behavioural responses to Pension Credit, 30% of wealth exempt and no change to factor prices or taxes
changes measure subgroup arithmetic means under the alternative policy counterfactuals, less arithmetic means under the Minimum Income Guarantee
Statistics for "All ages'' aggregated over lifetime, weighted by age specific survival rates
All other statistics reported as (unweighted) annual averages
*x denotes pre-tax and benefit (private) income in £ per week at age 65 under MIG
** percentage of average gross annual income
*** percentage of population subgroup

Table 3 reveals a substantial degree of variation between the simulated behavioural responses of different households to the policy environment. Households in subgroups defined by $x < 32$ in Table 3 (where x denotes private retirement income measured in £ per week) increase their savings and work longer, to enjoy higher consumption during retirement in response to a reduction in means testing. These responses are consistent with those of the 'low income' household discussed in Section 3, for whom improved incentives to save dominate associated income effects.

For households defined by $x < 32$, behavioural responses are exaggerated as private income increases. This is attributable to the fact that the replacement rate offered by state benefits is higher for very low income households. For example, in the case of the poorest 17% of simulated households that earn no private income at age 65 under the MIG ($x = 0$ in Table 3), the MIG provides a two-thirds replacement rate on average for disposable income during the working lifetime.[4] Many of these households do not save because of the generosity of the state pension system, not in response to the poor investment returns that they receive under the MIG – an income effect rather than a substitution effect. Hence, the analysis suggests that the PC is unlikely to be very effective in motivating households that would have been wholly dependent on the MIG to save their way out of welfare dependency.

In contrast, the improved incentives to save associated with the PC have a pronounced effect on households that accrue appreciable savings and yet are subject to the 100% taper under the MIG ($3.20 < x < 32$). The statistics reported in Table 3

[4] The median disposable income at age 45 for households that choose to save nothing under the MIG is £234.82 per week. In contrast, the Pension Guarantee at age 65 is worth £155.80 per week for a couple – implying a 66% replacement rate.

indicate that, between ages 60 and 64, these households will choose to increase their savings by 42% of average annual employment income under the PC on average, relative to the MIG. This increased accumulation of wealth is mirrored by a coincident prolonging of the working life, with 18% of households choosing to supply labour between ages 60 and 64 under the PC, where they did not under the MIG. Indeed the employment statistic for all ages – which weights the average age specific effects by the associated survival probabilities – indicates that households in this subgroup choose to work an additional year on average when subject to the PC. Furthermore, the consumption statistics reported in Table 3 reveal that the additional savings accrued by this population subgroup to age 64 are not generated solely by increased labour supply but are also obtained by reducing consumption, by 1.3% of average employment income between ages 60 and 64.

Interestingly, the behavioural responses of the population subgroup defined by $3.20 < x < 32$ imply that net tax revenues over the life-course to the state *increase* by 50% of average annual employment income. This is due to two effects. Firstly, households in this subgroup generally receive welfare benefits if they retire early. As they tend to retire later under the PC, they both pay more in income taxes and receive less in benefits during their working lifetime. Secondly, the lower taper rate applied by the PC does not lead to a substantial increase in the budgetary burden of this population subgroup during retirement. This second finding is similarly reflected in the fact that households with a private income $x < 3.20$ pay *higher* net taxes during retirement under the PC. This is because the reduction in revenues associated with the lower taper rate on private income under the PC is off-set by the increased revenues derived from the consequent rise in aggregate savings. Hence, the behaviour of households caught within the 100% taper rate under the MIG appears strongly to support the introduction of the lower taper rate applied by the PC.

In contrast to the above, the behavioural responses of population subgroups defined by $32 < x < 200$ in Table 3 reflect those described for the 'middle income' household in Section 3, for which income and substitution effects of a reduction in means testing motivate reduced savings and earlier retirement. The associated responses are particularly strong for the population subgroup $80 < x < 100$: average savings fall by 26% of average annual employment income between ages 60 and 64, and the proportion employed falls by 13 percentage points. The expenditure statistics reveal that the higher propensity of the population subgroup to consume prior to age 65 is the product of smoothing the financial benefits provided by the PC over the lifetime, with slightly higher consumption also observed between ages 65 and 69. Furthermore, the tax statistics reveal that these behavioural responses are purchased at a substantial cost to the welfare state.

