# A Structural Dynamic Micro-Simulation Model for Policy Analysis:

# Application to Pension Reform, Income Tax Changes and Rising Life Expectancy

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ABSTRACT

This paper describes the National Institute's Benefit and Tax Model, NIBAX and provides results of studies using it to explore i) the introduction of low-cost pensions similar to Personal Accounts, ii) the effects of the abolition of the 10p income tax rate and iii) the consequences of rising life expectancy.

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# 1 Summary

## *1.1 The Modelling Framework*

1. In recent years there has been increasing concern about the level of savings in the United Kingdom. At a macro-economic level the UK has one of the lowest savings rates of the advanced countries. At a micro-economic level rising longevity and an ageing population have focused attention in many advanced countries on whether retirement saving is adequate. It is often argued that the tax/benefit structure has important implications for incentives to save. For example the removal of dividend tax credits for pension funds is sometimes quoted as substantially affecting incentives to save in pension schemes. It is also often said that means testing of retirement benefits discourages saving for retirement. But so far it has been difficult to explore these claims. Not only are there very real data problems but there has not been any mechanism available for exploring how rational people might be expected to respond to these and other features of the tax/benefit system.

2. This paper reports on a project undertaken by NIESR for the Department for Work and Pensions and Her Majesty's Revenue and Customs to produce a new behavioural model of household savings behaviour (the National Institute Benefit and Tax Model, NIBAX). This is intended to provide a new simulation tool suited to exploring the implications of tax and benefit changes for long-term savings incentives and behaviour.

3. Work on the NIBAX project began in mid 2007, following on from earlier related modelling that NIESR conducted on behalf of both government departments in this area. The main purpose of this report is to provide an insight into the key challenges of modelling savings behaviour, details of our basic approach, and a summary of results from a series of policy simulations which we conducted to illustrate the potential uses and capabilities of the model.

4. The model aims to complement the wide array of existing techniques employed by government analysts for assessing the impact of changes to the taxes and benefits system, such that policy-makers can be better informed about the potential impact of policies on household savings behaviour.

5. The NIBAX fits within a generic class of 'life-cycle' savings models, built round the assumption of rational expectations. The latter assumption has been employed very widely in the field of economic modelling, partly due to its intuitive appeal and the consistency of results it generates. In the current setting, the basic premise is that people make decisions about work/leisure and consumption/saving with a reasonable understanding of the economic environment within which they operate. Thus, for example, they are assumed to know (or are able to find out about) the returns to work and to saving, and broadly to understand how these incentives are affected by the tax and benefit systems. They are also assumed to be forward-looking – which is not to say that they are certain about the future, or that they do not make mistakes – but, rather, that their decisions can be sensibly understood in context of their prevailing circumstances.

6. Obviously such an assumption is open to criticism; people may not be as rational as is assumed in our model. Or it may take people a long time to adjust and absorb the implications of changes to their environment. Thus, in so far as our model accurately represents household behaviour, it might be thought of as a model of long-run rather than short-run behaviour.

7. NIBAX therefore stands in stark contrast to many existing micro-simulation models. The latter are typically more detailed in their description of people's circumstances but do not take any account of how labour supply or savings behaviour is expected to change in response to changes in taxes or benefits, either during the working life or post-retirement. Such models are therefore probably best seen as short-term guides to the impact of policy changes on people's incomes and function well in this respect, but are less satisfactory as indicators of the full, longer-term effects of changes in government tax policy. We suggest that robust policy analysis should draw on all these models, but stress the importance of models such as NIBAX in this suite.

## *1.2 Key Assumptions & Parameters*

8. A fundamental assumption underpinning the model is that people maximise their expected life-time welfare, taking into account expectations of future earned income,

the taxes they expect to have to pay and the benefits that they expect to receive. In the light of these expectations, they make decisions about how much to work and how much to consume/save in each period. Depending on the framework specified by the model user, they may also make decisions about whether to contribute to a pension in order to save for retirement.

9. In the model, people make decisions about how much to work, and how much to consume or save in the face of four types of uncertainty:

i) Wage uncertainty — people do not know their future wage rates. Wages are predicted on the basis of current earnings and past experience, but there is a substantial random component to them.

ii) Household type – people do not know how their family circumstances are going to evolve over time. Uncertainty exists both in terms of relationship formation/breakdown and over number of children in a household.

iii) Mortality risk – although people know the risk of death at any age, they do not know how long they themselves will live.

iv) Investment risk – the return on risky assets in the model is uncertain.

10. The standard response to these uncertainties, observed in our simulations, is that people save more than they would in the absence of such uncertainty. In this sense, a general prediction from our model is that people with a forward-looking, rational approach to saving will tend to save sufficiently for 'rainy day' needs.

11. The model permits savings to be invested in either safe or risky assets. People can essentially choose to invest in interest bearing savings or equity type accounts. Saving in pensions is also handled by the model, with tax relief granted on contributions and investment returns and with income tax payable on retirement annuity incomes.

12. The model also handles personal debt in that people are allowed to be net debtors in their working lives prior to retirement. However, debt levels are limited in the model through a user-specified age-specific limit to net debt.

13. One aspect of household saving that does not feature explicitly in the model is saving in housing assets. Housing is not distinguished from other wealth in the core model but is treated through an add-on module which is used to identify how far wealth could be invested in housing assets conditional on overall levels of modelled saving.

14. Alongside the above aspects of the model, it is also worth briefly reflecting on the key choice parameters available to the user. Users are able to change both key behavioural and key environmental parameters. In the first category we include assumptions about the way in which people trade off consumption of goods for leisure, the extent to which they pay attention to the future and their attitudes to risk. The second, much wider set, includes the specification of the tax/benefit system, rates of return and the age profile of wages. Users can specify the extent to which the last two are uncertain.

15. Ideally, any model of this type should be related to underlying data and so the parameter choices in the core model represent the outcome of a process to ensure the model fits key data reasonably well. But, inevitably, there are trade-offs between the capacity of the model to fit different categories of data and as with most models of this type, these trade-offs are handled in a relatively arbitrary way, rather than being estimated by regression methods.

## *1.3 Interpreting Results*

16. In interpreting the results from the model it should be noted that the model is intended to represent the behaviour of a cohort which plans for the future while facing a stable economic environment. In practice we cannot observe the income, consumption and labour supply of such a cohort. In reality, even the behaviour of a group of people all born in the same year does not provide an ideal data set against which to compare the performance of the model, since they live through potentially very different economic circumstances.

17. In common with most other work of this type, we have therefore related the model's performance to cross-section data for a single year, 2005, but with the income and expenditure figures adjusted to allow for the reasonable assumption that people expect continuing economic growth. This provides a base run against which the effects of policy changes can be explored.

18. To keep the model manageable, we have also paid most attention to the capacity of the model to account for average labour supply and consumption patterns. In this respect, the base run of the model does reasonably well in replicating employment and

consumption profiles of both single people and couples by age. However, it does understate the variability of consumption by both single households and couples.

## *1.4 Modelling Policy Scenarios*

19. The NIBAX model is capable of simulating any combination of tax and benefit changes and so lends itself to a very wide range of tax policy simulations. As the main purpose of the present exercise has been to develop a model for use by government practitioners, our use of the model to examine policy simulations has thus far been limited to only three illustrative policy changes. These are intended to highlight the type of effects that can be examined through the use of the model and are not necessarily an accurate prediction of the long term impact of actual policy.

## *1.5 Low-cost Pensions*

20. The Government has recently legislated to reform private pensions with the reforms including the introduction of major private pension reforms. Key features of these are:

    i) a system of Personal Accounts with low charges designed to increase returns to savers

    ii) automatic enrolment with an opt-out

    iii) employer contributions which cannot be commuted into pay

    iv) tax relief on contributions

    v) calculation of means tested benefits on income net of pension contributions -or half contributions for housing benefit and council tax benefit.

    It should be noted that features iv) and v) apply to all pensions and not just to Personal Accounts.

21. Current computing limitations mean that all of these features cannot be represented exactly and so we have made a number of minor simplifications.

22. The effects of pension arrangements similar to the proposed Personal Accounts, as introduced by the Pensions Act, 2008, are explored by comparing our base run, in which they are available, with an alternative in which there are no tax-favoured pension saving schemes. In the simulations below we do not restrict the availability of this low cost pension to any specific group, even though in reality Personal Accounts are designed to attract those on relatively modest incomes. The simplifications

mentioned above also mean that our results slightly overstate the appeal of low-cost pensions as we model them in comparison to Personal Accounts. However, they have little impact on the analysis we do to show the impacts of rates of return/management fees, decision-making costs and high discount rates on participation in low-cost pensions.

23. The following points describe the main effects that the model shows resulting from the introduction of the policy.

24. The scheme is attractive to most people in all income categories at some point in their working lives.

25. In the absence of any qualifying conditions, the scheme would be more attractive to people on relatively high incomes paying higher-rate tax than those on low incomes. This is because tax relief is offered at the tax-payer's marginal rate on contributions which, for high earners may exceed the tax rate they pay on their subsequent pensions. Tax relief also means that the entitlement to draw a tax-free lump sum from a pension fund is worth more to higher rate payers than to basic rate payers. A contribution or income cap could prevent high earners from being its major beneficiaries.

26. It is not likely to be rational for all young people to join the scheme. There are two reasons for this which interact:

i) First of all, many young people are rationally debtors because they have sensible expectations of rising income. With interest rates on debt higher than the rate of return on pensions it becomes more sensible for them to reduce their debts than to contribute to a pension. Employer contributions may not be large enough to offset this effect.

ii) Secondly, money saved in pensions is illiquid and is therefore not available to meet the sort of emergencies that people can face. This is more important for young people with long working lives remaining than for old people closer to retirement for whom this type of uncertainty is less important.

27. Participation rates of low earners in the model are supported by the fact that, with incapacity and pension credit facilitating the possibility of early retirement, their working lives are relatively short. The mean working life of someone in the bottom life-time income decile is 29.4 years while for someone in the top income decile it is 36 years. This, combined with the observation that there is lower demand for savings

liquidity amongst lower-earners, motivates relatively high rates of participation amongst low-earners.

28. The favourable impact of low management costs raises participation rates. If, as in the illustration provided here, the real rate of return is raised from 4.5% p.a. to 5% p.a. due to the policy, then participation rates are raised by up to twenty percentage points. The effect is most marked for low earners in their thirties, a group for whom the decision to start pension saving is marginal. For people over forty the impact on participation is small but it rises again for people on moderate incomes late in working life.

29. Decision-making costs, represented here by a charge for joining, could be a very substantial barrier to membership by people in the lowest income groups. This suggests that policies to reduce decision-making costs, such as simplified joining or automatic enrolment with an opt-out, could significantly increase participation.

30. Myopia — which in a weak sense can be mimicked by assuming a very high discount rate in the model[1] typically reduces the likelihood of all groups joining the scheme, but also has a markedly bigger effect on the chances of low earners (compared with high earners) joining the scheme.

## *1.6 Changes in Income Tax Rates*

31. To demonstrate the capacity of the model for analysing changes in tax parameters, we have sought to model an illustrative reduction in the basic rate of income tax, accompanied by the removal of the 10p starter rate of income tax. This scenario resembles the recent changes to UK income tax rates, though not all aspects of the package of changes announced in Budget 2007 are modelled here.[2]

32. Changing tax rates in this way leads to some fairly obvious results in the model, but also generates some more surprising effects.

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[1] Behavioural economists use myopia to describe a situation in which high annual discount rates are applied to the near future but that lower discount rates are applied further into the future. The overall discount factor applied to any future year is calculated by compounding these different rates.

[2] To keep things simple, we have not included any changes in tax/NICs thresholds. We recognise that, the package of changes announced at Budget 2007 included important changes to tax/NICs thresholds. The simulation cannot therefore be taken to represent the later package of reforms, but merely provides a demonstration how changes in marginal tax rates impact in the model.

33. Relatively small changes in marginal tax rates of the sort contained in the package of changes announced in Budget 2007 (i.e. abolition of the 10p starting rate of income tax and a reduction in the base rate of tax from 22% to 20%) unsurprisingly also tend to generate relatively small effects in the model.

34. For households on relatively low incomes (broadly defined as the bottom quintile) lifetime incomes are reduced, while middle and high income households experience a net increase in lifetime incomes. This broadly reflects the relative impact of the starter and basic rates of income tax on the respective groups in the model.

35. As a result, lifetime consumption is lower for low income households and higher for middle and high income households. However, the impact in terms of the time profile of consumption reveals that even the increase in consumption of middle and higher income households will tend to fall away in early retirement. For the top two quintiles the benefit of the tax reduction is split reasonably equally between the working lifetime and retirement. For people lower down the income scale any benefit received tends to be consumed mainly during the working lifetime.

36. In terms of welfare, the effects are relatively small. The lowest quintile will be approximately 0.1% worse off during the working lifetime (as measured by life-time utility), and the highest quintile will be around 0.2% better off during their entire lifetime.

37. The impact on saving is broadly similar: those on low incomes reduce their savings slightly while those on high incomes increase theirs a little. Pension saving rises less than in proportion to total saving (largely because the model assumes that the benefit system is indexed to wages while pension income is indexed to prices).

38. Labour supply effects are very small (given the relatively small size of the simulated tax changes). Generally, people in the lowest income quintile increase their labour supply right into their late forties. The incentive effects also broadly serve to increase the labour supply of people in the top income quintile. But for middle income groups, labour supply actually shows a small fall by the age of around fifty.

## *1.7 Implications of High Life Expectancy*

39. Expected mortality rates influence economic behaviour mainly because they affect the retirement period for which people have to plan; they also influence the annuity rates people face. In our standard model we use the mortality rates forecast by the Government Actuary for the cohort of people aged twenty in 2006 (cohort mortality rates). On this basis the expected life of a household, defined as ending when the second spouse of a couple dies, is just over 96 years. In order to examine the effect of rising life expectancy we prepare an alternative base. Here the expected mortality rates are those observed in the cross-section for the population in 2006 (period mortality rates) giving an expected household life-span of just under 88 years. Comparison of the model solution on this assumption with that generated in our standard run provides a convenient means of indicating the effect of rising life expectancy.

40. To explore the effects of rising life expectancy, we undertake a new run of the model using current period mortality rates. The effects of the assumed cohort mortality rates can then be seen as a perturbation relative to this. The main effects of this simulation of changing mortality are as follows:

41. Intuitively one might expect that a rise in life expectancy would lead households both to work and to save more. However, any impact from changing mortality on savings is in part mitigated by the fact that the future is discounted in the model. As a result, the simulated rise in life expectancy (or equivalently, the fall in mortality) has very little impact on savings for people below age 35 (in any income quintile). Beyond this age, the saving of people in the top two income quintiles rises in line with standard life-cycle analysis. Average saving per person rises in step with this.

42. However, the simulation also shows that middle and low earners reduce their saving in response to rising life expectancy. This is because, with our model parameters, working life and thus life-time income does not rise in line with life expectancy. Thus average consumption over the life-cycle has to decline. This decline is reflected in lower planned pension income. But the lower pension income means that people are affected by means testing as a result of increased longevity, and this reduces the incentive to save for retirement.

43. Even for high earners, saving does not rise by enough to compensate fully for the effects of increased longevity on pension income. Consumption in the early years of

retirement declines across the board. Even without the distortion of means testing, high earners trade off leisure during the working age phase against maintained consumption in the retirement phase of their lives. Thus, although high and middle income groups increase their labour supply in response to increased life expectancy, the increase is not large enough to prevent reduced consumption just after retirement. There is no clear effect on the labour supply of the two lower quintiles.

44. Beyond the late seventies all income groups increase their consumption, as they benefit from lower rates of spending from non-pension wealth earlier in retirement. To the extent that people do not annuitise a higher probability of living longer discourages spending early in retirement leaving extra available later in retirement.

## *1.8 Key Insights*

45. It can be difficult to anticipate how changes to policy will affect incentives to work and save. These difficulties are normally exaggerated when incentives depend upon variable household characteristics such as wages, accrued wealth, demographics, and so on. One of the main attractions of our model is that it is designed to show the detailed effects that alternative policy environments can have on savings, wealth and labour supply over time, assuming that people both understand the world that they live in and act in their own best interests.

46. The report draws out the effects of a range of simulations which demonstrate the capacity of the model to accurately predict lifetime savings behaviour in response to changes in tax and benefits policy. Key insights from this analysis include:

47. Incentives regarding contributions to pensions vary in a complex manner over the income distribution. At the lowest incomes, incentives to save interact with the relative generosity of welfare payments. As incomes rise, incentives to save for retirement become stronger and uncertainty over uncertain future income becomes more important. The former of these effects provides a motive for saving in pensions, the latter is a motive to keep financial assets liquid to insure against a 'rainy day'. The model helps to clarify how these different incentives vary with age across the entire income distribution.

48. New savings opportunities affect incentives for both wealth accrual and labour supply. The introduction of pension schemes that offer higher rates of return than were otherwise possible can also lead to earlier retirement, as households choose to take some of the aggregate benefit in terms of increased leisure time.

49. The higher rate of return that low-cost pension schemes are expected to achieve also leads to higher participation and wealth accumulation among all income groups. However, the analysis shows that the proportional effects of the interest rate increase on accrued wealth are largest for poor households; aggregate savings increase by 30% at age 64 for the lowest income deciles.

50. Auto-enrolment is an important aspect of pensions reforms. The effect of this is mimicked by assuming that in its absence people would face transactions costs in starting to save in their Personal Accounts or low-cost pension. The analysis reported here suggests that the abolition of a modest, one time account opening cost of £500 could almost double participation rates in pensions amongst households in the lowest income decile to age 40. This demonstrates the importance of ensuring that access to pension saving is not costly.

51. The effects of stronger preferences for immediate consumption show that households in the lowest four income deciles tend to reduce their consumption throughout the simulated lifetime when the value they place on the future declines. This is primarily because an increased preference for immediate consumption weakens labour market participation, resulting in lower lifetime disposable income. This impact on labour supply is less acute for households higher up the income distribution.

52. The importance of not generalising can also be seen from looking at the behavioural effects of increasing life expectancy that are generated by the model. Increasing life expectancy intuitively represents a strengthening of the motives for retirement saving. But, if annuity providers also perceive an increase in life-expectancy, then annuity rates will fall. And the way in which annuity incomes interact with means tested retirement benefits then also has a bearing on simulated behaviour. In the case of lower income quintiles, the analysis undertaken suggests that switching from period to cohort mortality rates (implying an increase in life-expectancy) will actually reduce incentives to save for retirement. The saving of high income households, in contrast, puts them beyond means-tested retirement benefits in

both of the mortality rate scenarios that are considered here, so that these households tend to save more when life expectancy is higher.

## *1.9 Looking Forward*

53. NIBAX represents, so far as we are aware, the first model of individual behaviour constructed in a form which solves fast enough and conveniently enough for policy-makers to be able to use it as a day to day tool. However, all models inevitably have their limitations. We have already noted that the treatment of some aspects of pension contributions does not fully match reality. It is clear that these can be addressed in future work. But perhaps the most important assumption of the model is that people behave rationally when balancing present desires against future needs. A considerable amount of academic research effort is currently being devoted to developing alternatives to this. Future developments to NIBAX could give users the opportunity to explore the implications of myopic behaviour so as to be able to investigate how the effects of different savings incentives depend on the way in which people see the future.

# 2 Introduction

This report presents results from a project carried out for the Department for Work and Pensions and Her Majesty's Revenue and Customs. The purpose of the project was to develop a model which would allow both departments to investigate how changes in the tax and benefit system affect household saving and labour supply. This model was created from two existing models which the National Institute had constructed separately for these two departments.

There is a wide body of work devoted to investigating the effects of changes to the tax and benefit system and the key to understanding the importance of this model is to recognise that no single model or approach is capable of representing all possible economic effects in a way which might be desirable. Thus the model resulting from this work is best considered as part of a suite of tools available to the policy analyst.

The range of tools includes three broad categories. First there are regression methods. These have the advantage that the results they come up with are linked directly to their statistical ability to account for observed data and herein lies their importance. On the other hand there are many examples where regression equations represent reduced forms rather than underlying behaviour. For example in an analysis of how labour supply responds to the effective marginal tax rates generated by the tax/benefit system, it is often the case that age needs to be included as an explanatory variable over and above actual or potential earnings. In such a regression age is probably standing proxy for one or more other variables. For example, if people are close to the state pension age, then they may be less likely to work if they face high marginal tax rates, because they may already have some savings to tide them over to the state pension age. But this effect will depend on the magnitude of the state pension since that will affect how far people feel they need to build up their own resources for retirement. Thus in this case the age term in practice represents both the state pension age and the magnitude of the state pension. A change in either of these will therefore influence labour supply in a manner which would not be anticipated by the regression equation.

Secondly, there are detailed micro-simulation models. These are valuable because they allow the modelling of large numbers of people subject to a wide range of often random

effects over their working lives. They are extremely useful for partial analysis. For example the government has recently legislated to introduce a programme of pensions reform, including automatic enrolment, a compulsory employer contribution and a system of Personal Accounts. Automatic enrolment, an important part of the reform, has been criticised because of the risk that people who retire with pensions paid out of savings in low-cost pensions face withdrawal of benefits as a result; there is a risk that they may find themselves worse off than if they had not saved, or at least that they may, as a consequence, earn negative effective real rates of return on their low-cost pensions saving. Micro-simulation models make it possible to estimate the extent of this but on the basis of broad assumptions about people's behaviour which are not justified by any formal model. The answers to this and other similar questions are likely to be of great importance in exploring policy options, but the drawback of such an approach is that, given a change to the economic environment such as that associated with the introduction of low-cost pensions, people's behaviour is actually likely to change in ways which may be important. For example the magnitude of people's retirement savings may influence their retirement decisions in a way which such models do not usually represent satisfactorily because they do not identify people's underlying preferences.

Thus the model we describe here is intended to allow analysis of the impact of policy variations on the assumption that people's behaviour does change in response to changes to their economic environment. It is based on the premise that people understand their environment and make their decisions in the light of it, but in a manner which involves planning coherently for the future. This premise is controversial. It is often suggested that people are myopic or that there are large decision-making costs which impede the planning process assumed. This may result in them following well-entrenched habits or being led by social norms. But even if that were the case, policy advisers would still want to be aware of policy proposals which succeeded only because of inertia, decision making costs or misunderstanding and would probably want to avoid policies which turned out to be a bad thing if they were fully understood and if people responded to the incentives that they created. This is an advantage of the model presented here relative to both regression approaches and conventional micro-simulation approaches. The questions of myopia and inertia are best considered as developments of the model set out here rather than as alternatives to it. The disadvantages of this family of models are, relative to regression

models, that the fit to the data is assessed informally and is almost certainly less good and, relative to conventional micro-simulation, that the range of life-events, and the depth of the policy environment which can be considered is much more limited. Thus policy analysis of important issues is most satisfactorily carried out using a combination of these three approaches rather than through reliance on any one.

The importance of the treatment of expectations can be given more focus by thinking about how one might explore the effects on private savings of a proposed change to pensions policy. Any such analysis will necessarily involve making assumptions about how people react to the policy counterfactual, and then drawing out the logical implications of those assumptions. One common approach is to make very broad assumptions about how people will respond to the change, and the proportions of the population that will be affected.[3] This type of study has the advantage that it is usually easy to understand, and facilitates identification of big-picture conclusions through sensitivity analysis of alternative case studies. The broad-brush assumptions that are made, however, are ill-suited to the analysis of incentive effects that vary over a range of individual characteristics. This is because the responses are assumed to be exogenous and not generated by some underlying model of behaviour.

In a similar vein are studies that analyse behavioural responses to policy counterfactuals through the use of reduced form regression models. Like the studies referred to above, these are not based upon any formal model of behaviour. In place of 'back-of-the-envelope' assumptions about the effects of policy reform, reduced form analyses use statistical estimates calculated from existing survey data to obtain projections for the effects of policy reform.[4] Whilst this type of approach is very useful for summarising effects described by survey data — for example, following implementation of a real-world policy experiment — it is not suitable for considering behavioural responses to policy counterfactuals. This is because the statistical estimates upon which the respective models

[3] See, for example, Will personal accounts increase pension saving? Pensions Policy Institute (2007), and Steventon (2006).

[4] Prominent examples of this analytical approach include most simple linear regression models, the differences-in-differences regression method (e.g. Disney, Emmerson & Wakefield (2007)), and dynamic macro/micro-simulations that are based upon exogenously assumed transition probabilities (as in, for example, Pickard, Comas-Herrera, i Font, Gori, di Maio, Rothgang & Wittenberg (2007), or the SAGE model http://www.lse.ac.uk/collections/SAGE/), or PENSIM 2.

are based are themselves functions of the existing policy environment — a form of the Lucas critique. People's savings for retirement, in practice, are likely to be influenced by their expectations about the generosity of retirement benefits as well as by their past incomes and prevailing circumstances. Expectations with regard to the future receipt of state retirement benefits are typically not taken into account by reduced form studies. Furthermore, reduced form regressions are not usually practical for considering the long-term implications of a policy change, due to the time lags that are necessarily involved and the dynamic nature of the policy environment.

In contrast to the approaches described above are studies based upon explicit assumptions about how people make their decisions. In economics, decision making that is dynamic in nature is most commonly explored through the assumption of the life-cycle model of behaviour, usually under the assumption that individuals are free from any uncertainty. This omission of uncertainty is helpful because it allows regression analysis to be used (see, for example, Attanasio & Rohwedder (2003)). Although this analytical approach is robust to the policy environment considered for model estimation, it fails to reflect the casual observation that individuals must often make their decisions without knowing what the future holds. In the context of responses to a change in pensions policy, for example, decisions regarding private provisions for retirement must be made well before individuals can be certain of their circumstances in old age.

To address these concerns, this model assumes that individuals make their decisions taking explicit consideration of the uncertainty that characterises their future circumstances. The uncertainty significantly increases the computational complexity of the model. This is because an explicit allowance for uncertainty usually implies that no closed form solution exists to the behavioural problem, so that numerical solution methods need to be employed. This methodological approach, although numerically demanding, has the advantage that it focuses explicitly on the unobserved individual expectations and preferences considered important in determining dynamic behaviour. As computational capacity has increased with the advancement of computing technology, the methodology has been applied with increasing frequency to explore a range of issues including

retirement behaviour, savings and portfolio allocation, housing, fertility, and labour market decisions.[5]

The assumption that a policy is understood seems to be the most sensible basis upon which to analyse its behavioural implications. At the very least an assessment of its implications if understood is a crucial input into policy assessment. Put another way, it would hardly seem appropriate to adopt a policy that made sense only if people failed to understand it. In any case, decision making costs and difficulties attached to anticipating the effects of alternative choices are likely to be more important in the short-run than in the long-run. Although the short-run dynamics following policy implementation are of obvious concern, a long-run perspective is crucial to good policy design. The life-cycle framework of analysis upon which the model is based has been the backbone of economic theory in relation to inter-temporal decision making for the last half century.[6] Its resilience is attributable to the fact that it does a good job of capturing most of the characteristics that are considered to be of economic importance.

[5] See, for example, Gustman & Steinmeier (1986), Rust & Phelan (1997), French (2005), and Sefton, van de Ven & Weale (2008) for examples of the literature that has considered savings and retirement behaviour.

[6] Following Modigliani & Brumberg (1955). In relation to the date of this publication, it is interesting to note that one of the most influential criticisms of perfect rationality was published just two years later, Simon (1957).

# 3 Detailed Model Description

The model divides the life course into annual increments. At each age, households can be 'asked' to make decisions regarding labour supply, consumption, liquid savings, pension contributions, and their portfolio allocation. These decisions are considered to be made to maximise expected lifetime utility, given a household's prevailing circumstances, their preferences and beliefs regarding the future. Importantly, the belief structure is perfectly rational in the sense that expectations are consistent with the processes that are considered to generate intertemporal variation.

The remainder of the paper is divided into three parts. The first describes details of the model and the second provides illustrations of the way in which the model can be used to analyse questions of policy interest. A concluding third part includes directions for further research.

The decision unit in the model is the household. Households are considered to be fully described by (up to) twelve characteristics:

| | | | |
|---|---|---|---|
| -age | -number of adults | -number of children | -wage rates |
| -consumption | -labour supply | -safe liquid assets | -risky liquid assets |
| -low-cost pensions | -occupational pensions | -bequests | -time of death |

The model is designed to consider household behaviour at annual intervals during the life course. The potential longevity considered by the model can be adjusted by the user, with ages 20 to 110 being assumed for the calibration reported in Chapter 4. Longevity is considered by each household to be uncertain, subject to an exogenously defined age specific probability of mortality. Households choose their consumption, labour supply, low-cost pension contributions (and participation), and portfolio allocation to maximise expected lifetime utility, given their existing circumstances, preferences, and beliefs regarding the future. A household's circumstances are described by their age, number of adults, number of children, rights arising from endogenous pension schemes where

members can choose their contributions subject perhaps, under pensions reform, to a minimum employer and employee contribution rate, which we refer to as low-cost pensions, rights arising from exogenous pension schemes associated with particular employment, which we refer to as occupational pensions, wage rates, safe liquid assets, risky liquid assets, and time of death. Preferences are defined by a utility function (that is the same for all households), and beliefs are rational in the sense that they are consistent with the processes that generate the intertemporal evolution of household circumstances.

Incorporating an appreciation of uncertainty into individual expectations regarding future circumstances increases the complexity of the utility maximisation problem. Of the nine characteristics that define the circumstances of a household, seven can be considered stochastic (relationship status, number of children, low-cost pension rights, occupational pension rights, wage rates, the return on risky liquid assets, and time of death); these are driven by random or stochastic processes which cannot be predicted with certainty. Thus two different households in the same circumstances will both forecast the same wage in the next period. But the random nature of events means that they will actually receive different wages. Two variables are assumed to be deterministic (age and the return on safe liquid assets); these can be predicted at any point for any household with complete certainty.

The model has been designed to give the user a high degree of flexibility over the household characteristics and the economic environment that are considered for analysis. As a brief overview, the user can choose to:

- adjust preferences over consumption, leisure, and bequests
- adjust the nature of the imposed liquidity constraints, which are defined both in terms of hard credit limits and variable interest charges that depend on the debt to income ratio of households
- include or exclude uncertainty in the relationship status (single or couple) of a household
  — providing that relationship status is chosen to be uncertain, the user may also allow the number of children in a household to be modelled stochastically
- control the nature of uncertainty associated with labour incomes, including the possibility of receiving a low (zero) wage offer

- allow households to invest some of their liquid wealth in a risky asset
  — the nature of the uncertainty associated with returns to the risky asset can also be controlled

- allow households to choose their labour supply
  — where adults are modelled explicitly, labour supply can be selected from up to five alternatives for adult couples: two adults full-time employed, one full-time and one part-time employed, one full-time employed and one not employed, one part-time employed, and two not employed. Similarly, singles can choose from up to three alternatives: full-time, part-time, and not employed
  — where adults are not modelled explicitly, labour supply is selected from one of two options: employed or not employed

- alter a detailed tax and benefits structure that includes explicit adjustments for child care, housing costs and associated benefits

- include or exclude low-cost pensions
  — if included, contribution rates (and ultimately membership) can also be made a decision variable
  — if included, the stochastic nature of the return to low-cost pension wealth can be adjusted

- include or exclude occupational pensions
  — if included, the stochastic nature of the return to occupational pension wealth can be adjusted

In the terminology of the dynamic programming literature, consumption, labour supply, low-cost pension contributions, and the portfolio allocation are control variables, that are selected to maximise the value function described by a time separable utility function, subject to nine state variables, seven of which can be stochastic, and two are forced to be deterministic. This Chapter begins by defining the assumed preference relation, before describing the simulation of pensions, the wealth constraint, and the processes assumed for the evolution of income and household size. The Chapter concludes with a description of the approach adopted to solve the lifetime utility maximisation problem.

## *3.1 The Theoretical Underpinning of the Model*

The core of the model is the assumption that people's behaviour can be represented as the choices about consumption and labour supply which deliver the maximum possible level of expected welfare over their life-spans. This maximisation is, of course subject to an affordability or budget constraint. Affordability has two aspects to it. First of all, over people's life-time their income has to match their expenditure. Secondly, we assume that

there are practical limits on people's borrowing so that people whose income is believed to be temporarily low may be forced to spend less than they would like because they have difficulty in obtaining credit. The dynamic focus of our approach is quite different from one which looks only at the short-term benefits and dis-benefits of any particular decision, like how much labour to supply, because, for any given level of income decisions about consumption today also imply decisions about saving and this influences how much consumption is possible in the future. Similarly, decisions about labour supply affect income today and thus how much consumption is possible in the future. We also find that supplying labour in one period raises people's earning power in future periods so that the decision about how much labour to supply is not merely a choice between work and leisure today but also has some direct bearing on future consumption possibilities.

There are two aspects to the utility function. In any period utility is assumed to be derived from consumption of goods and services, and of leisure time. If there were no dynamic aspect to our analysis, then households would face a simple choice of deciding how much to work in a way which balanced the disutility of lost leisure time resulting from work against the benefit of the consumption income that work made possible. The outcome of this decision depends, of course, on the wage rate on offer. But it also depends on the functional relationship between consumption and leisure in the utility function. The details of this are specified in the technical paper, and are influenced by two parameters in our model; the utility price of leisure and the intratemporal elasticity of substitution between leisure and consumption of goods and services. Welfare is based on equivalised consumption, that is total household consumption adjusted for the numbers of adults and children in the household. The adjustment for household size is calculated using the companion to the revised OECD equivalence scale. This equivalence scale is currently used by the Department for Work and Pensions to adjust measures of income net of housing costs, and takes account of the fact that children's needs are smaller than those of adults and that there are economies of scale in household consumption.

Overall expected welfare, which is calculated by adding current welfare to future utility is assumed to be discounted at a constant rate which can be set by users. This reflects the idea that £1 of consumption in the future is less valuable than the same amount of consumption today. The underlying utility function assumes a constant elasticity of inter-temporal substitution. This framework is attractive because it assumes that the

proportionate impact of any given proportional change, or proportional uncertainty is independent of the actual scale of consumption. The assumed inter-temporal elasticity of substitution, in conjunction with the discount rate and the assumed real rate of interest, influences how people want their consumption to grow over time and it also determines the extent of precautionary saving -that is saving to provide protection against income being lower than expected. A low elasticity of substitution implies a high level of precautionary saving but also that the time path of consumption is not very sensitive to changes in the interest rate.

On top of this theoretical structure we impose a detailed structural model of the working of the tax and benefit system taken from the Department for Work and Pensions Tax Benefit Model Tables. Further details are provided in section 3.3. This allows us to relate people's labour income to their disposable income. This is obviously important because, on the one hand, it is part of the working of the affordability constraint and, on the other hand, it provides the mechanism for examining the influence of policy changes.

## *3.2 Life-span and Bequests*

A key feature of this model, like all life-cycle models, is that people have to plan for the remainder of their lives without knowing for how long they will live. The optimising framework sketched out above assumes that people only derive welfare while alive, so that the expectation of future welfare has to take into account the probability of survival; we assume that people know the probability of survival to any given age even though they do not know whether they themselves will survive to that age. It is these survival probabilities which determine overall life expectancy, and the latter is therefore changed by changing the survival probabilities. The base run of the model is prepared using the cohort survival rates shown on page 108. As noted above, we have assumed that the probability of surviving beyond the age of 110 is zero, even though the probabilities of surviving to younger ages may be exogenous parameters which users wish to explore. Intuitively it is easy to see that if people think they have a high chance of surviving into old age the prospective benefit of deferring current consumption will be greater than if they have only a low chance of survival; high survival probabilities therefore increase the incentive to

save for old age.[7] The incentive to save will be increased if people derive pleasure from the idea of leaving bequests as well as from their own consumption. The model takes account of the possibility that people may plan such bequests.

The issue of what happens to people's assets on death needs to be addressed. If their wealth is annuitised, then, effectively, it is distributed to the survivors of the same cohort. But if it is not annuitised, then, whether left as an accidental bequest or because people derive pleasure from leaving bequests, there is the question what happens to it.

There is no solution to this which is both satisfactory and manageable. We know that many people inherit wealth in middle age; the issue of how the anticipation of legacies influences their decisions before such legacies are received cannot be easily resolved in our modelling framework. It depends on the potential legatees' assessment of the circumstances of the anticipated legators-an issue too complex for our model to handle. The problem is much simplified if bequests are assumed to accrue to people at the start of their adult lives, because the question of anticipation does not arrive. However, it is not clear that this is more realistic than the simpler assumption, widespread with models of this type and which we make, that bequests are lost to the economy.

## *3.3 Pensions*

The user can permit up to two pension schemes to run in parallel in the model. One of these schemes is designed to reflect existing occupational pensions, and the other is designed to reflect the new minimum low-cost pension offer that will be available under the reformed private pensions system. The two schemes are identical with the exception that membership and contributions to occupational pensions are exogenously defined, whereas they can be specified as endogenous decisions for low-cost pensions.

Both pension schemes are modelled at the household level, and are Defined Contribution in the sense that every household is assigned an account into which their respective pension contributions are notionally deposited. The account associated with each scheme

[7] Although this is not the only incentive effect of rising life expectancy, as our later analysis (Chapter 10) shows.

accrues a (post-tax) rate of return which can be specified as either fixed or uncertain.[8] At the state pensionable age set by the user a proportion of the balance of each pension is converted into an inflation adjusted life annuity, with the remainder of the pension pot received as a tax free lump-sum. Hence, a separate account is kept of occupational and low-cost pensions only until the considered state pensionable age. The remainder of this Chapter describes how pension rights are simulated to pensionable age.

For occupational pensions membership is exogenously identified with respect to a lower threshold on labour income. Employee contributions to an occupational pension are calculated as a user-specified fixed percentage of (total) labour income, and may be tax-shielded. Employer (and government) contributions may also be considered for analysis, paid at a rate specified by the model user. For each household the fund is assumed to accumulate during working life.

Two alternatives are available for analysis of low-cost pensions. The first is to consider low-cost pensions as imposed exogenously on households in a similar fashion to that described for occupational pensions. Alternatively, membership and contribution rates to low-cost pensions can be considered as endogenous decisions in the model. We begin by discussing the former case before moving on to the latter.

When membership and contribution rates to low-cost pensions are exogenously imposed, their simulation progresses in a similar way to that described for occupational pensions, with two notable exceptions. First, membership of low-cost pensions can be specified with respect to an upper limit on labour income. And secondly, income below the lower bound is exempt from contributions.

When low-cost pensions are simulated endogenously by the model, then households are considered to choose the proportion of their labour incomes to contribute. Hence, households that choose not to supply labour in a given year are excluded from making pension contributions during that year. Contributions to low-cost pensions can be subject

[8] When returns to private and occupational pensions are assumed to be uncertain, then they are considered to be perfectly correlated with the returns to the risky liquid asset (if this is included in the analysis). Hence, accrued pension rights do not hedge against uncertainty in the liquid asset portfolio.

to a series of limits, upper and lower bounds on eligible incomes and contribution rates, and a ceiling on the value of the aggregate pension pot. Furthermore, two forms of transaction costs can be explored: an "account opening" cost can be imposed when a household first chooses to contribute to a pension; and an investment cost can be levied when a household chooses a contribution rate that departs from an exogenously defined "default" rate. These obviously affect the size of the pension pot and thus the eventual pension which can be drawn from it.

If people are given a choice about whether to contribute to low-cost pensions, then the model has the property that they will not do so while they are net debtors. This is because the interest charges on debt are higher than the risk-adjusted return on pension assets. If however, they are members of occupational schemes or if low-cost pensions choices are exogenous to the model, it is perfectly possible for them to make pension contributions at the same time as being net debtors.

## *3.4 Life Stages and Disposable Income*

We return now to describe details of the function that is used to evaluate disposable income. The lifetime is divided into three periods for the purpose of calculating disposable income: the working lifetime before early retirement is possible, the period between early retirement being possible and the state pension age, and the period from the state pension age until death. In each of these periods of life, household disposable income is calculated by:

1. evaluating aggregate take-home pay from the taxable incomes of each adult member of a household — this reflects the taxation of individual incomes in the UK

2. calculating benefits receipt (excluding adjustments for child care and housing costs) from aggregate household take-home pay — this reflects the fact that benefits tend to be provided at the level of the family unit

3. calculating net child care costs (after adjusting for child care related benefits) from aggregate take-home pay — identified separately from other benefits to permit explicit policy experimentation

4. calculating net housing costs (after adjusting for relevant benefits receipt) from aggregate take-home pay plus benefits less child care costs — this reflects the fact that

'Housing Benefit' and 'Council Tax Benefit' in the UK are means tested with respect to income net of most other elements of the tax and benefits system

5. household disposable income is then equal to aggregate take-home pay, plus benefits, less net child care costs, less net housing costs, less servicing costs on unsecured debt.

Calculation of taxable income for each adult in a household depends upon the household's age, with income from savings and taxable labour income being treated separately. Prior to state pensionable age, household taxable labour income considered for tax purposes is equal to labour income less the proportion of pension contributions that is considered tax exempt; from state pensionable age it is equal to labour income plus the proportion of pension annuity income that is considered taxable. The annuity purchased at state pension age is assumed to reduce by one half of its value if one member of a couple dies. We have previously found this adjustment to retirement income necessary to capture the decline in expenditure with age observed in survey data.

Where the household is identified as supplying labour, and is younger than state pensionable age, then taxable labour income is split between spouses (in the case of married couples) on basis of their respective labour supplies. A household that is identified with a single wage earner has all of its taxable labour income allocated to that one earner; a household with one full-time and one part-time earner has taxable labour income allocated on the basis of a user defined ratio; and a separate ratio is used to divide taxable labour income when both spouses of a household are full-time employed. A household without an employed adult has all of its taxable labour income allocated to a single spouse. All households of state pensionable age and above have all of their taxable labour income allocated to a single adult.

Similarly, income from savings is only allocated between spouses for households below state pensionable age, and who supply some labour. In this case, income from savings is allocated on the basis of an exogenous ratio that defines the proportion of wealth assumed to be held in the name of the lower-earning spouse. Property income is equal to the sum of returns from the safe and risky liquid assets.

The interest rate on safe liquid assets is assumed to depend upon whether the holding is positive or negative, and if negative the interest rate depends on the size of the debt

relative to annual gross labour income. The specification also means that households in debt are treated more generously if they have at least one adult earning a full-time wage than if they do not. The assumption that the maximum rate of interest is charged when net debt is equal to or greater than the household full-time employment wage reflects the observation that fewer than 1% of households recorded by the 2000/01 BHPS with some labour income had unsecured debt that exceeded their annual gross labour income. The rate of interest on debt is, in any case set high enough to prevent it being worthwhile for households to borrow in order to invest in the risky asset. Total taxable income is then equal to labour income, plus any return accruing to positive holdings of non-pension wealth.

The following sections describe the specifics of tax and benefits as they are applied to each of the three periods of life referred to above, before addressing the complex issue of benefits indexing.

## *3.5 The Working Lifetime before Early Retirement Age*

Take-home pay for all adults is calculated from their respective taxable incomes via a four piece linear spline. For the UK, this linear spline is designed to capture the effects of income taxes and National Insurance contributions. This means that our framework can accommodate four different marginal tax/National Insurance rates. Thus our first tax rate is zero and applies on earnings below the low earnings limit/tax threshold at which National Insurance contributions are also assumed to be payable. The second rate is the sum of the low income tax rate and the standard National Insurance rate. Beyond the basic rate threshold basic rate tax becomes payable along with standard National Insurance contributions. Above the upper earnings threshold the basic rate of income tax remains in force but the rate of National Insurance contributions drops to its low level. Finally, above the high rate threshold income tax is collected at the high rate and low-rate National Insurance contributions are collected. Thus there are four relevant tax rates and four switch points. For recipients of only unearned income no national insurance benefits are payable, so, although there are still four relevant tax rates (including zero) there are only three switch points. This structure obviously makes it possible to address simplifications of the tax system, such as the abolition of low-rate tax but would need to be expanded to address, for example, the 50p top rate introduced in the 2009 Budget.

Welfare benefits are calculated from aggregate household take-home pay via another four piece linear spline. Unlike the spline that is used to calculate take-home pay, however, the parameters of the spline used to calculate benefits receipt are a function of the numbers of adults and children in a household. This element of the disposable income module is designed to capture the Child Benefit, Working Tax Credit (excluding the child care element), the Child Tax Credit, and Jobseekers Allowance for the calibrations reported in Chapter 4.

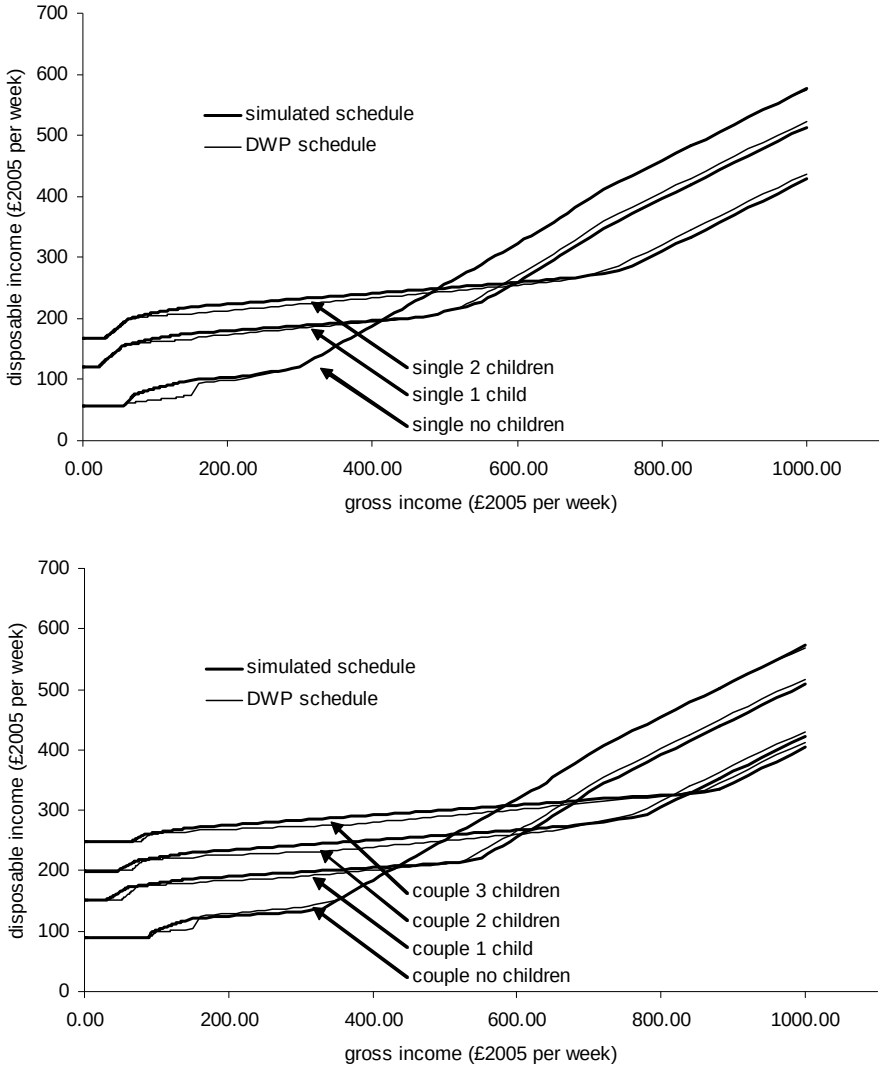
Net child care costs are calculated in a very similar way to welfare benefits, but with a three piece linear spline in aggregate take-home pay. Net child care costs are child care costs less associated government benefits (currently paid through the Working Tax Credit in the UK). The incidence of child care costs is user defined, either in terms of the labour supply of the lowest wage earner in a household, or in terms of their respective labour income.

Finally, net housing costs are based upon a three piece spline in net income before housing costs, and are currently designed to reflect housing costs net of Housing Benefit and Council Tax Benefit. For the calibrations that are reported in Chapter 4, the respective elements of the tax and benefits system were calibrated from schedules reported in the April 2005 edition of the Tax Benefit Model Tables (TBMT), issued by the Department for Work and Pensions.[9]

Figure 3-1 provides some examples of the disposable income schedules simulated by the tax and benefit module of the model, alongside the respective schedules described by the TBMTs.

[9] See http://www.dwp.gov.uk/asd/tbmt.asp.

**Figure 3-1 Disposable Income Schedules for the Working Lifetime**




*Gross income is equal to gross taxable income for households with all income accruing to a single adult.*

## *3.6 From the Early retirement Age to the State Pension Age*

In the UK, access to Incapacity Benefits and the Pension Guarantee has effectively enabled many individuals to retire before the State Pension Age. To capture practicalities of this type, the user can define up to two alternative benefits systems to apply to households without an employed adult at each of two age bands prior to State Pensionable Age — any household that is employed during this period is treated as described above for the working lifetime. Note that periods of preferential tax treatment prior to retirement need not be included in a simulation, but the model allows the user to choose to include them if they so wish.

If a household is identified as being eligible for early retirement benefits, then take-home pay is derived from income from savings via a four-piece linear spline.[10] In the current paper this spline is designed to reflect income taxes only, because relevant households are necessarily defined as not employed.

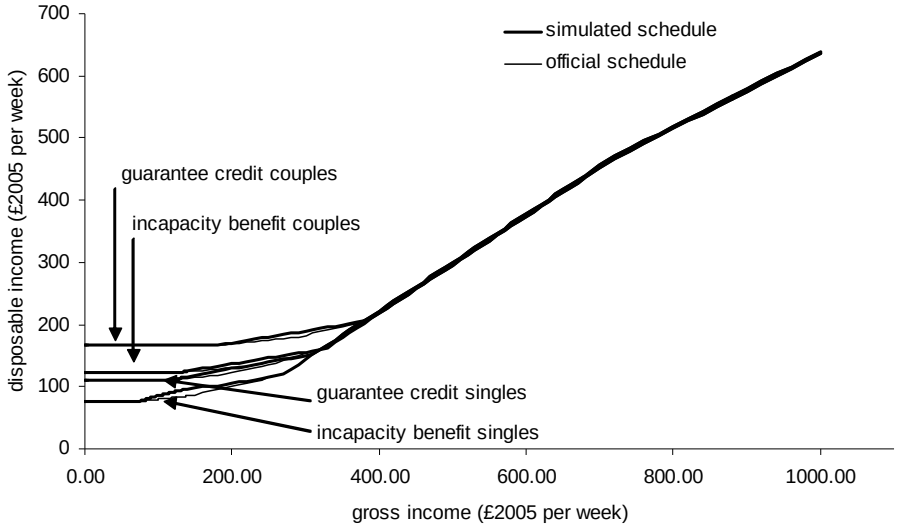
Benefits during the early retirement period are simulated as a means tested welfare payment, subject to a withdrawal rate on all take-home pay. Similarly, the benefits associated with housing costs are assumed to be subject to a withdrawal rate on any income in excess of the minimum described by welfare receipt. No child care costs are considered for the period of early retirement (as all relevant households do not supply any labour). The rates and thresholds used to simulate welfare benefits and net housing costs are defined in terms of the numbers of adults in the household.

Finally, a check is made to ensure that households which are eligible for treatment as early retired are at least as well off as they would be if they were treated under the rates and thresholds considered for the working lifetime.

For the calibrations that are reported in Chapter 4, the disposable income module is designed to reflect the availability of Incapacity Benefit between ages 55 and 59 and the Pension Guarantee between age 60 when the Minimum Income Guarantee is relevant and the State Pension Age. The relevant schedules for singles and couples are reported in Figure 3-2.

[10] Note that since households that are treated as early retired are not employed, and therefore all property income is considered to be received by a single adult.