The impact of the policy change on behaviour falls away for higher population subgroups. This last point is expected, as wealthy households are generally ineligible for means tested benefits. Hence they are largely unaffected by which benefit – PC or MIG – they *do not* receive. We turn now to consider sensitivity of the simulated behavioural responses to the policy environment, with reference to statistics reported in Table 4.

Replacing the MIG with the PC when 50% of wealth is exempt from means testing implies a slight reduction in the average lifetime tax burden paid by households, a fall in aggregate savings and a rise in aggregate labour supply, which are discussed at length below. These aggregate effects imply slightly higher tax rates on employed households to obtain budget neutrality and slightly higher factor prices for General Equilibrium in a closed economy. The effects of the higher factor prices and tax rates on household behavioural responses to replacing the MIG with the PC are reported under the 'GE PC reform' scenario in Table 4. Comparing the statistics for the GE PC reform with those obtained for the Partial PC reform reveals that households throughout the income distribution tend to save less, supply less labour and consume less when subject to the altered factor prices and tax rates. These behavioural differences between the two policy scenarios can be understood in terms of the higher tax rates that are applied under the GE PC reform. It is of note that the general observations made with regard to Table 3 are not sensitive to the adjustments considered for factor prices and tax rates. This last observation is largely attributable to the militating behavioural responses of alternative income groups, which dampen the adjustments required for budget neutrality and general equilibrium.

The Universal Pension (GE UP reform) exaggerates the GE PC reform scenario, reducing the means testing taper rate from 40% (under the PC) to 0% and requiring larger adjustments to factor prices for general equilibrium and marginal tax rates for budget neutrality. Comparing the effects on employment between ages 60 and 64 of the GE UP reform with the GE PC reform suggests that the GE UP reform produces exaggerated behavioural responses. This impression is, however, not supported by the effects on employment identified for all ages, which suggest that the higher tax rates associated with the GE UP reform discourage employment, particularly for poorer households. Although the improved savings incentives to poorer households under the UP does motivate higher employment about retirement, the accompanying increase in tax rates discourages labour supply between ages 20 and 50 by, on average, 3.1% of simulated households in subgroup $x = 0$, 1.5% of households in subgroup $0 < x < 3.2$, and 0.5% of households in subgroup $3.2 < x < 32$ (not reported in Table 4). This reflects the weak incentives that low income households have to supply labour in the simulations.

The wealth statistics reported in Table 4 for households in subgroups defined by $x < 100$ reflect the view that the GE UP reform exaggerates the behavioural responses of households that are not driven out of the labour market by the higher rates of taxation that are imposed by the policy counterfactual. In contrast, the wealth statistics reported for higher income households reflect two important effects of the GE UP reform: the greater generosity of the UP to high income households during retirement and the higher tax rates that are applied during the working lifetime. These two effects lead to substantial reductions in the private provisions made for retirement by high income households, relative to either the Partial or GE PC reform scenarios.

Similar effects are described by the consumption statistics reported in the Table, with the behavioural responses of households in subgroups $x < 100$ exaggerated by the GE UP reform (relative to either the Partial or GE PC reforms), and higher income households negatively affected by the higher tax rates imposed. Of particular note is the distributional profile of the change in consumption observed due to the GE UP reform for all ages. The statistics indicate that consumption aggregated over the lifetime falls (relative to either the MIG, Partial or GE PC reform scenarios) most substantially at the distributional extremes due to the GE UP reform, and peaks at a positive value for the subgroup defined by $32 < x < 80$. The preceding discussion reveals that, at the low end of the distribution, the fall is attributable to the effects of labour supply responses to the accompanying increase in tax rates. At the high end of the distribution it is attributable to the larger tax burden imposed. Although households in subgroup $32 < x < 80$ are also subject to higher taxes during the working lifetime under the GE UP reform, this is more than offset by the more generous benefits that they receive in retirement. These observations are reinforced by the tax statistics reported in Table 4, which indicate that – from a lifetime perspective – the higher benefits enjoyed by the 34% of households defined by $32 < x < 200$ are paid for by low income households on the one hand ($0 < x < 32$, who bear 45% of the burden) and by high income households on the other ($300 < x$).