**Figure 3-2 Disposable income schedules for early retirement**

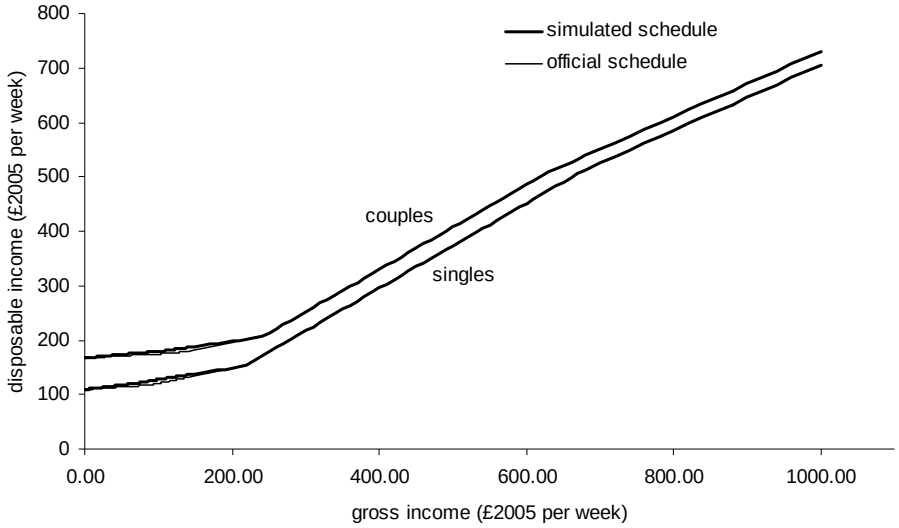



*Gross income is equal to gross taxable income for households with all income accruing to a single adult.*

## *3.7 State Pension Age and Older*

Pension receipt, both state and private, occurs exogenously at the user defined state pension age. After that age, the user can allow individuals to choose to work. Regardless of labour supply decisions from state pension age, however, all households are treated by the disposable income module in a similar way to that described for the period of early retirement. Specifically: no distinction is recorded regarding the income attributable to individual adults within a household; no adjustment is made for any remaining dependant children; taxes are simulated by a four piece linear spline in private income; and welfare and housing benefits are considered to be means tested, with rates and thresholds that depend upon the number of adults in a household.

**Figure 3-3 Disposable income schedules for the period of pension receipt**




*Gross income is equal to gross taxable income for households with all income accruing to a single adult.*

## 3.8 Trend Growth

It is likely that individuals take some account of wage growth when planning for the future: a 20 year old today can reasonably expect that labour incomes will be higher when they reach age 45 than are currently paid to today's 45 year olds. If this is true, then it is important that the rational agent model be calibrated against data that take wage growth into account (discussed at further length in Chapter 4). This gives rise to a host of complications regarding the appropriate intertemporal development to assume for the tax and benefits system: holding taxes and benefits fixed in the context of rising wages, for example, will result in wide-spread fiscal drag/ bracket creep and an erosion of the value of welfare benefits, with important implications for simulated behaviour.

The model allows the user to control the way in which the tax system evolves with time through four parameters. The first of these controls the rate at which the tax thresholds grow with time, thereby offsetting bracket creep. The second controls the rate of growth of welfare benefits. The third controls the growth rate of child care costs, and the fourth controls the rate of growth of housing costs. These schedules are adjusted in a way that is designed to omit the creation of poverty traps. Nevertheless, rapid adjustment of the tax system can give rise to analytical problems, and the model is programmed in a way that is

designed to indicate when excessive variation has been called for by the user. Separate routines have been developed that allow the user to view the disposable income schedules generated by the model (discussed in Chapter 4), and these should be reviewed to verify that a model simulation is sensible. The growth rates actually used are discussed in section 4.4.

## *3.9 Household Income Dynamics*

In the first period of the simulated lifetime, age 20 in the simulations reported below, each household is allocated a wage drawn from a suitable random distribution but in a way which depends on the number of adults in the household. Thereafter wages evolve randomly but with the rate of growth of wages depending on whether one or both of the household members worked in the previous period or not. This therefore embodies an element of learning from experience and is indeed a potent factor explaining why labour supply tends to be concentrated in a part of people's lifespan rather than spread out more evenly over adult life.

Although the concept of an experience term in a wage regression is not new, [11] its inclusion is an innovation for the related literature (e.g. Low (2005) and French (2005)). 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 at younger ages better.[12]

The model also includes the possibility of exposing households to an exogenous probability of (involuntary) unemployment (conceptually, the receipt of a zero wage offer), should they plan to supply labour at any given age. The probability of this happening can be set by the user.

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[11] With regard to statistical evidence of the effect of experience on income, Mincer & Ofek (1982) report that in the short run, every year out of the labour market can result in a 3.3%-7% fall in wages relative to those who remain employed. This study also finds, however, that the restoration of human capital tends to be faster than the original accumulation, so that the impact of early labour breaks reduce to 1.3%-1.8% in the long run. Eckstein & Wolpin (1989) do not make a distinction between the long run and short run impact of actual experience, but find that the first year out of the labour market reduces wages by around 2.5%, with subsequent years having a marginally diminishing effect. See also, Waldfogel (1998) and Myck & Paull (2004) for the role of experience in explaining the gender wage gap.

[12] See Sefton, van de Ven & Weale (2006) for further details.

## 3.10 Modelling Household Size and Family Structure

The numbers of adults and children in a household are considered to develop in a random fashion. There are two steps to the process. First of all the number of adults is determined. Secondly, given the number of adults and age, the number of children is established.

A household can be comprised of one or two adults, where the number of adults is considered to be uncertain between adjacent years.[13] The fact that children typically remain dependants in a household for a limited number of years implies that it is necessary to record both their numbers and ages when including them in the rational agent model. This substantially increases the computational burden. If, for example, a household were considered to be able to have children at any age between 20 and 45, with no more than one birth in any year, and no more than six dependent children at any one time, then this would add an additional 334,622 state variables to the computation problem (with a proportional increase in the associated computation time). The model has consequently been designed to permit a stylised representation of dependent children in a way that limits the computational burden.

The user can choose to limit "child birth" to a fixed number of household ages. At each specified child birth age, the user can also define the number of children that may be born, and the probabilities that are attached to each. The model is currently specified to permit households to receive up to three children at two discrete ages, so that the maximum number of dependent children in a household at any one time is limited to six.

## 3.11 Model Solution Procedure

The solution of the model is computationally intensive, which explains why models of this type have only recently become practical complements to more conventional micro-simulation models. The solution method implies working backwards from the maximum possible age, set to be 110 in our case. Since this is the last year of life a rational consumer will, unless they plan to leave a legacy, consume all of their wealth. Thus the "inter-temporal" decision problem has a straightforward solution because there is no inter-

[13] The user can also define an upper age, beyond which all households are considered to be comprised of a single adult.

temporal aspect to it. When age 109 someone can then choose to maximise the sum of the utility delivered in this year and the amount that they expect in the next year. The balancing act involves setting consumption high enough, but not so high that in the next year consumption will be undesirably low. This calculation can be done to take account of any future uncertainty, arising for example, from uncertainty in the rate of return on non-annuitised wealth. For any given value of wealth at age 109 and income while aged 109 we can then calculate the welfare maximising level of consumption at this age. The solution method is generally referred to as backwards recursion.

Our solution works by making these calculations for a table or grid of fixed values of wealth and income. For any actual value of wealth and income we can then interpolate or extrapolate as necessary to calculate the optimal consumption choice. We can also set up a similar grid to identify the discounted sum of current and future welfare as a function of current income and wealth.

Having done this we then move backwards, identifying, for given levels of wealth and income, the value of consumption which maximises the sum of current and discounted expected future welfare in each year. Below the maximum working age (65) people also need to make decisions about labour supply and about saving in pension schemes, but these are approached in the same sort of way. When the process has been taken back to the starting age of twenty it is possible to use the grids to look up each household's optimal consumption and labour supply in the light of its circumstances; this provides the basis for our simulations.

# 4 Model Calibration

The parameters of the model are usually adjusted to match the characteristics by age of a simulated population to those described by household micro data. This Chapter begins with a discussion of some fundamental issues that underlie the model calibration. The calibration strategy adopted for the current paper is then outlined, before describing the data upon which the calibration is based, and the Chapter concludes with a discussion of measures of fit.

## *4.1 Some Preliminary Issues regarding Data*

Economists are used to models fitted by regression techniques usually based on least squares minimisation or likelihood maximisation. With models of this type, unlike with regression models, there is no clear likelihood function to maximise, so that conventional regression methods cannot be used. In recent years the method of moments has gained ground as a technique for estimating parameters of models such as this. However, this is typically applied only to the first moment-or mean-of the variables of interest. It has not so far proved to be a practical means of ensuring that any account can be taken of a model's capacity to fit the higher moments such as the variance of data of interest.

This means that, although the parameters of the model can be chosen so as to ensure that, when the model is used to simulate household behaviour, it generates behaviour patterns of the synthetic or simulated households which match those of actual households as far as is possible, there are inevitably questions of judgement involved. These concern how to trade-off performance in ability to match the pattern of one variable relative to ability at matching another variable. A particular difficulty is that the current tax/benefit regime has not been in place for the whole lives of the households whose behaviour is currently observed. Thus their circumstances may be different from those of households of the same wage who have always lived in the same tax/benefit regime;[14] it is not practical to take account of this in identifying appropriate parameters. The process of making these

[14] See Nelissen (1998) for an early simulation study that takes into consideration the influence of the evolving tax structure. It is of note that this critique may be applied more broadly to much of the literature that is concerned with behavioural responses in an evolving economic environment.

judgements and choosing model parameters is described as calibration and it is inevitable that different people will calibrate models of this type in different ways.

The parameters of models similar to the type considered here are usually matched against moments estimated from one of three survey data sources. The first is (pseudo) panel data for an actual cohort. These data are affected by time and cohort effects that make them unrepresentative for the population in general. Alternatively, it is possible to control for time and cohort effects by econometric estimation. In this case, collinearity between age, cohort and time implies the need to introduce an additional restriction to permit identification. One popular restriction, suggested by Deaton (1997), is to assume that time effects[15] average out over the long run. This assumption produces estimated age profiles that represent an average taken over all cohorts included in the (pseudo) panel data set used for estimation. Calibrating the model against this sort of age profile implicitly assumes — as do calibrations based upon data for a single population cohort — that behaviour is invariant to changes in the policy environment that occurred during the period of estimation. This assumption is difficult to maintain when one of the objectives of the analysis is to consider behavioural responses to alternative policy experiments.[16] It is perfectly possible that the behaviour of an up to date cross-section of households is a better guide to the influence of the current policy framework than is the average behaviour of a panel which stretches back into a fairly distant past.

The third approach, which we adopt here, involves matching the model against suitably adjusted age profiles described by cross-sectional survey data. The adjustments are designed to take account of underlying economic growth, so that even if the income pattern observed in the cross-section is expected to persist, the income that a current thirty-year old expects to receive in twenty years time is derived from that of a current fifty-year old augmented to allow for twenty years of trend economic growth. For the calibrations that are reported here, we assume that households behave as though they will be subject to

[15] Time effects are those which are assumed to affect people of all ages at the same time. Cohort effects are those which are assumed to affect the position of one cohort relative to other cohorts. For these terms to be useful, they need to be additive or equiproportional. So a time effect is an additive or multiplicative shock to the variable in question applying to all cohorts equally at the same time. A cohort effect is a mulitplicative or additive increment to the variable applied equally for the whole of the cohort's life. See, for example, Attanasio, Low & Sanchez-Marcos (2005).

[16] See, for example, Sefton et al. (2008).

the prevailing policy environment for the remainder of their lives; that they expect their labour incomes to grow at a constant rate; and that the anticipated probabilities governing cohabitation and mortality reflect current cross-sectional data. Although these assumptions are open to critique, we believe that they are defensible in view of the model's limitations.

## *4.2 Calibration Strategy*

For the calibration that is reported here, households are considered to be distinguished by the following nine characteristics:

| | | |
|---|---|---|
| -age | -number of adults | -safe liquid assets |
| -wage rates | -occupational pensions | -labour supply |
| -consumption | -bequests | -time of death |

In this case, the model is consequently concerned with decisions over labour supply (including the possibility of part-time employment), consumption, and bequests, given a household's age, its number of adults, non-pension assets, wage rate and accrued pension rights. Uncertainty is taken into consideration for the intertemporal development of the number of adults in a household, wage rates, and the time of death — age, non-pension wealth, and accrued pension rights are considered to evolve deterministically. Furthermore, parameters for the bequest motive were exogenously assumed, and not calibrated to match survey data. The restricted nature of the model calibration was adopted to limit computation time, in view of the large number of simulations that are typically required to obtain a close fit between the model and survey data.[17]

The calibration is based upon the following grid-search procedure. First, we exogenously assumed values for a number of observable parameters of the model, based upon historical survey data. We then selected a starting value for the remaining income and preference parameters, against which a solution to the lifetime optimisation problem was obtained, following the methods outlined in section 3.11. Monte Carlo methods were used to generate the life-history for a cohort of households, based upon the behavioural responses

[17] The model was run 357 times for the calibration that is reported here.

described by the model solution, and the stochastic processes assumed for the intertemporal development of agent specific state variables. Calibration proceeded by (visually) comparing simulated age profiles with associated statistics calculated from survey data.

## *4.3 Exogenous Assumptions*

All households were assumed to start economic life at age 20 with zero pension wealth. Non-pension wealth at age 20 was generated by taking random draws from a log normal distribution, with a mean and standard deviation based upon data drawn from the 2005/06 wave of the British Household Panel Survey (BHPS).[18] Full-time employment prior to State Pensionable Age was assumed to entail a 50% reduction in leisure for both singles and couples. The leisure cost and labour incomes attached to the alternative employment choices considered for analysis were exogenously specified as proportions of the full-time employment decision, based upon statistics drawn from the 2005/06 Family Resources Survey.[19] The price of consumption was normalised, so that wages and interest rates were specified in real terms. The real interest rate for non-negative wealth balances was fixed at 4 per cent per annum,[20] the lower limit cost of debt was set to 7 per cent per annum, and the upper limit to 15 per cent per annum. This range of interest charges for household debt is based upon averages between January 2000 and June 2007 of the end of month average interest rates charged on unsecured personal loans for the lower bound, and of the end of month weighted average interest rates charged on credit cards for the upper bound, as reported by the Bank of England.[21] The survival probabilities assumed for the calibration are based upon period life tables published by the Government Actuary's Department for the UK for 2005, and are calculated to reflect the probability that at least one member of a (same aged) couple survives from age 20. The model was used to calculate the credit limit that provides simulated households with maximum flexibility, while at the same time

[18] The mean and standard deviation were calculated from the sub-sample of 160 households with reference people aged between 20 and 22, after adding 50,000 to the aggregate value of non-pension wealth described for each household by the BHPS. This gave a mean of 10.7915 (a geometric mean of -£1393) and a standard deviation of 0.6609.

[19] Age independent ratios were adopted after observing very little systematic variation in the respective ratios by age.

[20] This is higher than the average real return on safe assets (which is around 3%), to reflect the fact that non-pension wealth considered for the calibrations is a composite asset comprised of safe and risky investments.

[21] The average between January 2000 and June 2007 of the end of month interest rate charged on unsecured personal loans reported by the Bank of England (code IUMHPTL), is 9.3 percent, and for credit card debt (code IUMCCTL) is 16.5 percent. Discounting by the Consumer Prices Index (ONS code D7G7) for the same period, gives real interest rates of 7.6 and 14.7 percent respectively.

ensuring that no debt is held from age 69, and omitting the possibility of numerical errors in the solution procedure. State pensionable age was set to 65, and the age of mandatory retirement was set to 69. This age was chosen because, although quite a few people go on working beyond the state pension age, many fewer people aged 70 or more work and the solution to the model is facilitated by setting a definite final retirement age.

## *4.4 The Data*

To calibrate the model we require age profiles at the household level for both singles and couples of: [22]

1. The proportion of adult household members employed full-time, part-time and not at all

2. The (geometric) mean of household employment income

3. The variance of (log) household employment income

4. The mean of household disposable income net of housing and child care costs

5. The variance of household disposable income

6. The mean of household consumption net of housing and child care costs

7. The variance of household consumption

Following a review of the available data, the British Household Panel Survey (BHPS) was identified as the most comprehensive source of wealth data currently available for the UK. Nevertheless, the wealth data that the BHPS provides are very limited.[23] Hence, comparisons between the simulation model and the BHPS wealth data were undertaken as a sanity check, but were not considered a formal part of the model's calibration.

[22] Statistics of household wealth are prominently omitted from this list due to the limited nature of wealth data that are currently available for the UK. Nevertheless, a "sanity check" was performed by comparing age averages for wealth generated by the model against sample statistics imputed from the 2000/01 wave of the BHPS. These are available from the author upon request.

[23] This limitation is likely to be resolved when data from the Wealth and Assets Survey becomes available, currently scheduled for the second half of 2009.

The model is calibrated against age profiles calculated from the cross-sectional micro data provided by the 2005/06, waves of the Expenditure Food Survey, the Family Resources Survey and the British Household Panel Survey. All financial statistics derived from the cross sectional survey data were adjusted for per capita wage growth of 2.5% per annum.[24] If the cross-sectional survey data against which the model is calibrated described the population in a steady state equilibrium, then it would be possible to match against statistics for both labour income and disposable income. This would require the model to capture, amongst other things, the evolution of the tax and benefits system in the steady state. Unfortunately, the survey data do not describe a steady state. Hence we can only hope to capture these two measures of income in some imperfect way.

The problem is further complicated by the observation that labour incomes — and their relation to child care costs, housing costs, and welfare benefits — tend to have an important bearing on labour supply decisions, whereas disposable income has an important bearing on savings decisions. If the user is interested in both savings and consumption decisions, then it is consequently not sensible to match the model only to one or the other measure of income — both should be taken into account. For the calibrations that are reported here, we have consequently chosen to adopt an equal weighting to disposable and labour income.

It might seem desirable to adopt a uniform growth trend rate for the real growth of wages and consumption applied to the observed cross-section profiles, and to the growth of the thresholds associated with the tax/benefit system. However, this does not match reality and we found it was impossible, with such an assumption to calibrate the model satisfactorily to the observed data. We used a growth rate of 2 1/2% p.a. as the trend rate of growth for wages, consumption and tax thresholds, but assumed a real rate of growth of 2% p.a. for real welfare benefits since they have historically grown more slowly than consumption.

It should be noted that the assumption of continuing trend growth means that our results represent the behaviour of the cohort aged twenty in 2005 and not the cross-section of the population in 2005. A picture of the cross-section can be recovered by dividing the

[24] Based on the growth reported for real disposable household income per head between 1955 and 2005, as reported in Table 2.4 of Economic Trends Annual Supplement 2006 (ONS publication). Growth adjustment of cross-sectional micro-data calculated with respect to household age — i.e. $yt = zt1.025(t-20)$, where z denotes the respective financial characteristic (consumption, labour income, disposable income, or wealth) as described by survey data, y denotes the value considered for calibration, and t refers to the recorded age of the household.

financial figures at age t by $1.025^{t-20}$ . The effect of this trend is obviously powerful and it accounts for the fact that, for example, consumption profiles are level or rising in old age instead of, as we see in cross-section profiles, declining. The effect of this trend is probably to increase the incentive to save for retirement since it increases the amount of desired consumption in old age, as compared to a situation where people aspired to the profiles represented by the cross-section.

**Table 4-1 Key Model Parameters**

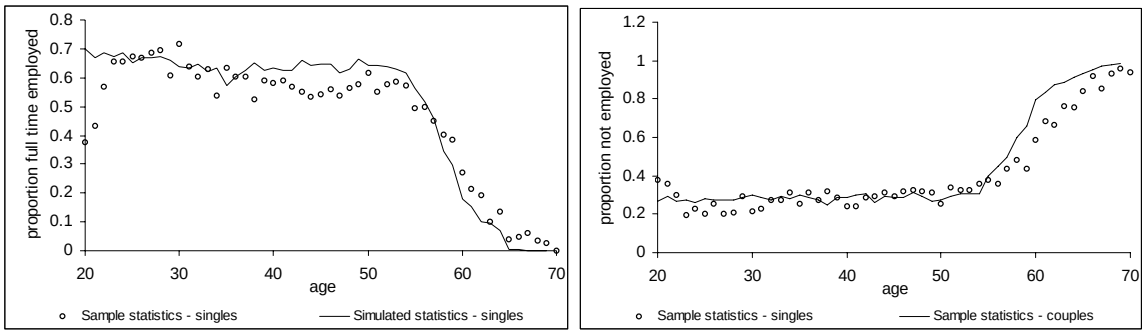
| General Model Parameters | | | | |
|---|---|---|---|---|
| Inter-temporal Elasticity ($\gamma$)<br>Intra-temporal Elasticity ($\varepsilon$)<br>Utility Price of Leisure ($\alpha$) | 0.31<br>0.62<br>0.97 | Interest Rate on Investments<br>Interest Rate on Debt (Lower Bound)<br>Interest Rate on Debt (Upper Bound) | 4% p.a.<br>7% p.a.<br>15% p.a. | |
| Discount Rate $(1-\delta) \times 100$ | 2.5 | Wealth at Age 20 | 0 | |
| Wage Generating Parameters | | | | |
| | Singles | Couples | | |
| Mean log Wage age 20 | 4.94 | 5.95 | | |
| Std. Dev log Wage age 20 | 0.45 | 0.36 | | |
| Wage Persistence[12]($\beta$) | 0.95 | 0.95 | | |
| Std. Dev log Wage Age 21+ | 0.25 | 0.16 | | |
| Probability of Low-wage Offer | 0.28 | 0.16 | | |

## *4.5 The Fit between Simulated and Sample Age Profiles*

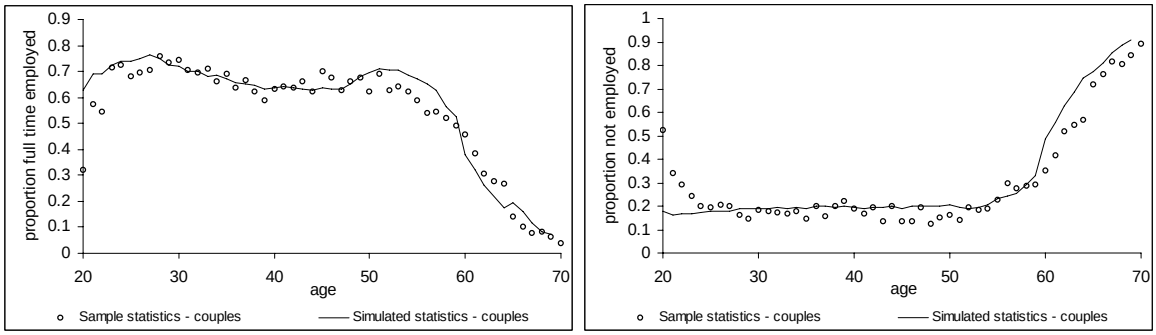
Following an extensive search, our preferred parameter values are reported in Table 4.1. The table is divided into two panels. The upper panel reports preference parameters and other exogenously assumed population characteristics and the lower panel reports parameters for the wage generating process variables. There are also age-specific dummies present in the wage process. These are needed to represent the age profile of wages adequately. Details of these are provided in the technical report together with the credit limits used and the survival rates assumed.

The relation between the simulated statistics obtained from the model using the calibrated parameter values reported in Table 4-1, and the statistics calculated from survey data are displayed in Figure 4-1 and Figure 4-2. The statistics calculated from the simulated data are referred to as “simulated statistics”, and those calculated from survey data are referred to as “sample statistics”. We show results for the key output variables of the model, labour supply and consumption. In general we regard the fit as good.

**Figure 4-1 Timing of Retirement- simulated versus survey data**



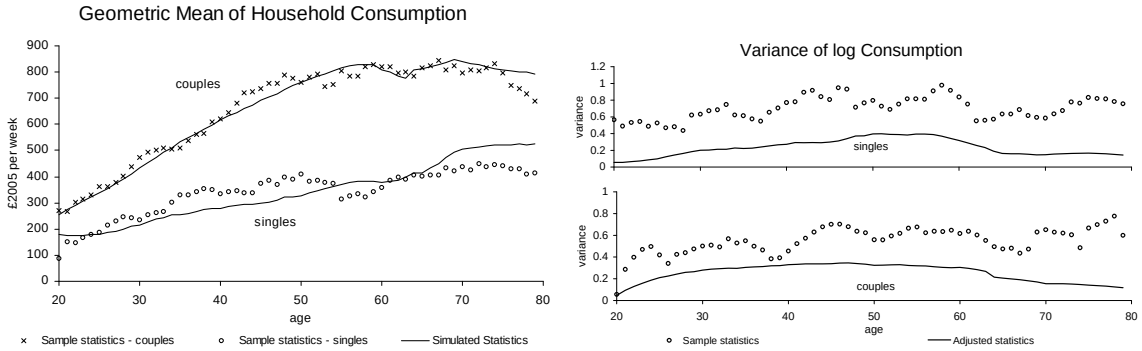

Panel A: single adults




Panel B: adult couples

*Sample statistics- age profiles from the 2005 Family Resources Survey*
*Simulated statistics- age profiles generated by the model using the parameters reported in Table 4-1*

**Figure 4-2 Consumption profiles by age- simulated versus survey data**




*Sample statistics- age profiles from the 2005 Family Resources Survey*
*Simulated statistics- age profiles generated by the model using the parameters reported in Table 4-1*

Figure 4-1 and Figure 4-2 reveal a reasonable match between simulated and sample moments, one that is adequate for undertaking the analytical examples that are reported in Chapters 7 to 10. Starting with Figure 4-1, the two panels indicate that the model does a

reasonable job of capturing the average incidence of full-time, part-time and non employment described by survey data (part-time employment omitted from the figure as it is the remainder).[25] The model does a slightly better job for couples than for singles of capturing the influence of child-care on rates of employment between ages 30 and 50 (indicated by the dip in full-time employment during the period). The statistics reported in the figure also suggest that the model overstates slightly rates of retirement described by survey data.

Finally, Figure 4-2 indicates that the model does a reasonable job of capturing the geometric mean of consumption by age for both singles and couples. We do not fit consumption figures as well for single people as we do for couples but it has to be remembered that there are fewer people in this category so that, overall, it is sensible to pay more attention to fitting the profiles to the data for couples. The lower half of the figure suggests that the model understates the disparity of the distribution of consumption described by survey data. This may suggest that households in the model tend to smooth their consumption through time more than in the survey data against which the model has been matched.

[25] Initial calibrations based upon a fixed leisure cost of employment revealed that up to 20% of individuals chose to return to employment from age 65. This was due to the less pronounced means-testing applied from state pensionable age as individuals are considered to become eligible for the Basic State Pension. It was consequently necessary to apply the higher leisure cost of 0.7 for full-time employment from age 65 for both singles and couples. We intend to explore this issue at greater length in future research.

# 5 Housing and Collateralised Debt

Owner occupied housing is a special type of asset for two reasons. First, it is "lumpy" in a way that few assets in the typical household balance sheet are. The indivisible nature of housing gives rise to a host of subsidiary complexities including minimum deposits, mortgage debt, and non-trivial transactions costs. Secondly, housing is desired for the services that it provides, in addition to the purely financial considerations that can reasonably be assumed to govern demand for other types of investment. This means that if housing is included in a model of rational behaviour, then it should enter as a term in the assumed utility function. These considerations complicate the inclusion of housing in a dynamic programming model of household savings behaviour, such as the one described by the current study.

In an alternative model developed by NIESR for HMRC, we have included housing under the assumption that housing wealth can be adjusted in a way that is very similar to liquid wealth. This adds substantially to the computational complexity of the problem, and its inclusion here would consequently crowd out other assets. At this stage of development, we have consequently opted to model housing and securitised debt through a nested logit model comprised of two levels, on the basis of the other household characteristics that are generated by the model. The first level of the nested model identifies whether a household is an owner occupier and, if so, the second level identifies whether they hold mortgage debt. Linear regression models are then used to identify the value of a household's housing wealth, and the value of any mortgage that they may hold. The results of the exercise do not feed back to affect the solution of the core model.

Although this analytical approach captures some aspects of the housing market, it is important to note that it represents an important methodological departure from the remainder of the study. The basic purpose of the model is to consider behaviour as determined by rational economic theory. Modelling housing using reduced form models is a clear departure from rational economic theory, which should be remembered when interpreting any associated results obtained.

The reduced form models considered for housing wealth and collateralised debt were arrived at after testing various alternatives econometrically using survey data from the BHPS. The logit regression does a very good job of capturing variation observed in the

data. The probability of being a house owner initially increases with age before levelling out, and finally declining later in life. The probability of being a house owner also increases, but at a decreasing rate, with labour income and net assets. Singles, and those with low net liquid wealth are less likely to own their own homes, an issue that is offset somewhat as the value of net debts rise. Finally and not surprisingly, house ownership in the previous year is a strong indicator of house ownership in the current year. Since the housing module in effect identifies an allocation of total wealth between housing and other (financial) assets it, like other non-annuitised wealth is treated as simply disappearing at death. The general observations about Section 3.2 apply to housing as much as to other non-annuitised wealth.

The various characteristics referred to above have a similar effect on the likely value of housing wealth as they do on the probability of owning a home. A conspicuous exception is the number of dependent children in a household, which was not found to have a significant influence on the probability of house ownership, but tends to increase the value of owner occupied housing. This is consistent with the increase in housing needs that comes with a larger family.

The probability of holding a mortgage is high at young ages and declines fairly sharply after age 40. Those with higher incomes tend to also have a higher probability of holding a mortgage, and the probability of holding a mortgage in any year is strongly correlated with holding a mortgage in the preceding year. Finally, house owners with low net liquid wealth are also far more likely to hold a mortgage than otherwise similar individuals. The value of a mortgage tends to decrease with the age of a household, and increase with labour income, house value, and low net liquid wealth.

# 6 Counterfactual Analysis

This Chapter provides an introductory demonstration of the types of analyses that can be undertaken using the model described above. Three counterfactual settings are considered for analysis. The first explores some of the behavioural and welfare effects of introducing pension saving into the model, to reflect the minimum low-cost pension offer discussed in recent Pensions White Papers and legislated for by the Pensions Act, 2008[26] as compared to a situation in which private personal pensions are not available. The second looks at the impact of a change to income tax rates. The third considers the effects of changes in life-expectancy. All analyses are based upon the calibrated model parameters that are reported in Chapter 4, and focus upon statistics generated for a simulated population cohort of 20,000 households. The 20,000 households are generated subject to the same temporal innovations, so that the only difference between alternative analytical contexts is the policy environment considered.

To focus upon the savings and labour supply behaviour with which the model is principally concerned, we have chosen to limit the extent of uncertainty that is included for the analyses that are reported here. Hence, the number of children in a household is considered to evolve deterministically, households are not able to invest in risky liquid assets, and returns to pension wealth are certain. Furthermore, it is important to add a qualifying note that it is not the purpose of the following Chapters to undertake an in-depth analysis of the implications of the respective counterfactual settings, but instead to provide firm examples of how the model can be used.

The overriding aim of the model is to simulate people's experiences over their lifetimes and to show how these are affected by various policy changes. Since the model allows us to simulate the experiences of people in different circumstances, it is possible to show the impact of policy changes on people classified by their incomes at any given age. We follow the normal route of showing people's experiences at the decile or quintile points of the income distribution. Since we are also interested in the effects of policy changes on saving, it also makes sense to look at decile or quintile points of the wealth distribution, while remembering that, even for people of a given age, the wealth ranking may be very

[26] See, DWP (2006b), DWP (2006a), and Parliament (2008).

different from the income ranking. However if we look only at people ranked by their current income it is difficult to give any meaning to the decile and quintile profiles. Given the random nature of income, people in a given decile in one year or at one age will not be in the same decile in a different year or at a different age. In Chapter 7 we explore the implications of the introduction of a low-cost pension. Chapter 8 explores the role of the rate of return, decision-making or transactions costs and impatience as determinants on saving in such a scheme. Chapter 9 shows how the model can be used to estimate the implications of changes to the income tax structure and Chapter 10 looks at the impact of rising life expectancy on people's behaviour.

# 7 Pensions after 2012

In November 2005, the Pensions Commission concluded that reforms to the state pension system would not be sufficient to meet the United Kingdom's long-term pension needs. This was in part attributed to the observation that:[27]

"There is a segment of the market, employees of average and lower earnings working in small and medium companies, plus many self employed, which the retail financial services industry cannot serve profitably except at Annual Management Charges (AMCs) which are disincentives to saving and which substantially reduce pensions available in retirement." Pensions Commission Second Report, p. 3.

The Pensions Commission consequently recommended

"The creation of a low cost, nationally funded pension savings scheme into which individuals will be automatically enrolled, but with the right to opt out, with a modest level of compulsory matching employer contributions, and delivering the opportunity to save for a pension at a low Annual Management Charge." Pensions Commission Second Report, p. 6.

This was intended

"to create the opportunity for all people to save at the low costs currently enjoyed by higher income individuals, employees in larger companies, and public sector employees", Pensions Commission (2005, p. 110).

In response to this recommendation, the Pensions Act, 2008 introduced future duties on employers to enroll workers into qualifying workplace pensions and to provide minimum employer contributions for those workers who choose not to opt out. The Act also introduces a low-cost work-place pensions scheme known as Personal Accounts, as recommended by the Pensions Commission.

[27] Three other reasons were also cited by the Pensions Commission: behavioural barriers to decision making, the limited impact of advice, and deteriorating employer attitudes toward the provision of occupational pensions.

Personal Accounts and the minimum employer contribution are being introduced specifically for individuals who do not currently have access to low-cost pension schemes or an employer contribution. This Chapter consequently focuses upon the effects of introducing a scheme that is structured to reflect key aspects of Personal Accounts where pension saving is otherwise unavailable. Thus the study shows the effects of the general availability of low-cost pension schemes on the terms similar to those offered by Personal Accounts rather than the specific effects of Personal Accounts. Nevertheless, it does, of course, indicate the benefits of the scheme to people in the various circumstances we identify who do not have access to employer sponsored occupational pensions or other forms of pension saving.

The low-cost personal pension in this simulation yields a return of 4.5%, compared with non-pension saving returns of 4%. This assumption fits a scenario where pension providers operate personal pensions at lower cost compared with other savings vehicles.

Hence, the incentives embodied in the minimum pension offer after reform provide a timely context against which to demonstrate the model's use. For the simulations that are reported here, the parameters of the low-cost pension scheme discussed in section 3.3 are, as far as the existing model allows this, specified to reflect Personal Accounts, as they are described in the DWP pensions White Papers and Pensions Act that are referred to above. The scheme includes minimum employer contributions and automatic enrolment as well as the general characteristics of private pensions. The Act requires participating households to contribute at least 5 per cent of their earnings gross of tax but net of national insurance to their low-cost pension accounts. As with other pension contributions, income tax relief is given at 20% for people who do not pay high rate tax and 40% for those who do pay high rate tax. Means-tested benefits for people of working age are calculated from income net of pension contributions, except that for housing benefit and council tax benefit only half of pension contributions can be offset. Households are permitted to 'opt-out' of the scheme and contribute nothing. If they do not opt-out (and supply some labour), then they receive a fixed employer contribution of 3% of labour income gross of income tax and employee National Insurance contributions. At state pensionable age (65 in the simulations), 25% of the accrued pension pot can be

taken as a tax free lump sum, and the remainder is used to purchase a fair level life annuity, which is subject to income tax. Hence, contributions to Personal Accounts are taxed via the EET[28] schedule (subject to the tax free lump sum). There is likely to be a cap on contributions of £4000-5000 p.a., which is not included here.

The White Paper scheme also sets out a lower annual labour income limit at the national insurance threshold (£5035 in 2007) and an upper earnings limit (£33540 in 2007). In our simulation we show the effects with the lower earnings limit in place. However since most high earners belong to pension schemes of some sort and little is known about scheme membership, we have left off the upper earnings limit. This means that our results show the combination of low-cost pensions, such as Personal Accounts, which may be more prevalent amongst low earners and general pension saving for higher earners.[29] Our model, in its current form, consolidates the tax and national insurance systems into a single system and offers pension contributions relief from both of these. In order to ensure the correct tax rebate with an employee national insurance rate of 11% on the minimum contribution, this means that the minimum contribution must be set at 4.45% of gross income (which we round to 4.5%). Also we do aggregate housing and council tax with other benefits and the model therefore gives full relief against these. These simplifications do make the scheme we represent slightly more favourable to its members in two respects, first in terms of the slightly lower contribution and secondly in terms of the extra tax/benefit relief. Extending the model to handle national insurance separately from taxation is, as with a differentiation of housing benefit and council tax benefit from other means tested benefits, an issue for future research.

We divide discussion into five sections. First, we outline life profiles for a base case scenario in which the simulated population is able to contribute to low-cost pensions, subject to a 4.5% p.a. rate of return, no transactions costs, and a discount rate of 2.5% p.a. This provides a basis for the comparisons that are made later in the section. We then report statistics for participation in low-cost pensions that underlie the base scenario, and explain how and why these depend upon exogenous household heterogeneity generated

[28] The EET tax schedule describes the tax treatment of different pension fund transactions. The first 'E' indicates that contributions to pension funds are tax exempt, the second 'E' indicates that earnings accruing to pensions are tax exempt, and the 'T' at the end indicates that pension fund dispersals are subject to tax.

[29] Although the terms of pension saving offered to some groups, such as those in the public sector, may be much more generous than those modelled here.

by the model. Finally we consider sensitivity of results to the interest rate that is assumed to accrue to savings in low-cost pensions, to alternative decision making costs attached to low-cost pensions, and to the assumed rate of time preference.

## *7.1 Life-course Profiles with Low-cost Pensions*

Figure 7-1 reports average consumption profiles by age for population quintiles distinguished by net income earned over the entire simulated lifetime (hence, each population subgroup is comprised of the same set of simulated households). The figure shows a classic hump-shaped profile for high-income households while that of low-income households rises fairly steadily with age. We can assume that high income households can choose consumption profiles which reflect their preferences and that low-income households have similar preferences for the time-path of consumption because the latter are driven by underlying preference structures which are similar for all households. The implication of this is that low income households are unable to consume as much as they would like in middle age because they are constrained. In contrast, households with higher incomes are able to adjust their consumption in response to changing household needs, consuming more during peak child rearing years. At the peak difference around age 50, households in the highest income quintile spend almost five times the weekly expenditure of households in the lowest quintile. Toward the end of the potential lifetime, the consumption of all income quintiles converges, as liquid assets are drawn down to zero. As noted earlier, these profiles are for the current cohort of twenty-year olds. The assumption of continuing trend growth means that they show consumption rising in old age even though cross-section profiles show it stable or falling.

**Figure 7-1 Age profile of simulated consumption by age and life-time income- full population**

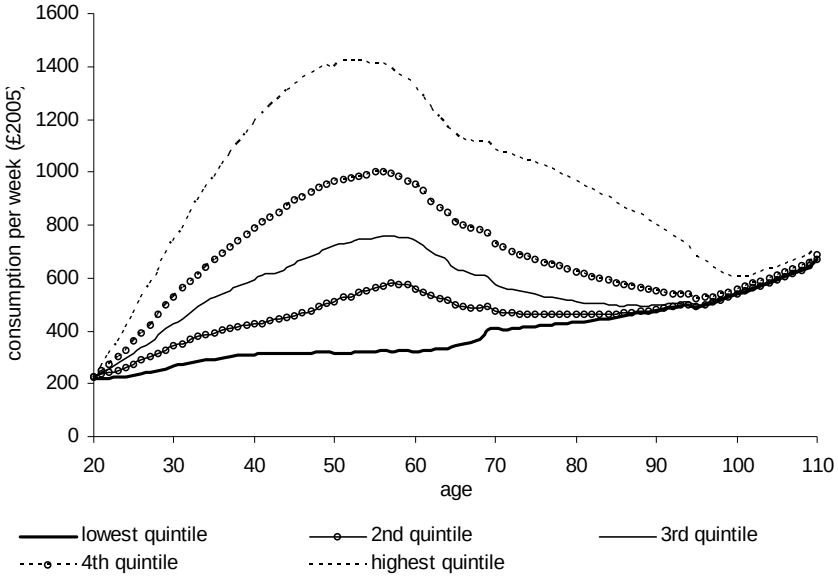
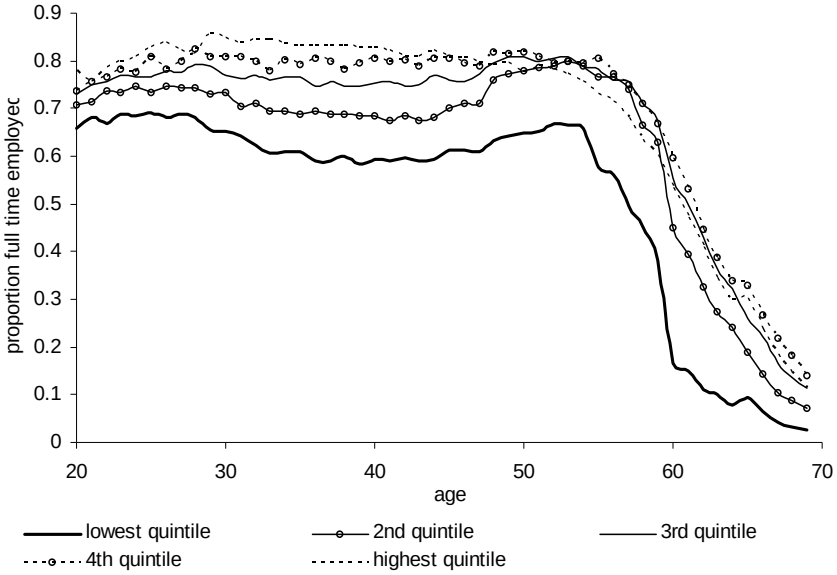


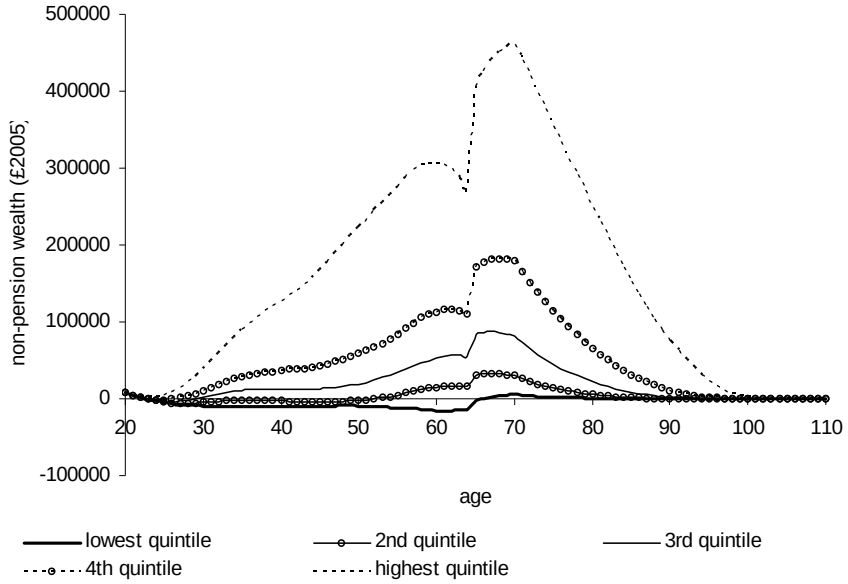

Figure 7-2 stands in stark contrast to Figure 7-1. It shows that, although households in the lowest income quintile are constrained in terms of their consumption expenditure, their labour supply tends to react to consumption needs, dipping down during peak child bearing years. This reflects the fact that consumption of leisure is relatively cheap for households with low labour incomes. The figure also clearly reveals the disparate incentives that apply late in the working lifetime — between ages 50 and 60, households in the lowest and highest quintiles tend to supply less labour than do households in the middle of the income distribution. At the low end of the income distribution, this is observed because the welfare benefits that are available represent a larger proportional share of their labour incomes. At the top end, less employment is observed because the respective households can afford to take additional leisure. These observations are qualitatively consistent with observations drawn from survey data (see, for example, Marmot, Banks, Blundell, Lessof & Nazroo (2003), p. 156).

**Figure 7-2 Age profile of simulated labour supply by age and life-time income- full population**

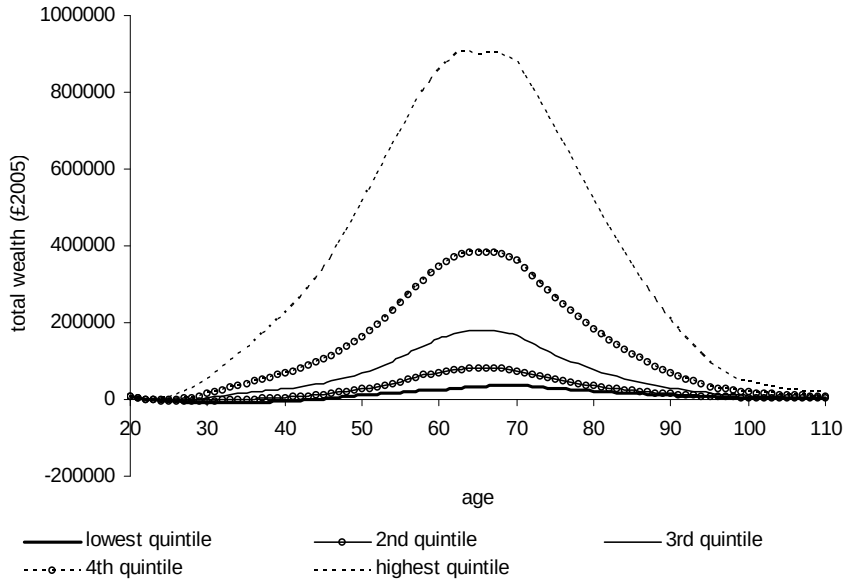



The statistics reported in Figure 7-3 indicate that wealth tends to be distributed more unequally than consumption, an observation that is primarily attributable to the equalising effect of tax and benefits payments. At its peak, the net worth of the top income quintile is approximately 16 times that of the poorest quintile. The bottom panel of the figure reveals that wealth is built up reasonably smoothly by simulated households, before being drawn down smoothly in retirement. The top panel of the figure is interesting in that it suggests households in the bottom wealth quintile tend to take on debts that can be approximately repaid by the tax free lump sum that they receive from their pension pots at state pensionable age.

**Figure 7-3 Profile of simulated wealth by age and life-time income**




Panel A: non-pension wealth




Panel B: total wealth

## *7.2 Simulated Contributions and Participation Rates*

A property of a model such as that used here— in which people are assumed to form rational expectations of future events — is that choices between different forms of savings assets are determined by the trade-offs which may exist between returns,

uncertainty and liquidity. Overall saving is motivated by a combination of the desire to provide for old age and the need to have resources to hand in the event of emergencies. Pension saving has the drawback that the funds saved in pensions are not available to meet emergencies. This cost of illiquidity associated with pension contributions is commonly offset by incentives offered by the government and / or employers.

In the UK, employer-provided incentives to contribute to pensions are commonly in the form of matching contributions that are made on behalf of employees who choose to participate in an occupational pension — most employers do not offer employees the alternative of receiving the same amount of money as conventional pay. Government incentives, by contrast, are primarily offered in the form of tax relief. This relief is derived primarily in two forms. First, as is common in many other economically developed countries, the UK system of income taxation in relation to pensions takes the EET form, with contributions and investment returns to pension funds being relieved from income tax, and pension income in retirement being taxable. The implied tax incentives are derived because, in most cases, the tax rate people face in retirement is lower than that which they face in working life, and also because a part of the pension fund that is accrued during the working lifetime can be withdrawn as a tax-free lump-sum on retirement. This effect is amplified by the fact that tax allowances for old people are higher than those for the population younger than 65. Secondly, employers' National Insurance contributions are paid on salaries but not on pension contributions. Thus, where employers treat all labour costs in the same way, and where no distinction is made between National Insurance collected from the employer and that collected from the employee, there are significant tax benefits to employees which encourage some commutation of employment income from salary to pension contributions.

Seen from this perspective, the low-cost pensions considered for analysis have three incentives to participation. The first is the benefit that derives from deferring income taxation into retirement. Secondly, there are the employer contributions, which it is assumed cannot be commuted into salary. And third, we consider the additional incentive of low management charges levied on low-cost pensions, which consequently offer improved rates of investment return compared with non-pension wealth. This last factor is

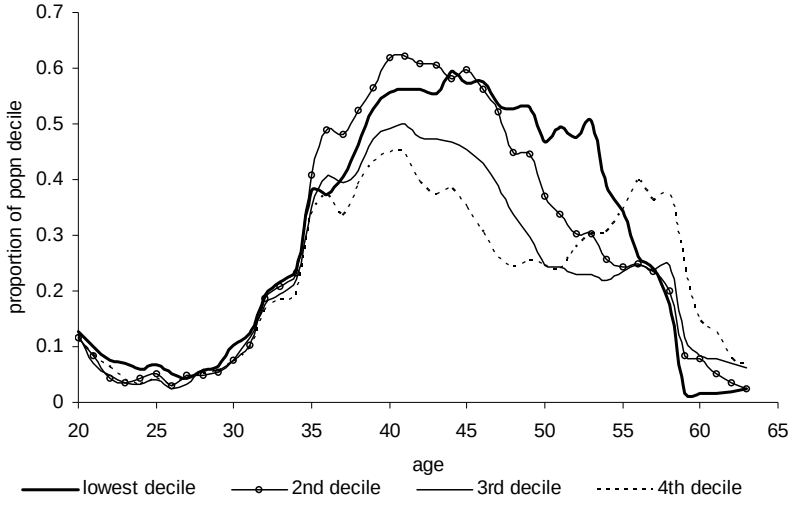
modelled by assuming that lower charges deliver a 4.5% annual rate of return to savings in low-cost pensions relative to a 4% return on non-pension wealth. Offsetting this, our model also represents two drawbacks of low-cost pensions as compared to non-pension saving that are likely to apply in practice. The first is the fact that pension contributions are illiquid, as discussed above. Secondly, in context of the prevailing tax and benefits system, people who have saved in low-cost pensions may find that their access to means tested benefits in retirement is reduced. This second effect can be dampened by the fact that people of working age have their eligibility for means tested benefits at this stage in their lives computed net of payments into low-cost pensions and other pension schemes (see Chapter 7). This section explores how the interaction of these incentives influence rates of participation in low-cost pensions, as simulated by the model.

It is natural to be interested in the participation rates and contribution patterns of people in different circumstances. The problem is that there are a number of different ways of identifying people's circumstances. Here we focus first on a classification by life-time employment income, and secondly by looking at employment income by age. Because many people's employment income is volatile, the first gives a much better impression of how low-cost pensions appeal to people in different economic circumstances — for example, distinguishing the rich from the poor. It also has the advantage that population subgroups are fixed throughout the simulated lifetime. In contrast, distinguishing the population by employment income at any given age results in population subgroups that vary through time, as some people enjoy favourable shocks to their circumstances and others suffer negative shocks. In context of labour income observed at any given age it makes sense to distinguish single households from couples, and we limit our attention here to the latter for reasons of brevity.

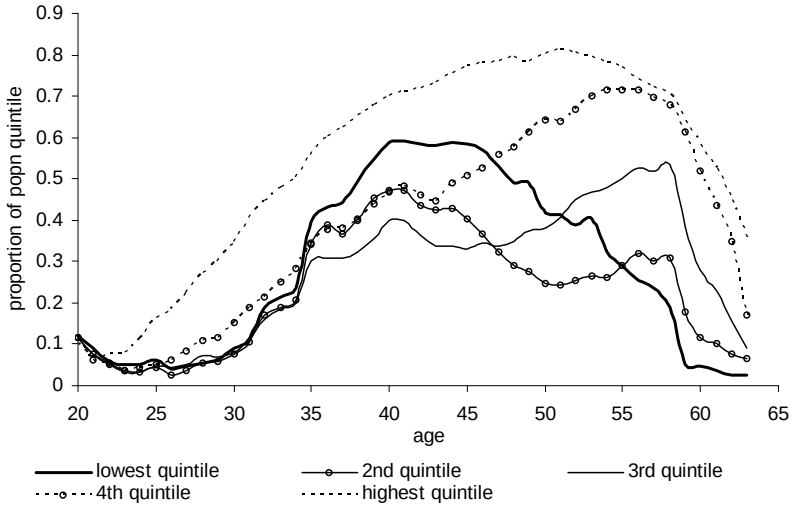
Figure 7-4 reports statistics for the population disaggregated by age and lifetime income. Not very surprisingly these results show the highest participation rates among people in the top income quintile. Amongst people aged 55 and over the participation rates are ranked in quintile order and this is what might have been expected over the whole life cycle. High income households in the top quintile increasingly make use of pensions as they go through their lives, such that almost 40% save in a pension by age 30 and almost 80% by their mid-forties. Thus the question raised by these results is whether we should expect high participation rates from people much lower down the life-time income scale.