The final policy scenario that is considered here involves reducing from 50% to 30% the proportion of wealth that is exempt from means testing ('Exemption Sensitivity Analysis', for which $\eta = 0.7$). The statistics reported in Table 4 indicate that reducing the proportion of assets exempt from means testing exaggerates the behavioural responses to replacing the MIG with the PC.

5.2. *Aggregate Effects*

Table 5 reports average age specific effects, aggregate lifetime effects and cross-sectional effects that are specified to reflect the population structure described by the 2001 UK census. The first two of these relate directly to the results presented in Table 4, while the third permits comparison with contemporary budgetary figures.

Focussing on the statistics reported for the Partial PC reform, Table 5 indicates that the off-setting behavioural responses of households that are identified in Section 5.1 imply a small delay in the timing of retirement, with 0.3% of the simulated cohort choosing to work under the Pension Credit between ages 60 and 64 where they did not under the Minimum Income Guarantee. Hence, from the perspective of the aggregate impact on labour supply, the substitution effects of poorer households tend to dominate. It is of note that this contradicts the effect that Disney and Smith (2002) find for men aged 60 to 64 following omission of a UK earnings test from age 65. In contrast, the savings statistics reported for the Partial PC reform in Table 5 reveal that income and substitution effects of middle income households dominate the long-run impact of the policy change on average household wealth. The Table suggests that average household wealth is likely to fall with the introduction of the PC, by 8% of average annual employment income for households aged 65–79. The increased labour supply and greater generosity of the pension system under the PC also generate higher average consumption throughout the lifetime under the Partial PC reform, by approximately 12% of average annual employment income when aggregated over the simulated lifetime.

One of the most interesting results revealed by Table 5 is the impact on behavioural responses of the proportion of wealth that is exempt from means testing. The Table indicates that increasing the proportion of wealth that is subject to the means test, produces more positive simulated behavioural responses to a shift from the MIG to the PC – households choose to both work more and save more in response to the PC when

Table 5

Aggregate Responses to Replacing the Minimum Income Guarantee with Alternative Policy Counterfactuals

Age Group	Partial PC reform	GE PC reform	GE UP reform	Exemption Sensitivity
		change in wealth (%*)		
20–49	−0.27	0.57	0.60	−0.07
50–54	−2.46	−0.42	−12.42	−1.38
55–59	−3.89	−2.18	−29.34	−2.15
60–64	−5.12	−4.20	−52.46	−1.73
65–79	−8.04	−8.68	−54.75	−2.88
80–110	−7.10	−6.31	−18.42	−2.57
lifetime average	−3.37	−2.67	−20.11	−1.28
2001 cross-section	−3.09	−2.27	−18.71	−1.19
		change in employment (%**)		
20–49	0.04	0.03	−1.11	0.03
50–54	0.10	0.00	−1.59	0.01
55–59	0.26	0.06	−2.02	0.34
60–64	0.34	0.02	−3.02	1.00
lifetime aggregate	4.57	1.29	−66.17	7.62
2001 cross-section	0.10	0.03	−1.46	0.16
		change in consumption (%*)		
20–49	0.06	−0.15	−2.48	0.04
50–54	0.27	0.09	−1.83	0.18
55–59	0.28	0.11	−1.57	0.15
60–64	0.20	0.11	−1.14	0.08
65–79	0.43	0.55	1.98	0.33
80–110	0.04	0.25	2.99	0.09
lifetime aggregate	11.73	5.90	−51.35	8.10
2001 cross-section	0.19	0.07	−1.13	0.13
		change in net taxes paid by households (%**)		
20–49	0.00	0.24	2.57	0.01
50–54	0.00	0.33	3.53	0.00
55–59	0.06	0.22	1.61	0.13
60–64	0.31	0.36	−0.23	0.67
65–79	−0.53	−0.45	−5.15	−0.23
80–110	−0.93	−0.91	−5.15	−0.50
lifetime aggregate	−11.01	−0.01	−0.02	−2.00
2001 cross-section	−0.13	0.06	0.53	−0.01

Changes measure difference between subgroup arithmetic means under alternative policy environments
'Lifetime aggregate' and age specific statistics weighted by survival rates
'2001 cross-section' statistics weighted to reflect census data for UK
*percentage of average gross annual income
** percentage of population subgroup

the exemption is reduced. This observation reflects the fact that the behavioural responses of low income households to the PC are exaggerated, relative to those of higher income households, as the proportion of wealth subject to the means test rises.