Although less than 10% of households in the lowest income quintile save in pensions by age 30, these households in their forties have the second highest average contribution rate, as Panel B of Figure 7-4 shows. Furthermore panel A shows the bottom two deciles have the highest participation rates from age 35 until the early fifties.

**Figure 7-4 Proportion of population choosing to participate in Low-cost pensions by age and life-time income category- full population**




Panel A: bottom four life-time income deciles




Panel B: full population by life-time income quintile

Participation rates of low-income households are influenced by a number of interrelated factors. First, households on low wages and with low wealth anticipate short working

lives (due to the inter-temporal persistence of wages, and the positive relationship between labour market participation and wage rates that tends to be generated by the model). Second, the life-cycle savings motive increases with wealth and labour income (because the basic state pension becomes proportionately less important). And thirdly, households on the lowest incomes have the smallest incentive to build up precautionary (liquid) savings (this is returned to below). The first of these considerations implies that households with low wages anticipate a relatively short period over which they will be able to take advantage of saving in low-cost pensions (because pension contributions can be made only when a household is employed) and thus benefit from employer contributions. The ability to offset pension contributions partially or fully against income before calculation of working age means-tested benefits such as tax credits obviously enhances this. The second two considerations (precautionary and life-cycle savings motives) imply that households on low wages care less about the illiquidity of pension savings than do higher wage households, but also care less about saving for retirement. As wages increase, motives for both liquid savings, and savings for retirement increase, and it is the balance of these incentives — alongside expectations regarding the period of employment — that drives the preferences for pension scheme participation that are reported above.

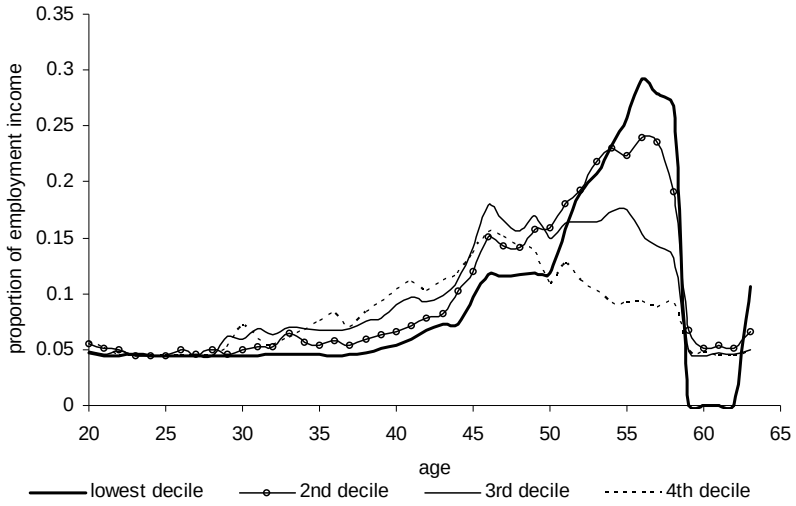
The statistics discussed above indicate that at low wage levels, concerns over liquidity are dominated by the desire to save for retirement and expectations regarding the limited duration of employment, so that participation rates are high. At higher wage levels, however, increasing liquidity concerns and the expectation of a longer period of employment begin to dominate, and participation falls. The relative strengths of these countervailing motives are driven by a range of issues including preferences for employment, the degree of risk aversion, the generosity of the benefits system relative to wages, and expectations regarding the lifetime wage profile. The balance between them explains the pattern shown in Figure 7-4. The current policy experiment is a perfect example of how the simulation model can both report the logical implications of the assumptions upon which it is based, and help to improve our understanding of how incentives embodied by a policy counterfactual may translate into observed behaviour.

In absolute terms, older households with higher incomes will save more in pensions than low income households. However, among those that do participate, the proportion of income devoted to a pension is very similar across all income and age groups.

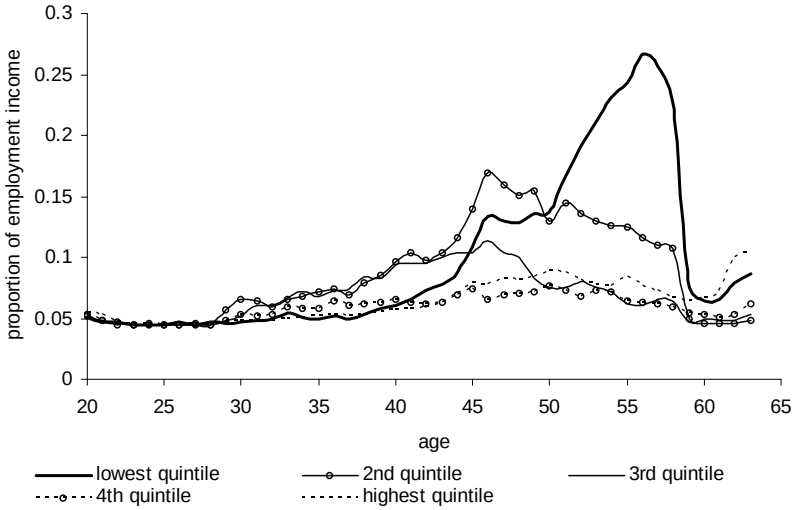
Contribution rates typically increase with age, reaching a peak at ages 50-60 for all income groups. In part, this suggests that despite the favourable return on pensions relative to other saving in the model, households put off a good deal of pension saving until later in life in order to retain wealth in liquid form for as long as possible.

Figure 7-5 indicates the desired contribution rates of those who choose to participate in low-cost pensions, and that participation is limited to people who are actually employed at the time. This explains why people in the lowest life-time income quintile both choose to contribute very high proportions of their labour income between ages 50 and 59, and have low rates of scheme participation, relative to the wider population.

**Figure 7-5 Average desired contribution rate of contributors to low-cost pensions by age and life-time income- full population (employee contribution rate only)**




Panel A: bottom four life-time income deciles



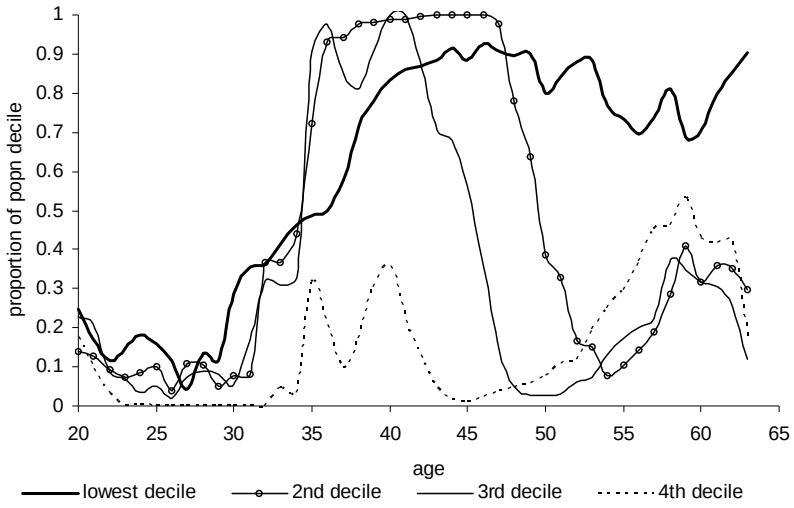

Panel B: full population by life-time income quintile

Overall, the pattern shown here is a balance between the desire to put off contributions to low-cost pensions for as long as possible (to avoid the loss of liquidity), and the wish to contribute while employed in order to benefit from the employer contribution. Those in the low deciles who are in a position to take advantage of the scheme late in working life

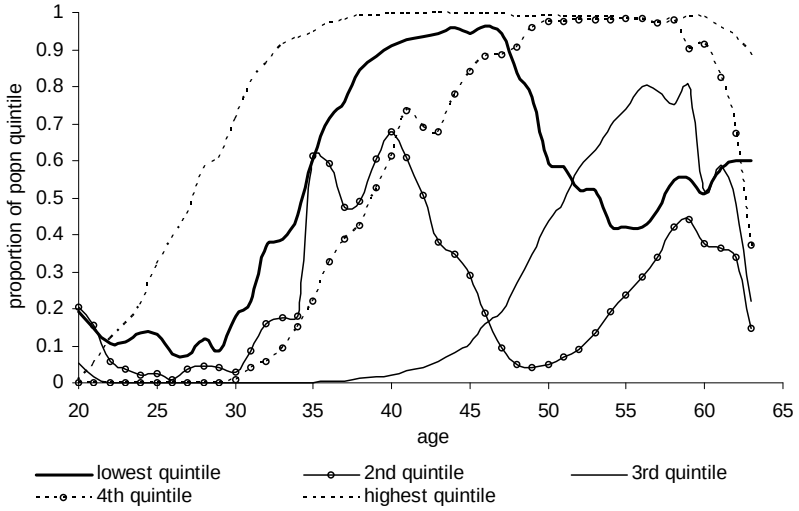
have a strong incentive to do so. People in the higher income quintiles have a more stable employment history and have contributed more steadily; thus those who are employed late in working life feel less pressure to contribute a high proportion of their salary. We also note that the contribution rates of people in low income deciles are inflated because the graph shows the contribution as a proportion of eligible salary. People with low eligible pay have to contribute a higher proportion of that in order to obtain a given contribution rate from their total pay.

From this background we now look at the rather more complicated picture generated for contribution patterns from employed couples ranked by actual employment income. Here too, in Panel B of Figure 7-6 we see that the top quintile is keenest to participate with close to universal membership from the early thirties onwards. The fourth quintile follows a similar pattern but takes much longer to reach full participation. The participation rate of the third quintile is delayed further — so that it never reaches full participation. But the pattern is similar to that of the fourth and fifth quintiles. The participation of the first and second quintiles, however, shows clear peaks in the middle of working life. Looking at the bottom four deciles in Panel A we can see that, for the lowest decile, the rate does not drop off very much as people age. The forces driving this pattern are similar to those mentioned in the analysis of patterns based on life-time income. Moving down the scale from the top quintile, the illiquidity of pension contributions is of increasing concern and an increasing deterrent which is why the fourth quintile reaches its peak rate later than the top quintile and the third quintile never reaches close to universal participation. But for the lower income groups the illiquidity is less of a problem because, relative to their earnings, state benefits are more of a cushion. At the same time employment rates are lower, so these groups want to take advantage of the scheme while they can.

**Figure 7-6 Proportion of employed population choosing to participate in Low-cost pensions by age and aggregate labour income- couples**




Panel A: bottom four labour income deciles

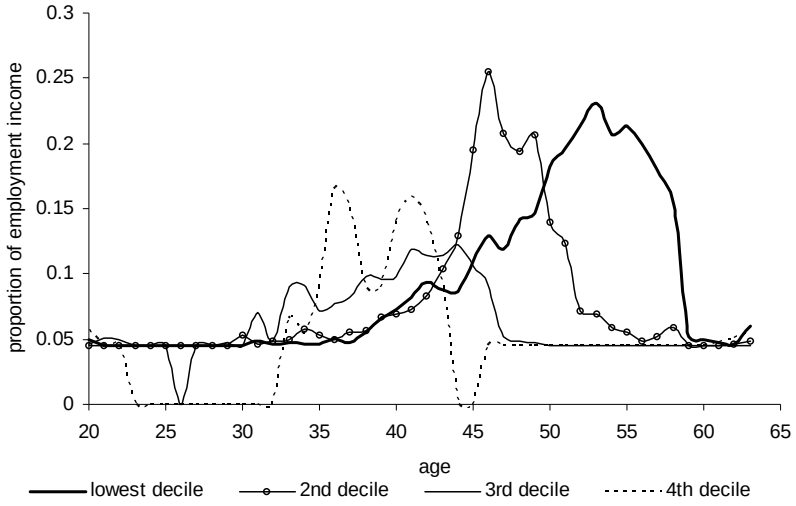



Panel B: population by labour income quintile

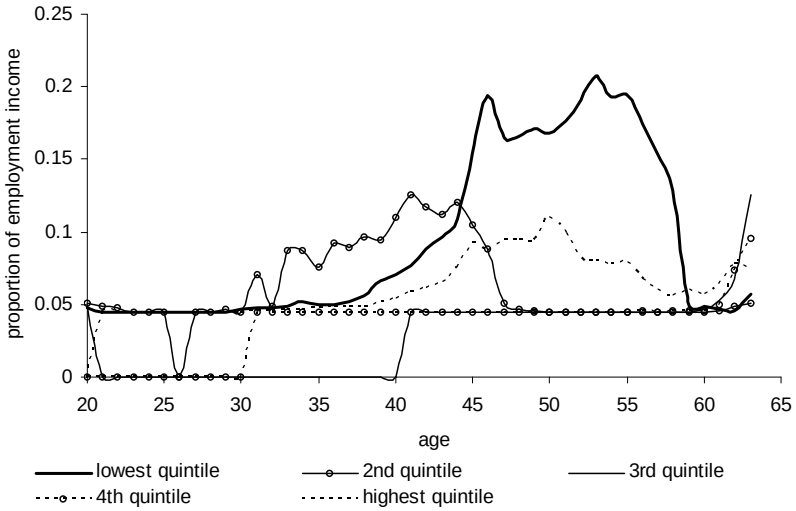
Similar effects are shown in Figure 7-7. Looking at the quintiles in Panel B, the top quintile contributes more late in working life, which reflects the fact that earnings rise later in working life and that the illiquidity effects are less important. Nevertheless, the fact that the return in a low-cost pension scheme is higher than with other forms of saving, and the availability of the employer contribution, provides a good reason not to defer contributions until the latest possible date. The third and fourth quintiles, in contrast, choose to contribute at the minimum rate when they contribute. They are

primarily driven to participate by the higher investment returns that they enjoy in the low-cost pension and by the matching contributions made by their employers. The liquidity concerns of these households are such, however, that they do not choose to contribute above the minimum required for scheme participation.

**Figure 7-7 Average employee contribution rate to low-cost pensions as a proportion of eligible employment income by age and employment income- couples**




Panel A: bottom four labour income deciles




Panel B: full population by labour income quintile

Turning now to the lowest two quintiles, we can see that the contribution rate of the second quintile peaks in the middle of working life - influenced by the same factors which drive up the participation rate. Lower down the income scale, contributions are deferred later into working life. The reason for this follows from the dynamic nature of the wage process. Low earners in the middle of working life have a reasonable expectation that their earnings will recover — so it is sensible for them to defer their saving in the anticipation of higher future income. The later in working life one experiences low income the lower is the chance of recovery and therefore the greater the point to making pension contributions out of current income. The figures for the lower parts of the income distribution are again swollen by the fact that the graphs show the proportion of eligible income contributed — requiring people on low incomes to contribute higher proportions of eligible income to achieve any given contribution rate out of total income.

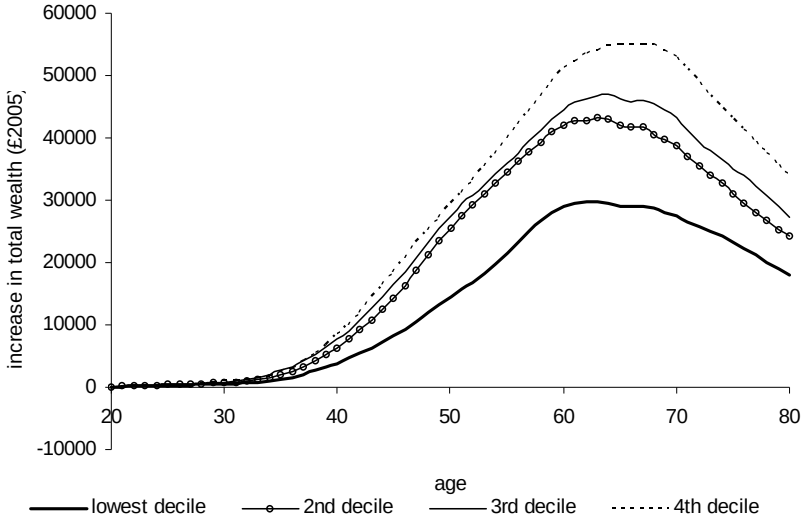
## *7.3 Welfare Effects of Low-cost Pensions*

Low-cost pensions are planned to be introduced to cater specifically for the population subgroup that does not currently receive adequate coverage by private market providers. The current section consequently reports long-run behavioural and welfare effects of introducing low-cost pensions into an economic environment where no private pensions are considered to exist previously. Specifically, the current Chapter reports differences between the 'base population' explored above, relative to a population that is similar in all respects except that it does not have the opportunity to invest labour income in low-cost pensions.

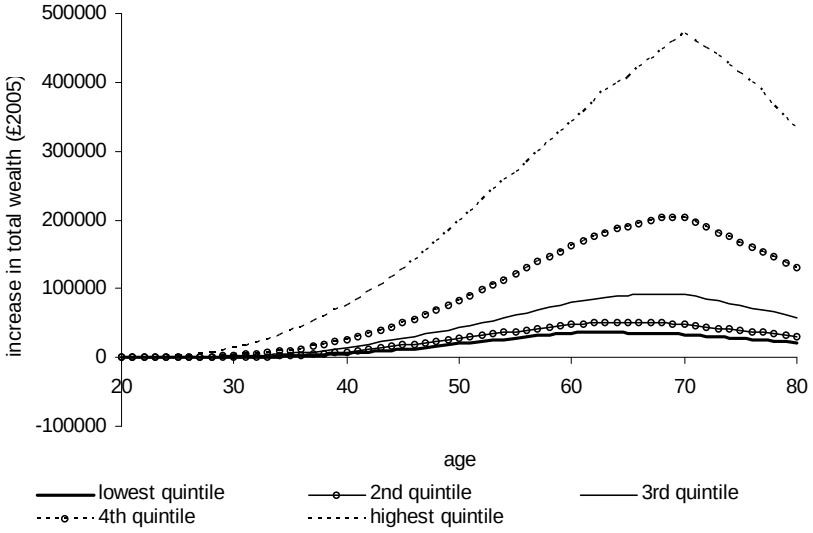
Figure 7-8 reports the effects on aggregate savings of being able to contribute to low-cost pensions. Consistent with intuition, the higher rates of return offered by low-cost pensions, relative to non-pension wealth, encourage individuals to accumulate a larger stock of assets. Saving in pensions inevitably boosts wealth holdings over the lifetime of households that participate in pensions. The bottom panel of the figure reveals that this is particularly true of households in the highest income quintile, who have the strongest a priori propensities to save, and accumulate an additional £350,000 by the age of 60. But even in the lower income deciles, households choose to accumulate substantially more

wealth when given the opportunity to invest in low-cost pensions. This extra wealth amounts to around £25,000.

**Figure 7-8 Effects of low-cost pensions on total wealth accumulation by age and life-time income- full population**



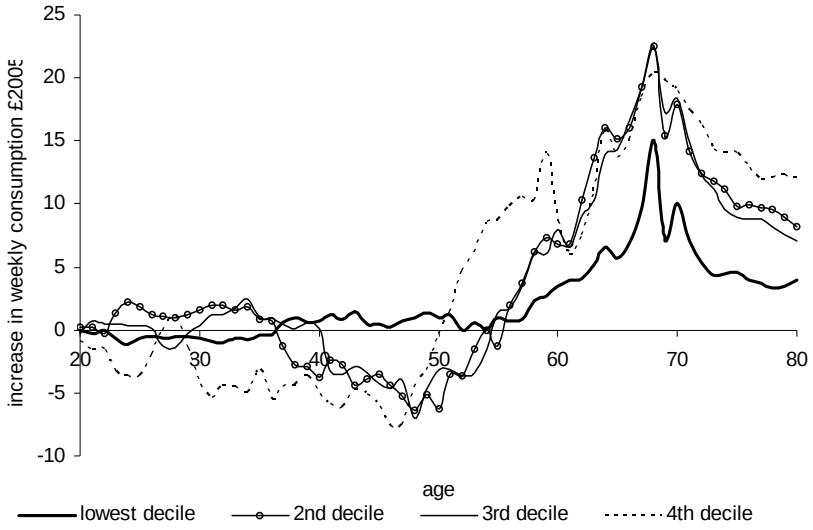

Panel A: bottom four income deciles



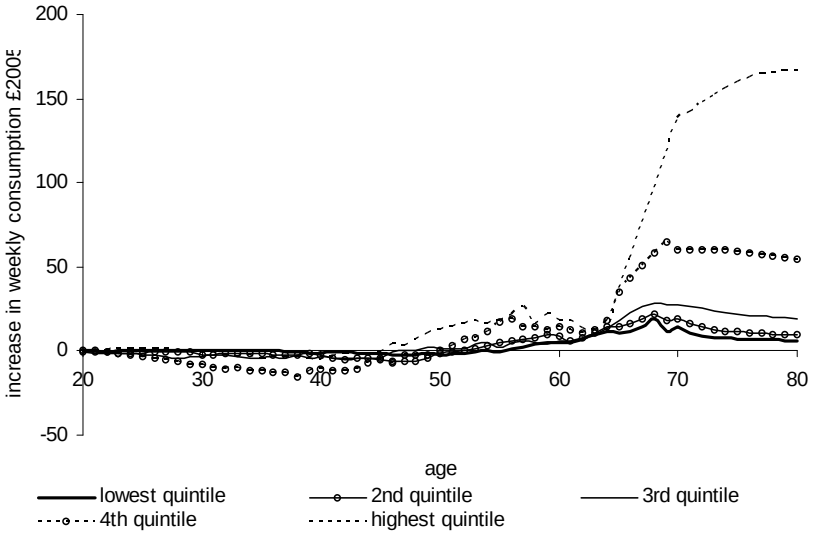

Panel B: full population by income quintile

The effects on consumption of allowing households to contribute to low-cost pensions are reported in Figure 7-9. Saving allows households to consume more over the lifetime. The strong compounding effects of saving in the model are evident in the sense that by giving up a little income in early working life, households are able to reap big gains in consumption in later life. The top panel of this figure indicates that the opportunity to contribute to low-cost pensions does tend to encourage households on modest incomes, but not those in the lowest decile, to save more of their disposable income during the working lifetime, and delay consumption until retirement. The bottom panel of the figure reveals that the improved rates of investment return offered by low-cost pensions enable higher income households to fund much higher consumption in retirement than would otherwise be the case. Of course, most higher income households currently have access to adequate pension provision. Hence, the effects reported in the bottom panel of the figure for high income households are representative of the counterfactual considered here and may already be enjoyed by high-income households as a result of access to existing occupational pensions.

**Figure 7-9 Increase in Consumption with low-cost pensions relative to base without low-cost pensions by age and life-time income- full population**




Panel A: bottom four income deciles

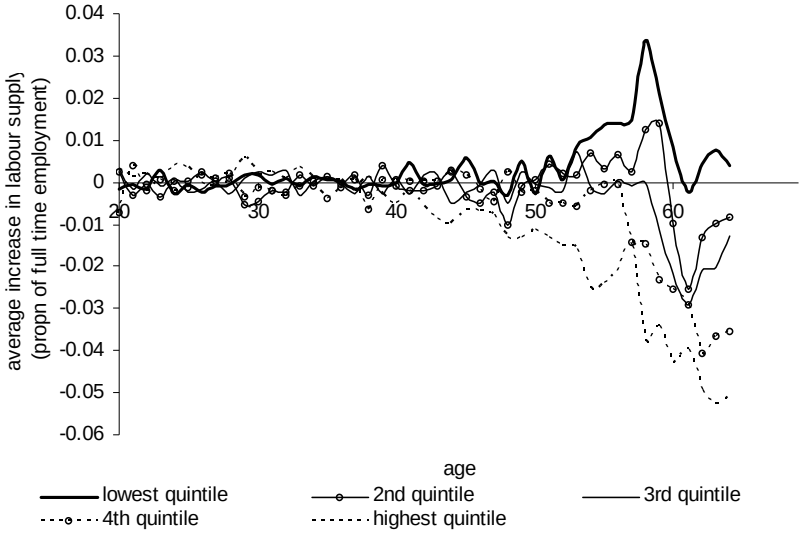



Panel B: full population by income quintile

With regard to labour supply, Figure 7-10 indicates that introduction of low-cost pensions is unlikely to have a very substantial effect during the majority of the working lifetime. Later in working life, however, important differences between different income groups

start to emerge. Those in the lowest quintile increase their labour supply because low-cost pensions have made working slightly more attractive. The substitution effect dominates. By contrast, those in the highest income quintile reduce their labour market participation because there is less "need" to work-the income effect dominates. For intermediate deciles, the income effects dominate later than with the top decile. But all except the bottom decile reduce their labour supply late in working life.

**Figure 7-10 Increase in labour supply with low-cost pensions relative to base without low-cost pensions. Full-time Equivalent Participation Rate by age and life-time income- full population**

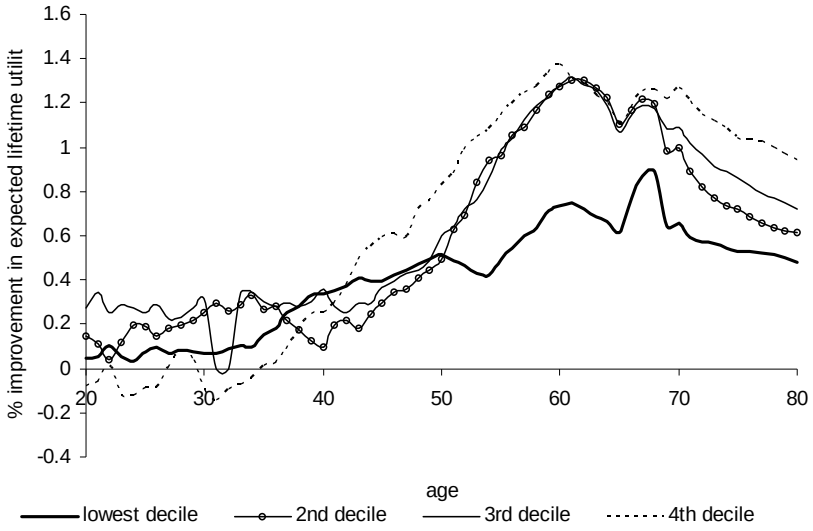



In addition to generating observable household characteristics and behaviour, the model also produces measures of expected lifetime utility. These measures can be thought of as a composite household characteristic that takes into account all of the aspects that are considered to influence household welfare. As such, these measures are a particularly useful measure for gauging the 'desirability' of a particular policy measure.