The proportion of wealth exempt from means testing also has an important influence on how the average tax burden of households is affected by replacing the MIG with the PC. With a 50% exemption (the Partial PC reform), the average lifetime tax burden of households is reduced by 11% of annual employment income by the PC relative to the MIG. This figure is reduced to a 2% fall when the exemption is reduced to 30%, which underscores the fact that the welfare effects of replacing the MIG with the PC are strongly influenced by the permitted exemptions of means tested pension benefits. The PC is unambiguously more generous than the MIG. Putting aside issues such as potential General-Equilibrium feedback effects for wages and investment, if the PC can be implemented at the same or lower cost than the MIG, then the PC will be strictly preferable to the MIG. Welfare effects are discussed at greater length in the following subsection.

Given approximate budget neutrality, comparisons between the GE PC reform and UP statistics reported in Table 5 indicate that the UP implies a larger reduction in labour supply than the PC, and a larger fall in aggregate consumption (aggregated over both the cross-section and lifetime). The more generous retirement benefits provided by the UP do, however, lead to higher consumption during retirement, relative to the three alternative policy scenarios considered for analysis.

Aggregating the age specific data generated by the cohort simulations to reflect the age profile of the UK population, as described by the 2001 Census (See Table S003, 'Age of Household Reference Person (HRP) by sex and marital status ('headship')', ONS publication, http://www.statistics.gov.uk/StatBase/Expodata/Spreadsheets/D7511.xls), suggests an annual aggregate cost of payments made under the MIG of between £1.23 ($\eta = 0.7$) and £1.33 ($\eta = 0.5$) billion.[5] This compares with an annual aggregate cost of payments made under the PC of between £1.30 ($\eta = 0.7$) and £1.47 ($\eta = 0.5$) billion, a rise of between £77 and £143 million.

Focusing only upon the impact of payments made directly under the MIG and PC fails to capture the full budgetary impact of the pension policy regime. Aggregating all tax and benefits payments to households of pensioner age and weighting the population to reflect the 2001 Census suggests that the transfer system that incorporates the MIG provides a net transfer benefit to pensioners of between £21.0 ($\eta = 0.7$) and £22.4 ($\eta = 0.5$) billion per year.[6] Similarly, the PC provides a net transfer benefit of between £21.4 ($\eta = 0.7$) and £23.2 ($\eta = 0.5$) billion per year – £373–797 million more than under the MIG. The higher budgetary cost observed for the PC when the impact of taxes is taken into consideration, follows from the lower aggregate savings of households. Consequently, the simulations suggest that replacing the MIG with the PC will increase the reliance on the welfare state in the long-run, and increase the aggregate budgetary burden of the retired population.

Extending the analysis to consider an entire population cross-section suggests that the PC will reduce the aggregate tax revenue from households. Simulations undertaken assuming $\eta = 0.7$ suggest net tax receipts for the population will fall from £107,671 million under the MIG to £107,602 million under the PC, a reduction of £69 million per year, while assuming $\eta = 0.5$ suggests net tax receipts will fall from £106,536 million to £105,881 million per year. The improvement in the net budgetary effect of shifting to the PC, relative to the comparison of retired households only, is attributable to the prolonged working life of households under the PC.

[5] Calculating the average household Income Support/MIG receipt by age described by the 2002/3 Family Resource Survey, and weighting by the age profile described by the 2001 Census suggests an aggregate annual payment of £1.62 billion.

[6] The corresponding figure obtained by combining FRS and Census data is a net expenditure of £35.1 billion per year.

5.3. *Welfare Effects*

Table 6 reports the effects on expected lifetime utility of the two policy counterfactuals considered above that include tax adjustments for budget neutrality and factor price adjustments to reflect a competitive equilibrium in a closed economy. The first policy reform involves replacing the Minimum Income Guarantee (MIG) with the Pension Credit (PC), which reduces the taper rate on pension benefits from 100% to 40%. The second reform involves replacing the Minimum Income Guarantee with a Universal Pension (UP), which does away with means testing of pension benefits entirely. The Table reports compensating variations of each of these policy counterfactuals, measured from age 20 (taking into account the entire simulated lifetime) and age 65 (focussing upon retirement). The Table also disaggregates the population into the same income categories that are considered in Subsection 5.1, which facilitates a distributional analysis. Disaggregating the simulated population by human capital at age 20 gave similar distributional results to those reported here.

Beginning with the statistics reported for age 20, the results obtained are striking – welfare is improved, indicated by negative values under the reformed policy, on average throughout the income distribution by reducing taper rates from 100% to 40% (PC) but it is reduced when means testing is omitted entirely from the pension system (UP). The analysis reported in the preceding subsections suggests that these observations are primarily attributable to the tax adjustments that are required to obtain budget neutrality between the alternative policy counterfactuals. Both the PC and the UP are strictly more generous pension schemes that improve incentives to save, relative to the MIG. The increase in taxes required to fund the more generous pension benefits paid under the PC is small in the simulations, because low income households choose to save more and work longer in response to their improved incentives to save. In contrast, the incentive effects on poorer households under the UP are more than offset by those of richer households, so that the accompanying increase in marginal tax rates is

Table 6

Compensating Variations of Replacing the Minimum Income Guarantee with Alternative Policy Counterfactuals

	From age 20		From age 65	
Income Group*	Pension Credit	Universal Pension	Pension Credit	Universal Pension
0.00	−0.701	7.344	0.299	1.007
0.01 to 3.20	−0.724	8.349	−0.145	0.183
3.21 to 32.00	−0.731	8.685	−17.777	−27.941
32.01 to 80.00	−0.734	8.820	−73.813	−124.348
80.01 to 100.00	−0.736	8.895	−60.020	−147.162
100.01 to 200.00	−0.741	9.144	−23.257	−137.620
200.01 to 300.00	−0.749	9.540	−7.204	−138.719
300.01 and over	−0.756	9.996	−6.934	−168.490
All	−0.736	8.941	−16.437	−101.991

* Groups defined in terms of pre-tax and benefit income in £ per week at age 65 under MIG
The two policy counterfactuals reported here include tax adjustments for budget neutrality and factor price adjustments to reflect market responses in a closed economy. Compensating variations are measured as percentages of average annual gross employment income equal to £22,724.

approximately 14 times that applied under the PC. The statistics reported in Table 6 indicate that the effects of increased taxes during the working lifetime imposed under the UP more than offset the improvement in savings incentives for lower income households and increased generosity of pension benefits, resulting in lower expected lifetime utility. The opposite holds true for the PC.

Comparing the compensating variations reported from age 20 with those from age 65 reveals that welfare effects calculated for retirement exhibit wider variation between income groups and a larger magnitude, relative to those calculated for the entire simulated lifetime. The flatter profiles by income group obtained for the entire simulated lifetime reflect the fact that the simulated cohort is more homogenous at age 20 than it is at age 64, due to the influence of household specific disturbances in the wage generating process between ages 21 and 64. This greater homogeneity at age 20 and the associated uncertainty with regard to the evolution of wages during the working lifetime also partly explain the small magnitude of the compensating variations calculated at age 20, relative to age 64. The small magnitude of life-time effects is also due to the influence of discounting, the offsetting influence of the welfare gains obtained under the PC/UP relative to the MIG and the welfare losses associated with the accompanying increase in tax rates during the working lifetime.

The compensating variations reported from age 65 in Table 6 indicate that both the PC and UP tend to increase welfare during retirement, compared with the MIG. This is clearly consistent with the more generous pension benefits payable under the PC and UP. In the case of the PC, the welfare gains increase from zero for the poorest household group, to peak for the income group $32 < x < 80$, before falling away for richer households. In contrast, the welfare effects for the UP describe a rapid rise from between $3.2 < x < 80$, before levelling off for higher income groups. These welfare effects observed for the PC and UP mirror the impact that the respective policy counterfactuals have on benefits eligibility. It is, however, of particular interest to note that the compensating variations reported from different ages in Table 6 suggest very different judgements regarding the relative merits of the three alternative pension schemes – MIG, PC, and UP – that are considered here. This highlights the problems that can arise by adopting an analytical focus that is too narrow.