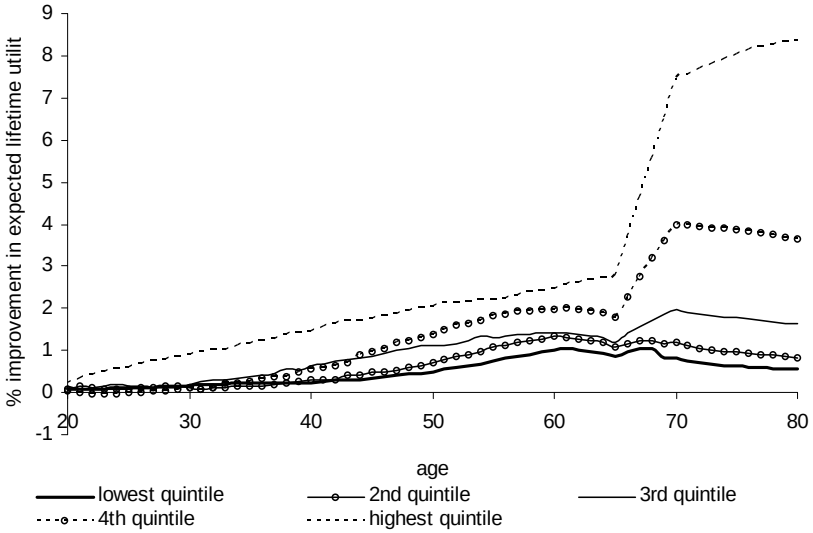
Figure 7-11 reports the effects of low-cost pensions on measures of expected lifetime utility as percentages of welfare in the absence of any low-cost pensions. The two panels of the figure indicate that low-cost pensions have an unambiguously positive impact on welfare. This should come as no surprise. In the current context low-cost pensions are purely voluntary, and so permitting individuals to make contributions cannot but improve their circumstances. If contributing to a low-cost pension would make someone worse off, then they will choose not to contribute in the model. The improvement in welfare reflects, of course, the tax benefits and employer contributions associated with low-cost pensions

as well as the increased return on savings which the low cost aspect makes possible. This remains the case even if these are ultimately offset by higher taxes elsewhere or lower wages generally because, from the point of view of the participant, they are benefits which would not accrue without joining a low-cost pension scheme.

**Figure 7-11 Increase in expected life-time utility with low-cost pensions relative to base without low-cost pensions by age and life-time income- full population**




Panel A: bottom four income deciles




Panel B: full population by income quintile

The two panels of the figure indicate that low-cost pensions have very little influence on expected lifetime utility when measured from age 20. This is due to two effects. First, the benefits from low-cost pensions are only obtained from age 65 in the model, and these

benefits are consequently discounted significantly in evaluating expected lifetime utility at age 20. Second, the benefits of low-cost pensions can only be obtained by making contributions during the working lifetime, and these contributions tend to depress consumption prior to age 50, which reduces the contribution to lifetime utility obtained during those years. As retirement draws nearer, low-cost pensions have a more pronounced impact on welfare, both because fewer additional contributions will be made and because the benefits are subject to less discounting. The welfare benefits of low-cost pensions fall away following state pensionable age as the implicit savings are drawn down.

As in the case of consumption, the largest effects on welfare are observed for high income households. Nevertheless, the top panel of Figure 7-11 reveals that low-cost pensions improve the circumstances of households in the bottom 4 quintiles by between 1% and 3% at the time of retirement. The benefit then declines simply because the amount of time over which people can enjoy their enhanced consumption diminishes.

# 8 Influences on Saving in Low-cost Pensions

The previous Chapter set out our analysis of the effects of introducing low-cost pensions in an environment where they did not previously exist. In this Chapter we look at three possible influences on both people's desire to contribute to them and on the amount that they wish to contribute. We look first at the effect of the rate of return, exploring how important the effect of raising the assumed real rate of return from 4.5% per annum to 5% per annum would be. In the second section we assess the impact of decision-making costs by assuming that people who wish to open low-cost pension plans have to make a one-off contribution of £500. In the third example we explore what would happen if people were more impatient than we have assumed, i.e. if their discount rate were higher.

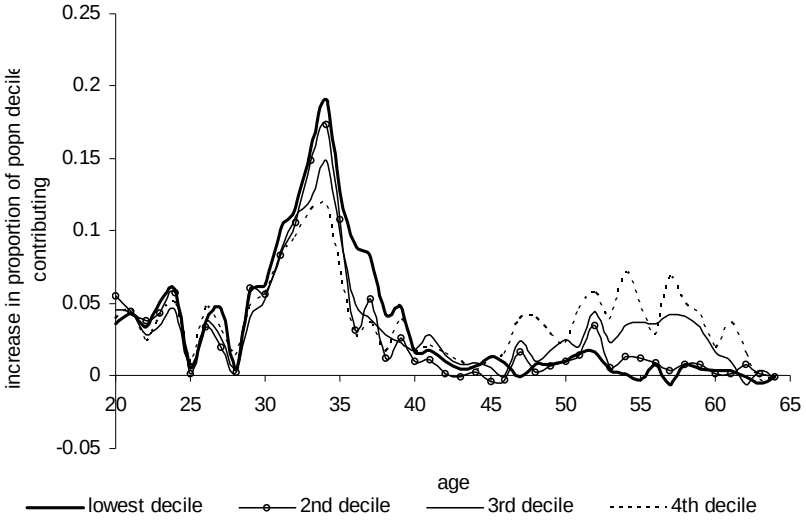
## *8.1 Rates of Return and Low-cost Pensions*

In its Second Report, the Pensions Commission suggests that the management cost ceiling currently imposed on Stakeholder pensions — approximately equal to 1.3% on the capital value per annum for a policy maintained over 25 years — makes it unprofitable for private providers to sell low-cost pensions to people on modest incomes.[30] The Commission also suggests that the system of low-cost pensions should have a core objective of reducing management charges to 0.3% per annum or less (see p. 396). The analysis reported above assumes that savings in low-cost pensions accrue a return premium, relative to non-pension wealth, of 0.5% per annum reflecting lower charges and management costs. Here we consider the impact of doubling this premium to reflect the figures reported by the Pensions Commission, increasing the rate of return for low-cost pensions from 4.5 to 5% per annum. This simulation can be interpreted as a scenario in which a new personal pension such as Personal Accounts operates with very low costs, overtaking existing pension products on offer.

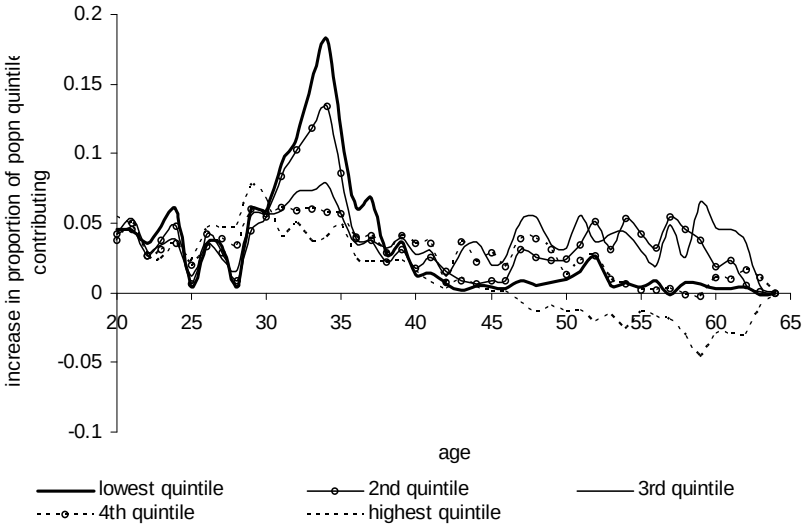
[30] See, for example, Pensions Commission (2005), p. 110.

We focus here upon how the improved rates of return to low-cost pensions affect three key statistics: rates of scheme participation; total accrued wealth prior to state pensionable age; and consumption over the life-course.

**Figure 8-1 Increase in proportion of population with low-cost pensions resulting from raising return from 4.5% p.a. to 5% p.a.- full population**




Panel A: bottom four income deciles




Panel B: full population by income quintile

Figure 8-1 reports the effects of increasing the rate of return to savings in low-cost pensions from 4.5% to 5% p.a. on participation rates in the scheme. The two panels of the figure indicate that the higher rates of return tend to encourage increased scheme participation, which is hardly surprising. A number of points are, however, of particular

note. First, the higher rates of return tend to have the most pronounced influence on the lowest income deciles early in the simulated lifetime. Participation among households in the two lowest income deciles during their thirties increases by between 10 – 20%. Secondly, although increased scheme participation is in general encouraged by higher rates of return, lower participation rates are observed by the top income decile toward the end of the working lifetime. This effect arises because in general the higher rates of return make households richer. This leads to a marked tendency by high income households, which benefit most from enhanced returns, to take some of the financial gain in the form of increased leisure and earlier retirement. This can be seen in the bottom panel of Figure 8-1, and the associated labour statistics reported in Figure 8-2.

**Figure 8-2 Increase in labour supply resulting from an increase in the return on low-cost pensions from 4.5% p.a. to 5% p.a. Full population**

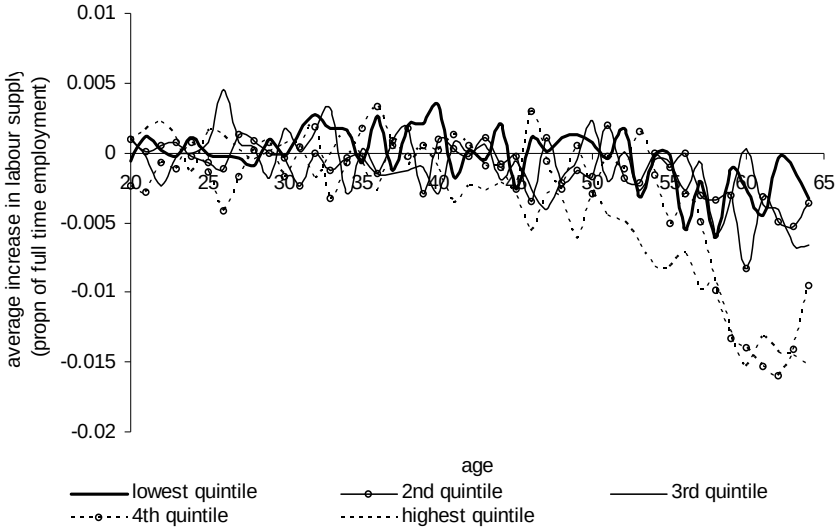
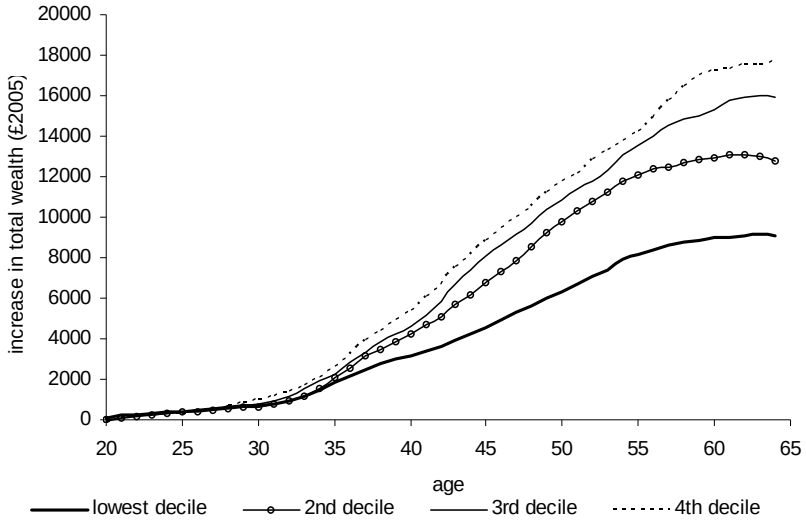
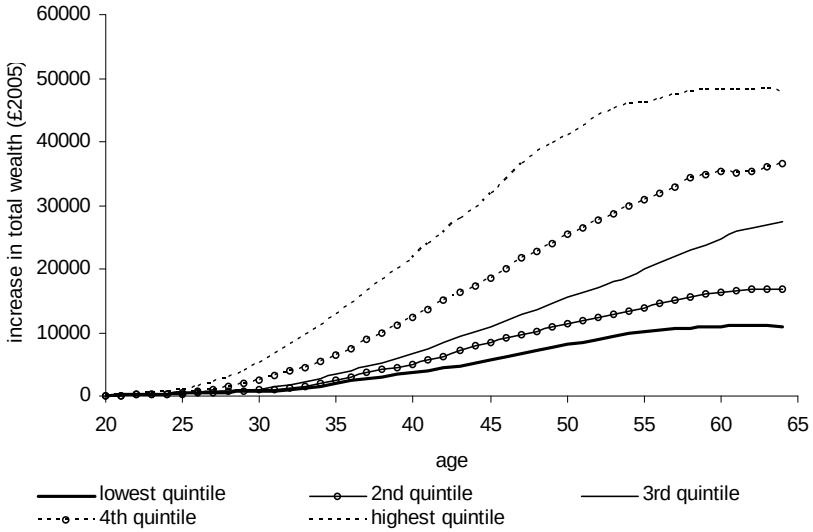


**Figure 8-3 Increase in wealth holding resulting from an increase in the return on low-cost pensions from 4.5% p.a. to 5% p.a.- full population**




Panel A: bottom four income deciles

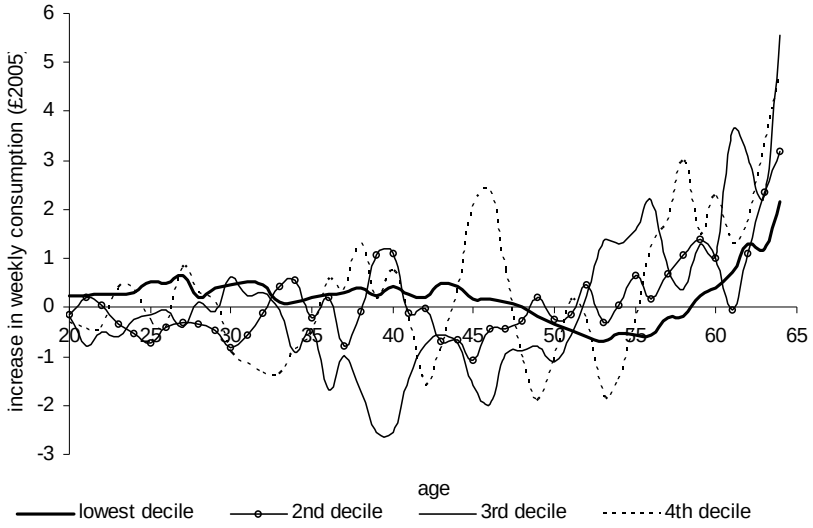



Panel B: full population by income quintile

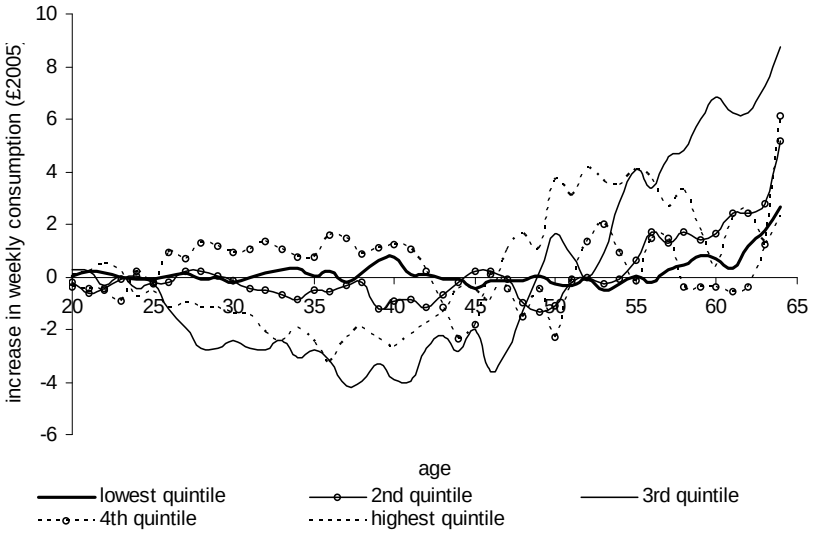
The two panels of Figure 8-3 indicate the extent to which the higher rate of return and rate of scheme participation reported above increase aggregate savings. Increases are observed for all of the income subgroups reported in the figure, with the rate of increase tending to fall away toward state pensionable age as reduced labour supply starts to bite.

Although Figure 8-3 indicates larger increases for higher income subgroups, the proportional effects of the interest rate increase on accrued wealth are largest for poor households; aggregate savings increase by 30% (roughly £10,000) at age 64 for the lowest income decile, and by just 4% for the highest income quintile. This is attributable to the increased contribution rates that are reported in Figure 8-1.

**Figure 8-4 Increase in consumption resulting from an increase in the return on low-cost pensions from 4.5% p.a. to 5% p.a. by age and life-time income- full population**




Panel A: bottom four income deciles




Panel B: full population by income quintile

Figure 8-4 reports statistics for the effects on consumption of increased pension returns. As in the case of labour supply, Figure 8-4 reveals that the most substantial effects on consumption occur just prior to retirement, as households seek to draw some of the financial advantage gained into the working lifetime. Earlier in working life there is an interplay of different effects so that no distinct pattern by income group emerges.

However, it is clear that the effect of the change in the rate of return does not have a large effect on consumption while people are of working age. In keeping with the life-cycle approach, consumption increases are mainly felt in later life, following earlier sacrifices.

Hence, the rate of return accruing to savings in low-cost pensions has an appreciable impact on the funds that are available at retirement. However, behaviour does not appear to be especially sensitive to the magnitude of interest rate variation that is likely to be attributable to the efficiency of the scheme's operation — particularly amongst households on modest incomes. It would clearly be of some interest to consider how much the interest rate variation would need to be before the behaviour of households in alternative income deciles is substantially altered.

## *8.2 Transaction Costs and Low-cost Pensions*

The simulations discussed in the preceding sections are based upon the assumption that people both understand their economic environment, and are capable of performing the complex calculations that are necessary to determine which actions are best for them, given their environment. Put another way, there are no decision making costs — information gathering and processing are both free and instantaneous. It is of note, however, that both the Pensions Commission and the 2006 DWP White Paper, *Personal Accounts: a new way to save*, explicitly refer to behavioural inertia (decision making costs) in justifying automatic enrolment into Personal Accounts or a similar work-place scheme.

In relation to the issue of inertia, it is perhaps surprising that decision making costs are rarely included in analytical contexts like the one considered here, despite the influence that such costs are likely to have on savings behaviour in practice.[31] One possible

[31] There are, of course, exceptions. See, for example, Stigler (1961) and Sargent (1993).

explanation for the omission is the "infinite regression problem": in order to determine whether to incur the costs involved in making some decision, it is necessary to compare those costs against the anticipated benefits of making the decision, and those benefits can only be understood if the computations necessary in making the decision are undertaken.[32] However, in order to provide a practical indication of the effects of decision-making costs we short-cut these very real problems by exploring the effects of imposing a fixed £500 charge (measured in 2005 money but rising over time in line with wages) upon making the first contribution to a low-cost pension. This charge can be viewed as a cost of inertia or information gathering associated with saving in a pension. As one of the main rationales for the auto-enrolment feature of Personal Accounts (under the Pensions Act 2008) is the idea that the policy will help reduce inertia and decision-making costs for savers, the simulation presented here (which looks at the effect of removing this charge) can be very loosely interpreted as one of auto-enrolment of a low-cost pension scheme. This may not indicate the effects of decision-making costs fully satisfactorily, but it does indicate what might happen if potential participants face very real burdens in coming to decisions and these burdens can be reduced to an illustrative monetary value. A more general consideration of decision making costs is beyond the scope of the model considered here.[33]

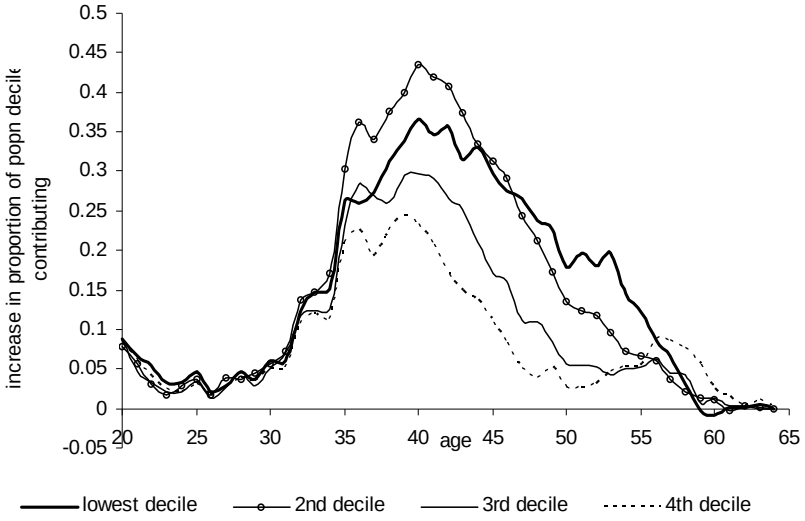
When comparing the results from the simulation with transactions costs to results from the simulation with auto-enrolment (no transactions costs) we find that the effects of auto-enrolment are substantial. Among all income and age groups, participation increases. However, the biggest increases are seen among those aged 35-50 years. Among relatively low income groups, participation increases by around 25%-45%. The remaining effects follow the usual pattern. The higher saving in pensions induced by the policy generates higher lifetime wealth and consumption, most of which is enjoyed in later life. Wealth increases among households in the lowest income quintile on average around £5,000-£10,000 at age 60.

[32] See, for example, Gigerenzer & Selten (2002), p. 5.

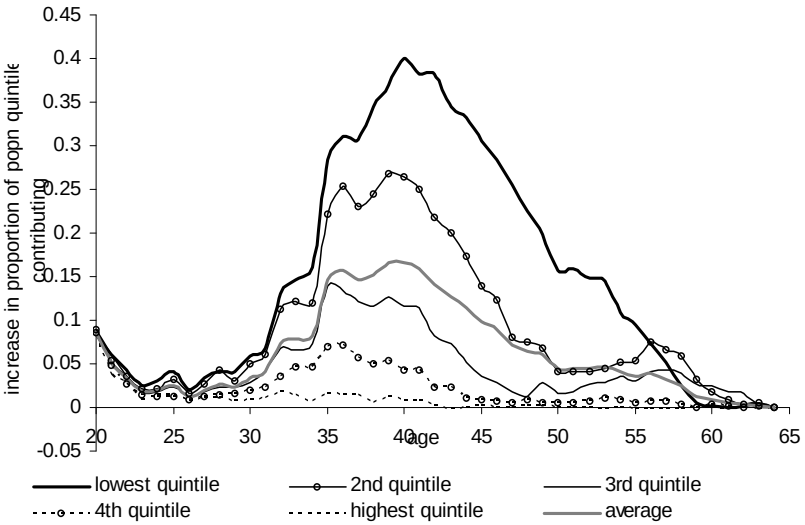
[33] The model does, however, also permit the user to consider the effects of imposing a variable cost on decisions to contribute at a rate different from an exogenously specified 'default rate'.

The current discussion considers the effects of the penalty, of introducing transactions costs, on (i) contribution rates, (ii) accrued wealth, and (iii) consumption over the life course. Statistics relating to these three are reported in Figure 8-5 to Figure 8-7. The results are presented as the effects of removing the transactions costs, which appear on the base case for this section.