6. Conclusions

This study uses a structural model of household behaviour to infer long-run behavioural responses to the replacement of the Minimum Income Guarantee with the Pension Credit, both considered in the absence of second tier pensions. The selection of this policy counterfactual is designed to focus upon the incentive effects of means testing pensions policy, with particular regard to savings and retirement behaviour. Careful attention is also paid to the distributional variation that underlies population aggregates.

The simulations reported here suggest that the reduction in means testing taper (phase-out) rates from 100% to 40% associated with the introduction of the PC is likely to have a desirable impact on the behaviour of poorer households – the poorest third of the population (based on wealth at age 64 under the MIG) are encouraged to both work longer and save more by the higher effective rates of return that they enjoy under the PC. In contrast, households in the middle third of the population are induced to work and save less, as the introduction of the PC implies that these households need to sacrifice less consumption in retirement per additional pound consumed prior to the State Pensionable Age. The most affluent third of the population are largely unaffected. In aggregate, the simulations imply an overall delay in the timing of retirement, a fall in average savings and a small reduction in the net lifetime tax burden.

There is a general question associated with means testing, which is whether it is better to have narrowly focused benefits and high withdrawal rates, or benefits that are more widely available and subject to lower withdrawal rates. The general assumption is that the second of these policy options is more expensive than the first, and so imposes a higher burden on the public purse. However, our study finds, using plausible assumptions about elasticities of labour supply and intertemporal substitution, that the shift to lower withdrawal rates associated with the introduction of the PC does not impose a substantial additional burden on the government budget. Indeed, we find that expected lifetime utility is higher under the PC than the MIG when taxes during the working lifetime are adjusted to maintain budget neutrality. Furthermore, we find that when means testing is eliminated from the pension system entirely, the tax adjustments necessary to maintain budget neutrality imply a fall in expected lifetime utility. Hence, the Pension Credit appears to provide a reasonable compromise between the distortions associated with high marginal tax rates, and the costs implied by universal benefits provision.

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References

Atkinson, A. B., Bourguignon, F., O'Donoghue, C., Sutherland, H. and Utili, F. (2002). 'Micro-simulation of social policy in the European Union: case study of a European minimum pension', *Economica*, vol. 69, pp. 229–43.

Attanasio, O. P. and Weber, G. (1993). 'Consumption growth, the interest rate and aggregation', *Review of Economic Studies*, vol. 60, pp. 631–49.

Attanasio, O. P. and Weber, G. (1995). 'Is consumption growth consistent with intertemporal optimization?', *Journal of Political Economy*, vol. 103, pp. 1121–57.

Balcer, Y. and Sadka, E. 1986. 'Equivalence scales, horizontal equity and optimal taxation under utilitarianism', *Journal of Public Economics*, vol. 29, pp. 79–97.

Blundell, R., Browning, M. and Meghir, C. (1994). 'Consumer demand and the life cycle allocation of household expenditure', *Review of Economic Studies*, vol. 61, pp. 57–80.

Brewer, M. and Emmerson, C. (2003). 'Two cheers for the Pension Credit?', IFS Briefing Note No. 39.

Browning, M., Deaton, A. and Irish, M. (1985). 'A profitable approach to labor supply and commodity demands over the life-cycle', *Econometrica*, vol. 53, pp. 503–44.

Chou, S., Liu, J. and Huang, C. J. (2004). 'Health insurance and savings over the life-cycle – a semiparametric smooth coefficient estimation', *Journal of Applied Econometrics*, vol. 19, pp. 295–322.

Deaton, A. (1997). *The Analysis of Household Surveys*, Baltimore: John Hopkins University Press.

Deaton, A. and Muellbauer, J. (1980). *Economics and Consumer Behaviour*, Cambridge: Cambridge University Press.

Disney, R. and Smith, S. (2002). 'The labour supply effect of the abolition of the earnings rule for older workers in the United Kingdom', Economic Journal, vol. 112, pp. C136–52.

Fagan, C. (2003). 'Working-time preferences and work-life balance in the EU: some policy considerations for enhancing the quality of life', Dublin: European Foundation for the Improvement of Living and Working Conditions.

Feldstein, M. S. (1987). 'Should social security benefits be means tested?', *Journal of Political Economy*, vol. 95, pp. 468–84.

French, E. (2005). 'The effects of health, wealth, and wages on labour supply and retirement behaviour', *Review of Economic Studies*, vol. 72, pp. 395–427.

Friedberg, L. (2000). 'The labor supply effects of the social security earnings test', *Review of Economics and Statistics*, vol. 82, pp. 48–63.

Gourinchas, P. and Parker, J. (2002). 'Consumption over the life cycle', *Econometrica*, vol. 70, pp. 47–89.

Gruber, J. and Yelowitz, A. (1999). 'Public health insurance and private savings', *Journal of Political Economy*, vol. 107, pp. 1249–74.

Gustman, A. L. and Steinmeier, T. L. (1986). 'A structural retirement model', *Econometrica*, vol. 54, pp. 555–84.

Gustman, A. L. and Steinmeier, T. L. (2004). 'The social security retirement earnings test, retirement and benefit claiming', NBER Working Paper No. 10905.

Gustman, A. L. and Steinmeier, T. L. (2005). 'The social security early entitlement age in a structural model of retirement and wealth', *Journal of Public Economics*, vol. 89, pp. 441–64.

Heckman, J. (1974). 'Life cycle consumption and labor supply: an explanation of the relationship between income and consumption over the life cycle', *American Economic Review*, vol. 64, pp. 188–94.

Heer, B. (2002). 'The German unemployment compensation system: effects on aggregate savings and wealth distribution', *Review of Income and Wealth*, vol. 48, pp. 371–94.

Hicks, J. R. (1939). *Value and Capital*, Oxford: Clarendon Press.

Hubbard, R. G., Skinner, J. and Zeldes, S. P. (1995). 'Precautionary saving and social insurance', *Journal of Political Economy*, vol. 103, pp. 360–99.

Low, H. (2005). 'Self-insurance in a life-cycle model of labour supply and savings', *Review of Economic Dynamics*, vol. 8, pp. 945–975.

Marmot, M., Banks, J., Blundell, R., Lessof, C. and Nazroo, J. (2003). *Health, Wealth and Lifestyles of the Older Population in England: The 2002 English Study of Longitudinal Ageing*, London: Institute for Fiscal Studies.

McClements, L. (1977). 'Equivalence scales for children', *Journal of Public Economics*, vol. 8, pp. 191–210.

Mincer, J. and Ofek, H. (1982). 'Depreciation and restoration of human capital', *Journal of Human Resources*, vol. 17, pp. 3–24.

Muellbauer, J. and van de Ven, J. (2004). 'Estimating equivalence scales for tax and benefits systems', NIESR Working Paper No. 229.

Neumark, D. and Powers, E. (1998). 'The effect of means-tested income support for the elderly on pre-retirement saving: evidence from the SSI program in the US', *Journal of Public Economics*, vol. 68, pp. 181–206.

Neumark, D. and Powers, E. (2000). 'Welfare for the elderly: the effects of SSI on pre-retirement labour supply', *Journal of Public Economics*, vol. 78, pp. 51–80.

Powers, E. (1998). 'Does means-testing welfare discourage saving? Evidence from a change in AFDC policy in the United States', *Jounal of Public Economics*, vol. 68, pp. 33–53.

Rust, J. and Phelan, C. (1997). 'How social security and medicare affect retirement behavior in a world of incomplete markets', *Econometrica*, vol. 65, pp. 781–831.

Sefton, J. A. (2000). 'A solution method for consumption decisions in a dynamic stochastic general equilibrium model', *Journal of Economic Dynamics and Control*, vol. 24, pp. 1097–119.

Sefton, J. and van de Ven, J. (2004). 'Simulating household savings and labour supply: an application of dynamic programming', *National Institute Economic Review*, vol. 188, pp. 56–72.

Sefton, J., van de Ven, J. and Weale, M. (2005). 'The effects of means testing pensions on savings and retirement', NIESR Discussion Paper No. 265.

Sefton, J., van de Ven, J. and Weale, M. (2006). 'Means testing retirement benefits: fostering equity or discouraging savings?' NIESR Discussion Paper No. 283.

van de Ven, J. (2006). 'The incentive effects of means tested UK retirement benefits – has the Pension Credit gone too far?', NIESR Discussion Paper No. 284.

Ziliak, J. P. and Kniesner, T. J. (2005). 'The effect of income taxation on consumption and labor supply', *Journal of Labor Economics*, vol. 23, pp. 769–96.