**Figure 8-5 Rise in participation rates in low-cost pensions on omitting a £500 one-off opening fee by age and life-time income- full population. Negative numbers indicate fall in participation.**

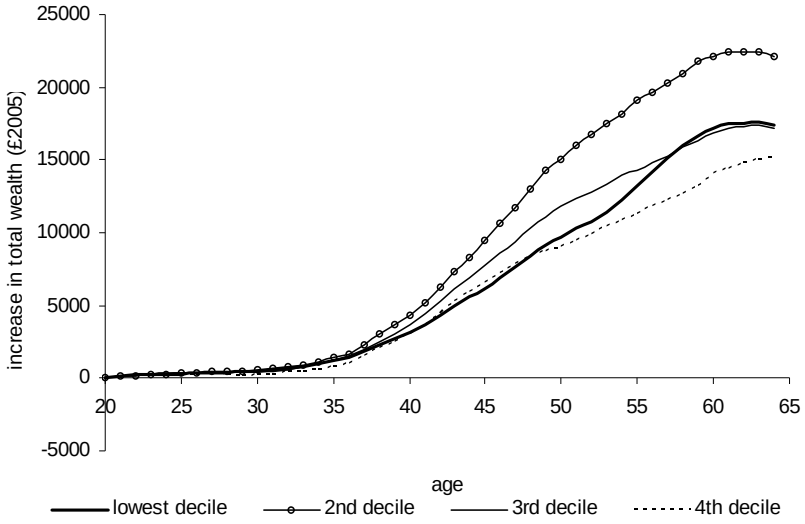



Panel A: bottom four income deciles

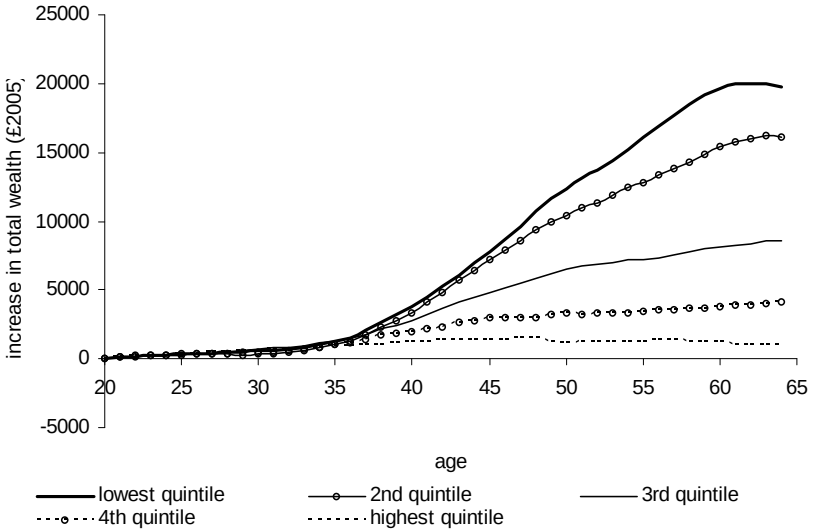



Panel B: full population by income quintile

**Figure 8-6 The effect of removing a £500 one-off opening fee on accrued wealth by age and life-time income- full population. Negative numbers indicate decline in wealth**




Panel A: bottom four income deciles

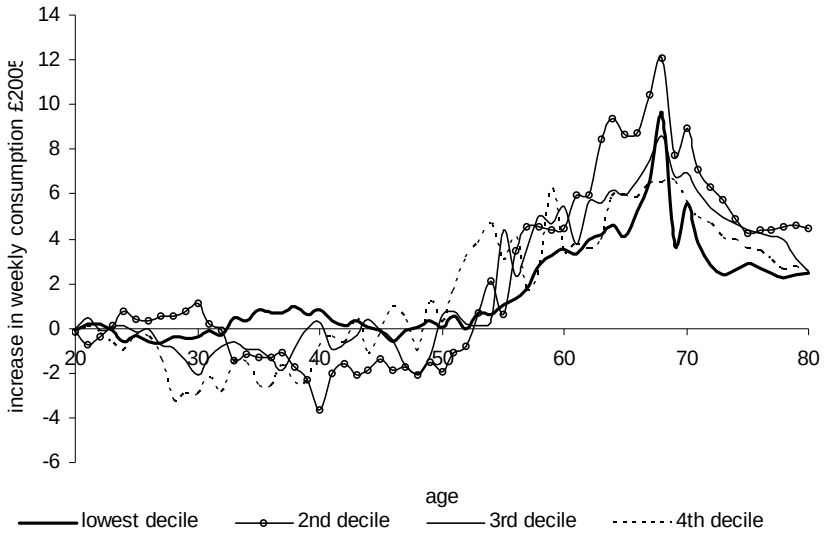



Panel B: full population by income quintile

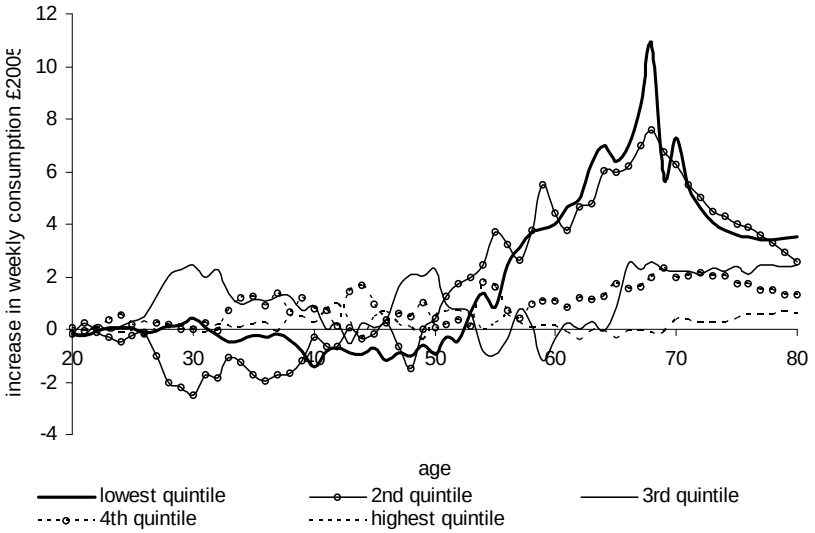
These show the increase in the variables presented in the absence of transactions costs relative to their presence and therefore do not show participation, wealth or consumption over and above that already identified earlier.

The single most striking impression made by these three figures is the substantial impact that the assumed transaction cost has on households in the lowest income deciles. Rates of participation in low-cost pensions are decimated amongst households with the lowest incomes, which results in a fall in total wealth about retirement that is more than fifty times the value assumed for the fixed cost incurred when choosing to participate. Although affected households are able to finance higher consumption during the working lifetime, the reduced wealth produces a sharp fall in consumption during retirement. Higher income households, by contrast, are virtually unaffected by the transaction cost considered. The implications of these results are therefore that policies to minimise enrolment costs can have important influences on the participation of low-income people in low-cost pensions and then on their subsequent consumption possibilities. Similar conclusions can probably be drawn about the effects of policies to offset possible inertia.

**Figure 8-7 The rise in consumption resulting from omitting a £500 one-off opening fee for low-cost pensions- full population. Negative numbers indicate fall in consumption**




Panel A: bottom four income deciles




Panel B: full population by income quintile

## *8.3 Impatience and Low-cost Pensions*

Throughout the analyses that are reported above, preferences are time consistent, in the sense that an individual is assumed to make their decisions today safe in the knowledge that they will make decisions in the future that they would approve of today. This analytical framework rules out the possibility of myopic behaviour to which the Pensions

Commission also referred when it outlined the reasons why a system of low-cost pensions and automatic enrolment was needed.[34]

In relation to behavioural myopia, a growing research effort has explored the implications of adopting a time-inconsistent preference structure. Much of this work is based upon the assumption of quasi-hyperbolic discounting, following Laibson (1997).[35] Modelling quasi-hyperbolic discounting is beyond the scope of the current work. However, as the model is able to handle different user-defined discount rates, we conduct a sensitivity analysis to illustrate the effects of differing time-preference rates, increasing the discount rate from 2.5% per annum, to 4% per annum.[36]

Figure 8-8 to Figure 8-10 report statistics relating, respectively, to participation rates, accrued wealth, and consumption. The careful reader may note a passing resemblance in mirror-image between the profiles reported here, and those reported in respect of higher rates of investment return to low-cost pensions. This observation arises because the two issues — investment returns and rate of time discounting — are intimately related in the behavioural model upon which the simulations are based.

Increased impatience implies that households are biased towards current consumption and are less inclined to delay consumption today, in return for increased consumption tomorrow. In this respect the statistics reported in Figure 8-8 to Figure 8-10 are hardly surprising. What is of interest with regard to the statistics reported here is the scale of the effects consequent on a 1.5% p.a. increase in the assumed discount rate. As one would expect, the more impatient households become in the model, the less likely they are generally to save and in particular to lock away money in a pension. The biggest effect from this can be seen in the decisions of the households in the lowest two income quintiles, who reduce their participation in pensions in between ages 30-40 by around 30%. Levels of household wealth and consumption also predictably fall over the lifecycle, due to the fall in savings. This provides a useful lesson for saving policy

[34] See, for example, Pensions Commission (2004), pp. 208-209. It is interesting to note that myopia is not also discussed in the 2006 DWP White Paper Personal Accounts: a new way to save, see p. 50.

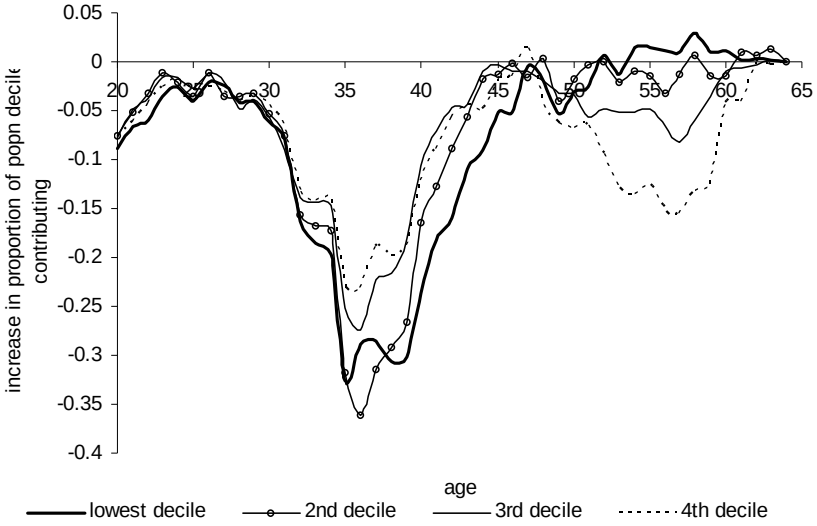
[35] On recent advances in this field, see, for example, Laibson, Repetto & Tobacman (2007) and Fang & Silverman (2007).

[36] As a trailer for future work, we hope to include quasi-hyperbolic in the model, sometime in the near future.

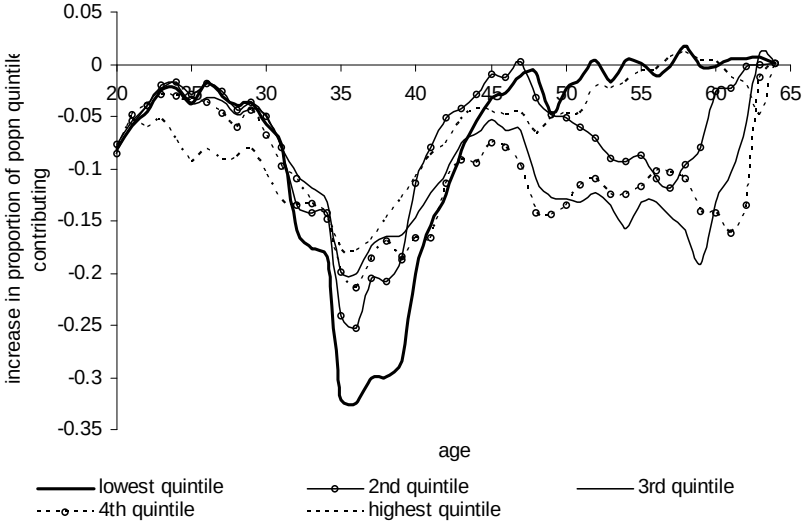
development, as it suggests that solutions based on reducing household myopia could help boost long-term saving.

Figure 8-8 indicates that the increased impatience considered here has a pronounced impact on contribution rates, particularly among lower income households that have the weakest a priori saving incentives. At its peak around age 35, the increase considered for the discount rate reduces participation by over 30% among households in the lowest two income deciles. It is interesting to note that these effects are comparable in magnitude to those generated due to the transaction costs that are reported in the preceding section, particularly in the case of the second lowest income decile. This is also approximately twice the peak effect on participation rates among households in the top income quintile.

**Figure 8-8 The effect of a discount rate of 4% p.a. rather than 2.5% p.a. on participation rates in low-cost pensions by age and life-time income- total population. Negative entries indicate declining participation.**




Panel A: bottom four income deciles

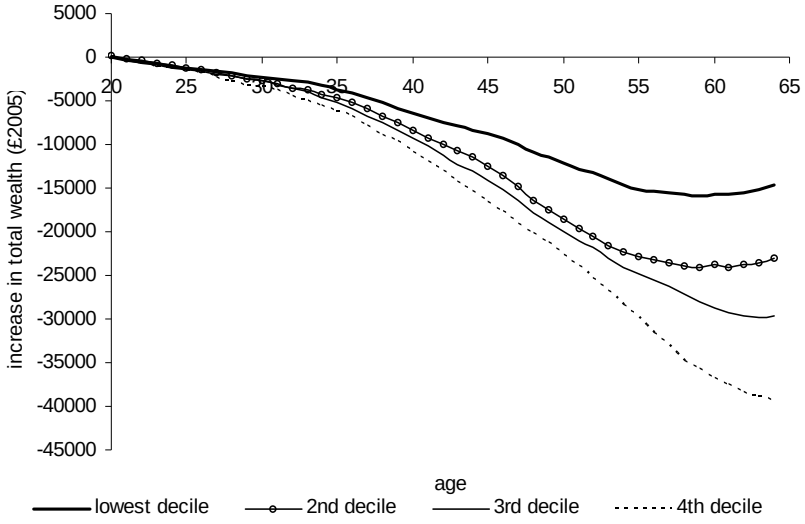



Panel B: full population by income quintile

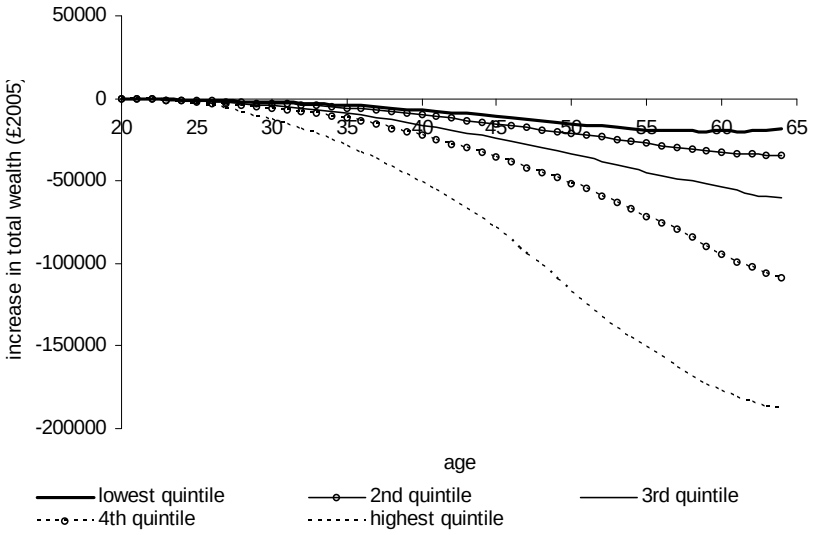
Comparing Figure 8-9 and Figure 8-3 indicates that the 1.5% increase considered here for the discount rate reduces wealth accumulation of low-income households by approximately twice the absolute size of the increases reported in response to a 0.5% rise in the rate of return to savings in low-cost pensions. For high-income households the effect is larger still, at over three times.

The effects of reduced incentives to save on household consumption are reported in Figure 8-10. This figure reveals that households in the lowest four income deciles tend to reduce their consumption throughout the simulated lifetime when the value they place on the future declines. This is primarily because an increased preference for immediate consumption weakens labour market participation, resulting in lower lifetime disposable income. This impact on labour supply is less acute for households higher up the income distribution. Households in the top two income quintiles are consequently observed in Panel B of the figure to increase their consumption substantially between ages 20 and 40, rather than to take increased leisure.

**Figure 8-9 The effect of an increase in the discount rate from 2.5% p.a. to 4% p.a. on accrued wealth by age and life-time income- full population. Negative numbers indicate decline in wealth.**

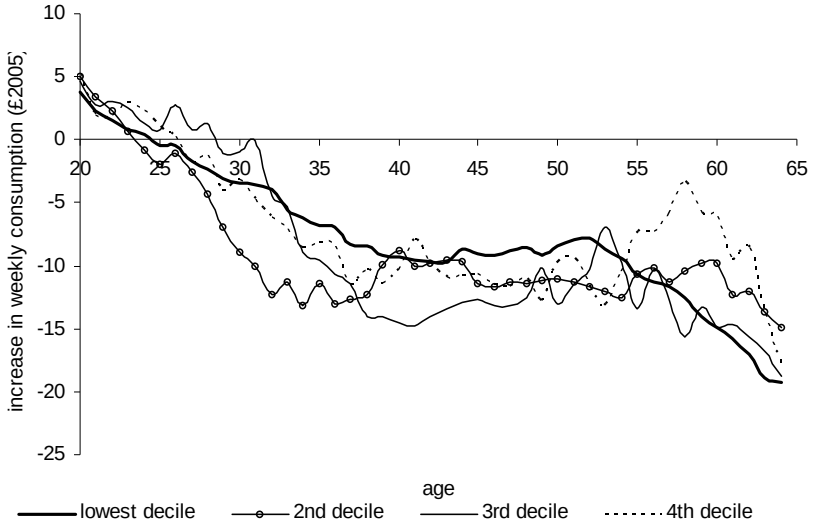



Panel A: bottom four income deciles

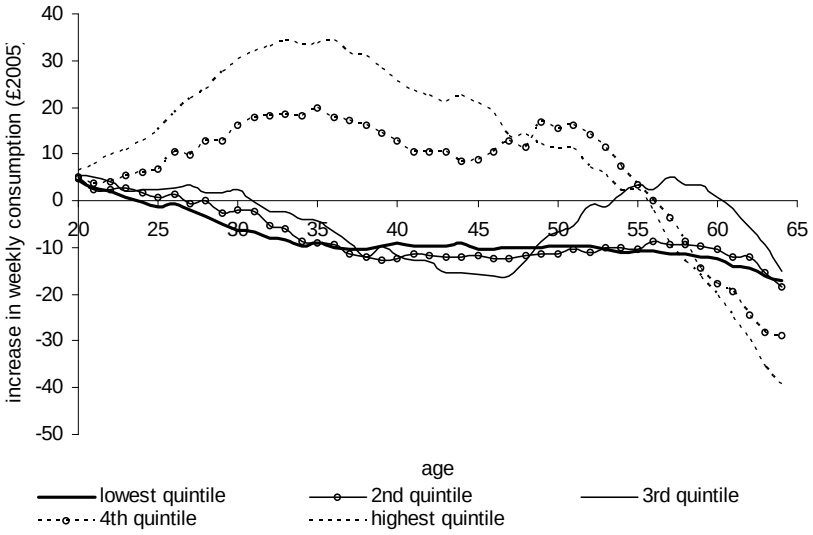



Panel B: full population by income quintile

**Figure 8-10 The increase in consumption resulting from an increase in the discount rate from 2.5% to 4% by age and life-time income- full population.**




Panel A: bottom four income deciles




Panel B: full population by income quintile

# 9 Changes to Income Tax Rates

The 2007 Budget announced a range of changes to personal income taxation and National Insurance contributions. Among them, two significant changes were the removal of the lower rate 10% income tax band, and a reduction in the basic rate of tax from 22% to 20%. Changes were also made to tax and NICs thresholds, however for simplicity we have not included these aspects of the Budget in the following simulation. The simulation cannot therefore be taken to represent the later package of reforms in full, but merely provides a demonstration of how changes in marginal tax rates impact in the model.

The changes to income tax rates imply a revised income tax system consisting of three marginal rates: 0% up to an individual's "Personal Allowance", 20% between the Personal Allowance and the higher tax rate threshold, and 40% thereafter. This Chapter shows how the National Institute Tax and Benefit Model can be used to explore the effects of these changes to the tax system. Our analysis focuses on what happens to households ranked in terms of their life-time incomes. The use of life-time income is more satisfactory than the use of actual income in any year because households can have low incomes in one year and high incomes in another year. Life-time income allows us to identify the people who are, on average, worse off or better off over their lives.

The change in household incomes is broadly consistent with the government's own published analysis of the Budget 2008 package produced at the time of the announcement. A relatively small number of households who previously paid income tax at the 10p marginal rate are worse off over a small band of income, whilst most basic rate taxpayers gain from the tax change. The simulation also shows higher rate taxpayers gaining from the tax change, although in actual fact these gains were largely offset by changes announced to National Insurance contributions at the Budget 2008.

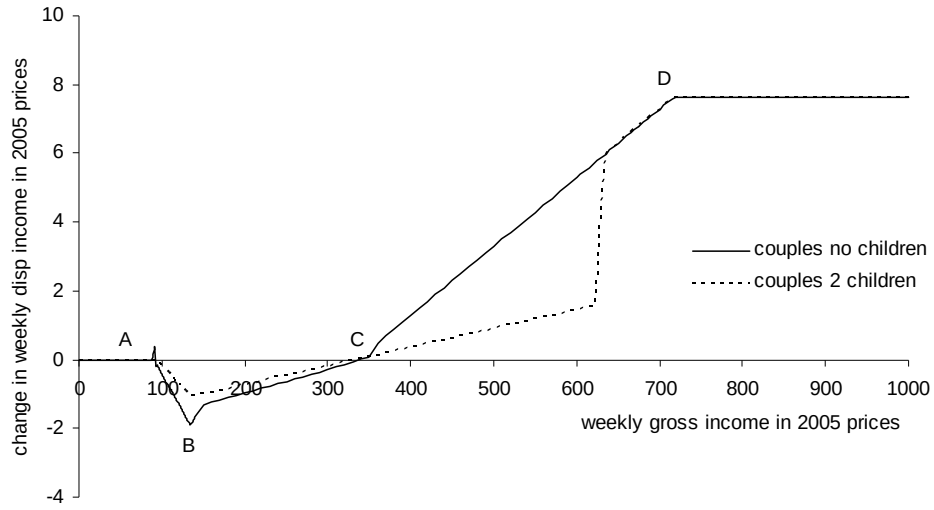
The Chapter begins by describing the influence of the policy change in further detail, before presenting associated simulated behavioural responses.

## *9.1 Income Tax Changes and Tax/Benefit Schedules*

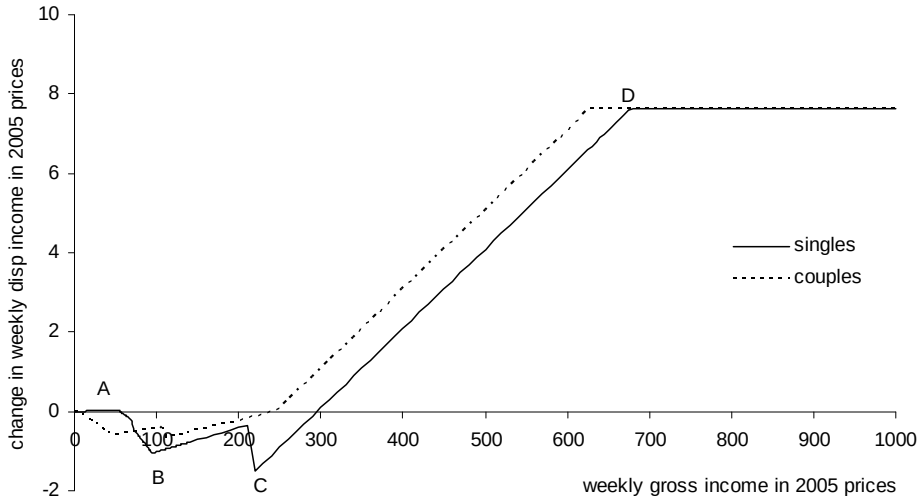
The change in tax rates explored has a very similar impact on the tax and benefit schedules of all household demographic types. Examples for working aged couples and

retired households are reported in Figure 9-1. The tax change has no effect on household disposable income before the Personal Allowance threshold, at which the lower rate of income tax was payable prior to the policy reform. This point is denoted A in the two panels of Figure 9-1, where reference is made to singles in the lower panel of the figure. Between the Personal Allowance and the threshold at which the basic rate of tax was payable prior to the reform (B in the figure), the tax burden increases steadily under the revised system. This reflects the effect of increasing the associated rate of income tax from 10% to 20%. The extent of the increase is influenced by the incidence of welfare benefits, which take into consideration household demographics.

**Figure 9-1 Impact of Policy Change on Tax and Benefit Schedules by Household Type**




Panel A: working age couples




Panel B: households over pension age

As household private income exceeds the basic tax threshold (B), the tax burden imposed by the reformed system tends to fall, relative to the system prior to the reform, until the threshold at which the higher rate of income tax is payable(denoted D in the figure). This reflects the effect of reducing the basic rate of tax from 22% to 20%. There are some "wobbles" at intermediate levels of private income (between B and D — e.g. C), which are principally attributable to the effects of housing benefits.

Regarding the figure as a whole, it can be seen that the largest losses incurred by households on low incomes tend to be approximately one quarter the value of the gains enjoyed by higher income households. Furthermore, financial losses as a result of the policy change are limited to a small band of private income, relative to the range of private incomes over which individuals gain. The break-even point of private income is between £200 and £300 per week. In this regard, it is of note that the (geometric) mean income of all employed households during the working lifetime is £575 per week in the simulations, and median income during the simulated retired lifetime is £150 per week.

## *9.2 Effects on Behaviour*

### 9.2.1 Consumption

**Figure 9-2 The increase in consumption resulting from the abolition of the low rate of income tax and setting the standard rate to 20p by age and life-time income quintile**

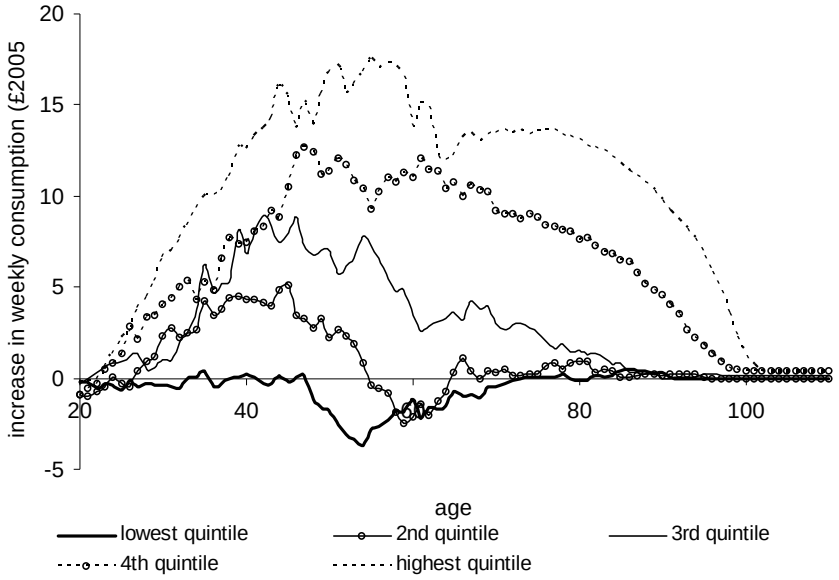



Figure 9-2 reports the effects of the tax change on average consumption, by age and lifetime income quintile. The statistics reported in the figure quantify the practical implications of the policy change described above for households of different financial circumstances. The poorest households — those in the bottom lifetime income quintile — consume less throughout the simulated lifetime, in response to the higher taxes that are payable due to removal of the lower rate of income tax. In response to these changes in

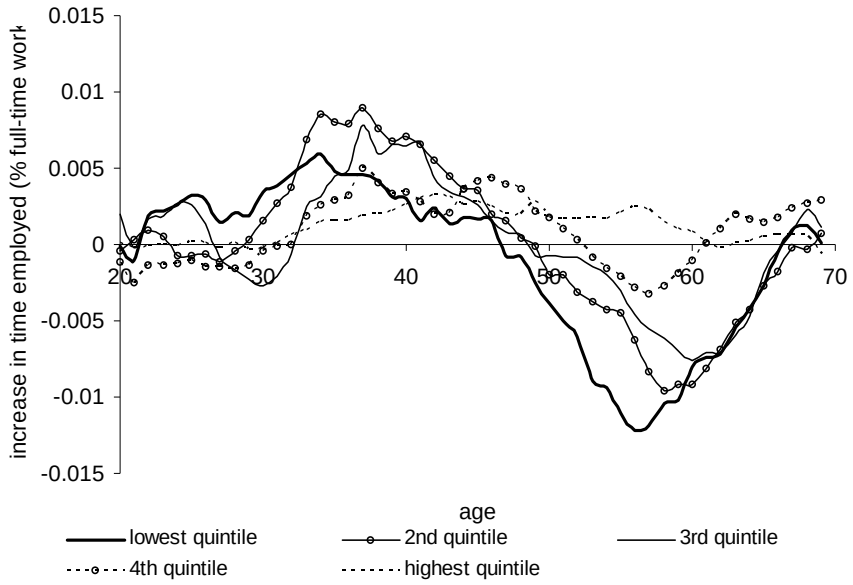
income, households in the bottom quintile tend to reduce consumption by around 1%-3% over their lifetime.

Households on higher incomes, in contrast, benefit from an increase in weekly consumption (£2005) and a coincident reduction in the basic rate of tax. At the peak during ages 40-50, households in the top quintile increase consumption by around 10%-15%. Indeed, it is of note that the consumption gains enjoyed by higher income households are much larger than the consumption losses suffered by households in the lowest income quintile, a result that relates closely to the altered tax schedules that are described above.

### 9.2.2 Labour Supply

Figure 9-3 reports the impact of the tax change on labour supply. The effect of the change in the basic rate, leads to slightly higher labour market participation between ages 30-50 years. This is offset by early retirement effects which show up as a reduction in post-retirement labour market participation. As the change in marginal tax rates is small, the simulated statistics considered for analysis exhibited significant variation, indicative of a marginal behavioural response. Despite the temporal sensitivity of the simulated results obtained, the five point moving averages by age reported in the figure reflect some interesting incentive effects.

**Figure 9-3 The effect on labour supply of removing the low rate of income tax and reducing the standard rate to 20p by age and life-time income quintile**



The statistics reported in Figure 9-3 indicate that the tax changes tend to encourage more labour supply before age 50, and — except for households in the top income quintile — earlier retirement. In spite of the similarities between the labour supply responses of different income quintiles that are reported in Figure 9-3, however, the underlying incentives vary in important ways between the various income subgroups. Households in the lowest income quintile have less disposable income as a result of the policy change, which tends to increase labour market participation. On the other hand, households in the lowest income quintile tend to receive a lower return from working, which tends to discourage labour market participation. A similar pattern is seen for households in the next three quintiles, although the labour supply of people in the fourth quintile is raised beyond the age of 61. For people in the top quintile the effects of the incentive to work dominate, and labour supply increases at all ages. This conclusion is driven by the parameterisation of the model-the choice of the elasticity of substitution between work and leisure, the "price" of leisure and the intertemporal elasticity of substitution. Model users are able to explore the sensitivity of the outcome to these parameters.

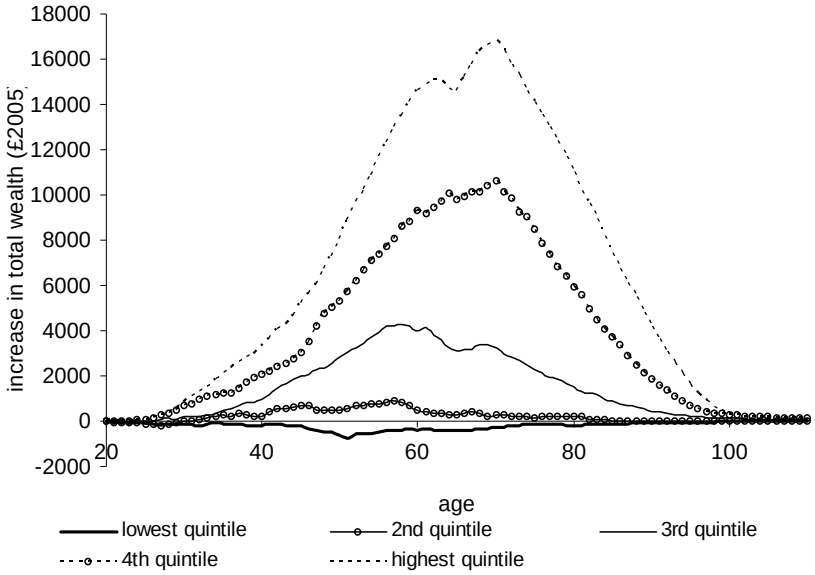
### 9.2.3 Total Saving

The effects of the policy change on total household savings are reported in Figure 9-4. As household incomes change, so do saving patterns. The poorest 20% of households save slightly less as a result of the policy change. Further up the income scale, households generally save more over their lifetime due to the higher disposable incomes generated by the policy. However, given that the reduction in the basic rate of income tax also means less tax relief on pension contributions, there is a small shift of saving from pensions to non-pension products.

This figure indicates that households in the highest four income quintiles tend to save more in aggregate as a result of the policy change, with only the bottom quintile saving less. The largest increase in savings is observed for the highest income quintile, who save approximately £14,500 more at about age 65, equivalent to a 1.6% increase in their saving prior to the policy change. The lowest quintile reduces saving by £400 or 1.3% of saving before the policy change. The increase in average household savings at age 65 is £5500, or an increase of 1.7% of its initial value. Nevertheless, throughout the above discussion it is important to bear in mind the tax changes simulated are not budget neutral

(the accompanying changes in tax and National Insurance contributions thresholds in Budget 2007 have not been modelled) with the additional benefits enjoyed by higher income households being larger than the costs imposed on lower income households.

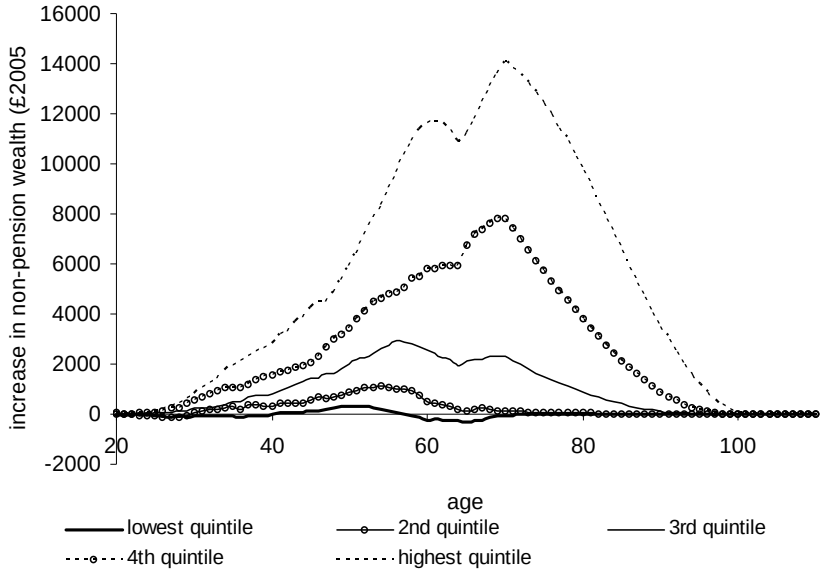
**Figure 9-4 The increase in total saving resulting from removing the low rate of income tax and reducing the standard rate to 20p by age and life-time income quintile**




## 9.2.4 Non-pension Saving

Nevertheless the distinction between pension and non-pension saving is of considerable interest. Figure 9-5 indicates that households in all but the lowest population quintile tend to increase their non-pension saving in response to the change in income tax rates. In the case of households in the highest population quintile, the increase in saving is equal to approximately £11,300 at age 65. Average saving rose by just over £4000 at age 60.

**Figure 9-5 The increase in non-pension saving resulting from removing the low rate of income tax and reducing the standard rate to 20p by age and life-time income quintile**

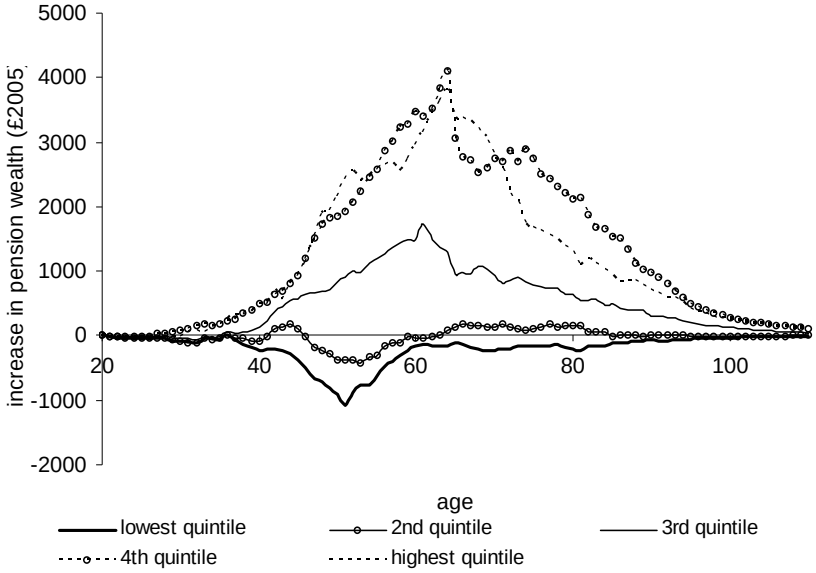



## 9.2.5 Pension Saving

The increases observed for non-pension wealth are partially the result of substitution out of pension funds in response to the weaker tax incentives following the policy change. The scale of this substitution is reported in Figure 9-6 which shows how the lowest quintile reduces its pension saving as a result of the tax change. The top three quintiles plainly increase their saving, while the pension saving of the second quintile is reduced between the ages of 45 and 60 but otherwise not much affected. Since people receive tax relief on pension contributions at their marginal tax rate while of working age, the tax change increases the benefits of pension saving to people who pay 40% tax while of working age, but reduces it to those who paid basic rate tax before the change but expected to pay tax at only 10% on a significant proportion of their pension income after retirement. These incentive effects are superimposed on the income effects -relatively high earners benefit more from the changes than low earners-and they tend to amplify them. However, the apparent tax benefits to high tax payers are abated by the fact that, in our model, tax thresholds are indexed to wages while pension income is constant in real terms. This means that late in life most pensioners find themselves paying only low rate tax. Since for all the quintiles for which wealth increases (quintiles two to five) pension

wealth increases less than in proportion to total wealth. The reduction in the basic rate raises most people's incomes during their working lives and this should be expected to raise pension saving. But a part of the incentive was that people received relief at basic or high rate and paid only low rate tax on a part of their pension. With the abolition of low rate tax this extra incentive to save in pension schemes is removed. Thus for quintiles two to five pension wealth increases but less than in proportion to total wealth. This result would probably be very different if tax thresholds were indexed to prices rather than wages, so that the simulations were affected by fiscal drag.

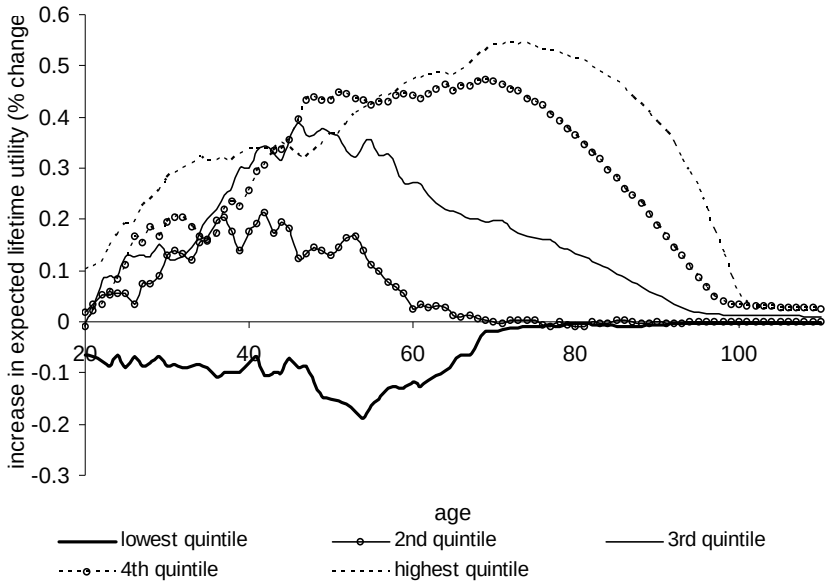
**Figure 9-6 The increase in pension saving resulting from removing the low rate of income tax and reducing the standard rate to 20p by age and life-time income**




## *9.3 Welfare*

The welfare effects of the policy change are reported in Figure 9-7. Consistent with the above discussion, Figure 9-7 indicates the extent to which lower income households lose out, and higher income households gain as a result of the policy change. The benefits to high income households decline with age, first because the households tend to spend their increased non-pension wealth and secondly because, as discussed above, nearly all households eventually face higher tax bills as a result of the change. This result, which seems surprising on the face of it, arises because we assume that tax brackets are indexed to wages whereas pensions pay amounts which are fixed in real terms. This means that someone who retires with what seems to be a high pension at the age of 65 is likely to find themselves only a low rate tax-payer in extreme old age.

**Figure 9-7 The increase in expected life-time utility resulting from removing the low rate of income tax and reducing the standard rate to 20p by age and life-time income quintile**



# 10 Implications of High Life Expectancy

Life expectancy is an important consideration that underlies planning decisions for both individuals and governments. In recent years increasing life expectancy has added to concerns regarding the sustainability of pension arrangements. In this Chapter we consider the influence of alternative assumptions regarding life-expectancy on decision making at the household level.

The analysis focuses upon comparisons between two simulated populations that differ only in terms of the assumed mortality rates. In the first, households are considered to assume the period (or cross-section) mortality rates observed for 2005 in planning for the future. This might be taken as a naive basis for life-expectancy, given the persistent downward trend that is evident in historical data for mortality rates. In the second scenario, households are consequently assumed to base their decisions on the expectation of mortality rates described by current official projections for the cohort aged 20 in 2005, which take into account contemporary trends in life expectancy. Hence, the population simulated on the basis of period mortality rates anticipates a shorter life-expectancy, relative to the one simulated on the basis of official projections for cohort specific mortality. The analysis is concerned with identifying how far behaviour would be affected if the population were to base their decisions on alternative — and arguably, extreme — assumptions regarding life expectancy.

The current Chapter begins by describing these alternative assumptions in further detail, before presenting associated behavioural and welfare effects.

## *10.1 Alternative Assumptions for Age Specific Mortality*

All of the profiles for life expectancy that are used were calculated from historical mortality rates for 1981 to 2006, and assumed calendar year mortality rates from the 2006 - based principal projections produced by the Office for National Statistics. Household probabilities of mortality were calculated from data for men and women to reflect the circumstances of a same-aged couple.

The ONS data enable probabilities to be calculated to age 94. A manual adjustment was applied from that age to ensure death by age 110 for the schedule of period mortality rates. Projections for the cohort mortality rates beyond age 94 were derived from the period mortality rates as follows. The cohort mortality rate reported at age 94 for the population aged 20 in 2005 is 7.1%. This is closest to the period mortality rate observed for age 86. Hence, the cohort mortality rate for age 96 was taken as the period mortality rate for age 87, and so on for higher ages.

**Table 10-1 Cohort and Period Mortality Rates**

| age | Period Mortality | Cohort Mortality | age | Period Mortality | Cohort Mortality |
|---|---|---|---|---|---|
| 60 | 0.0011 | 0.0004 | 90 | 0.1269 | 0.0429 |
| 61 | 0.0015 | 0.0006 | 91 | 0.1438 | 0.0463 |
| 62 | 0.0018 | 0.0006 | 92 | 0.1598 | 0.0527 |
| 63 | 0.0011 | 0.0007 | 93 | 0.1645 | 0.0435 |
| 64 | 0.0022 | 0.0011 | 94 | 0.1900 | 0.0716 |
| 65 | 0.0024 | 0.0008 | 95 | 0.2500 | 0.1020 |
| 66 | 0.0027 | 0.0013 | 96 | 0.2948 | 0.1348 |
| 67 | 0.0038 | 0.0010 | 97 | 0.3433 | 0.1702 |
| 68 | 0.0050 | 0.0016 | 98 | 0.3956 | 0.2086 |
| 69 | 0.0057 | 0.0012 | 99 | 0.4522 | 0.2500 |
| 70 | 0.0065 | 0.0023 | 100 | 0.5134 | 0.2948 |
| 71 | 0.0074 | 0.0021 | 101 | 0.5796 | 0.3433 |
| 72 | 0.0094 | 0.0028 | 102 | 0.6511 | 0.3956 |
| 73 | 0.0112 | 0.0031 | 103 | 0.7284 | 0.4522 |
| 74 | 0.0108 | 0.0032 | 104 | 0.8120 | 0.5134 |
| 75 | 0.0158 | 0.0052 | 105 | 0.9023 | 0.5796 |
| 76 | 0.0180 | 0.0033 | 106 | 1.0000 | 0.6511 |
| 77 | 0.0203 | 0.0052 | 107 | | 0.7284 |
| 78 | 0.0281 | 0.0065 | 108 | | 0.8120 |
| 79 | 0.0293 | 0.0072 | 109 | | 0.9023 |
| 80 | 0.0317 | 0.0069 | 110 | | 1.0000 |
| 81 | 0.0399 | 0.0098 | | | |
| 82 | 0.0446 | 0.0110 | | | |
| 83 | 0.0499 | 0.0101 | | | |
| 84 | 0.0656 | 0.0149 | | | |
| 85 | 0.0602 | 0.0191 | | | |
| 86 | 0.0797 | 0.0163 | | | |
| 87 | 0.0942 | 0.0169 | | | |
| 88 | 0.1075 | 0.0201 | | | |
| 89 | 0.1128 | 0.0343 | | | |

Source: Author calculations using ONS life expectancy data

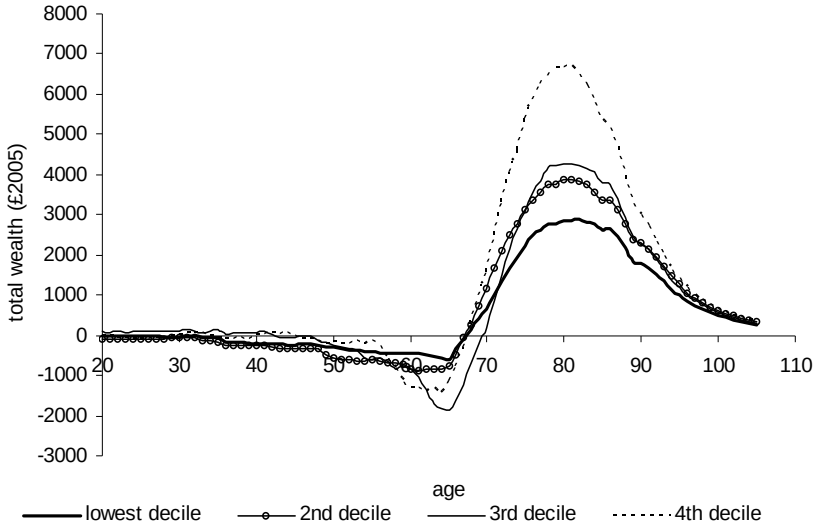
Table 10-1 reports the age specific mortality probabilities associated with the two scenarios studied. This table indicates that the period mortality rates substantially

overstate the cohort mortality rates throughout the simulated lifetime, reflecting the strong improvements in life-expectancy that are implicit in official projections for the coming decades. In aggregate, the period mortality rates imply a (household) life expectancy of 87.8 years, and the cohort mortality rates imply a life expectancy of 96.4 years. Thus, households simulated under the cohort rates expect to live for almost a decade longer than those simulated under the period rates.

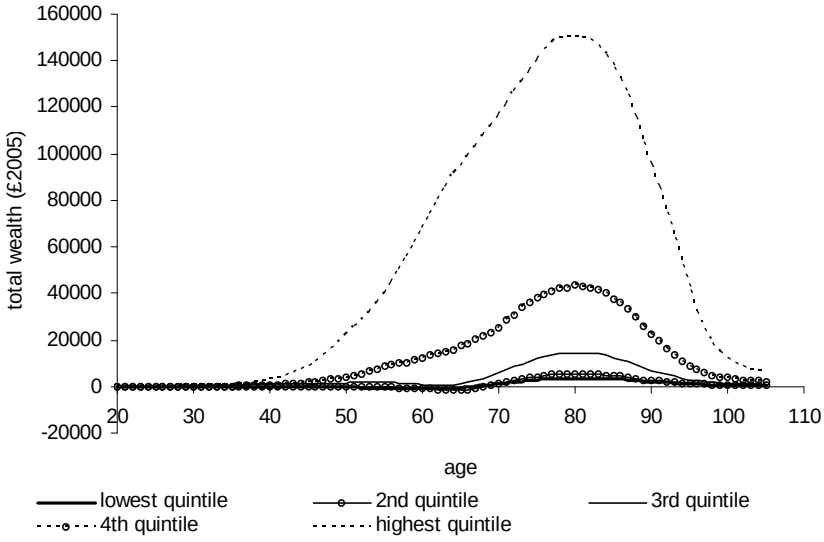
## *10.2 The Impact of Life Expectancy on Behaviour*

The statistics reported in Figure 10-1 show that, for the top two quintiles, wealth holdings are increased except early in working life. People in these categories save more for their retirement as would be expected. The wealth holding of the top quintile rises by 11.8% at age 65 and the average wealth holding in the economy is increased by 7.6%. The wealth holding of the middle quintile is little changed, although higher wealth holdings after retirement show that wealth is decumulated slightly less rapidly. But wealth holding by people in the four bottom income deciles is discouraged by the increase in life expectancy, contrary to what would be expected. The explanation of this is once again the interaction between their savings and means testing. With means testing thresholds indexed to wages, the fact that increased life expectancy reduces annuity income means that incentives to save for retirement are actually reduced. The drop in wealth held at age 65 amounts to 2-3% of wealth for people in the four bottom income deciles. Beyond age 65-70 the wealth of these groups is higher than in the base run. As with higher income people, this reflects the fact that wealth is decumulated more slowly when the population is longer-lived.

**Figure 10-1 Increase in accrued wealth of households which plan for cohort rather than period mortality by age and life-time income- full population**




Panel A: bottom four income deciles

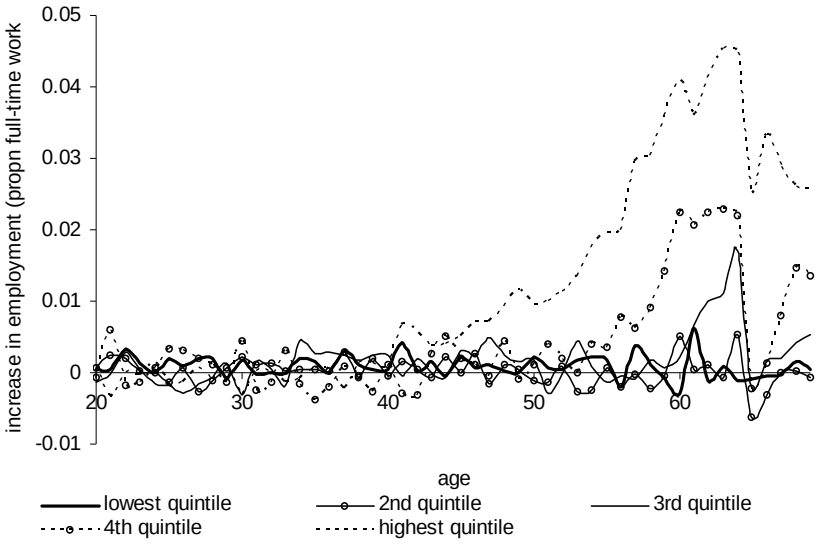



Panel B: population by income quintile

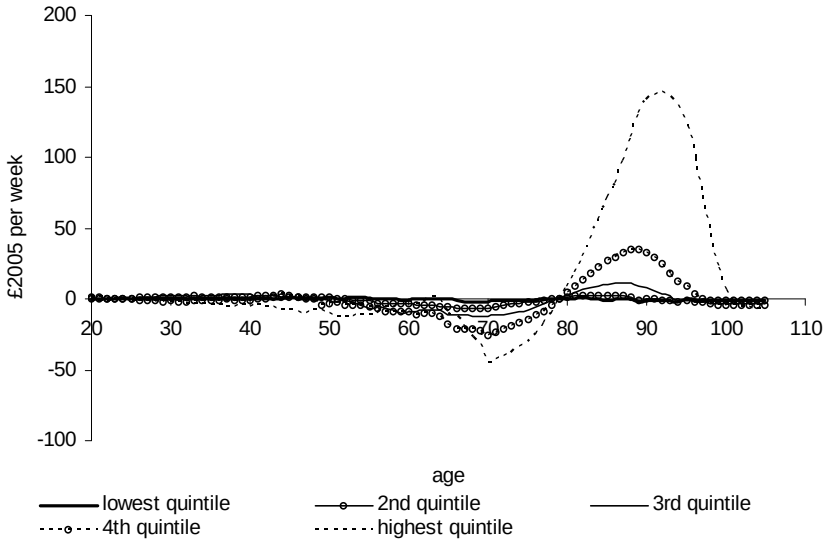
The additional savings reported in Figure 10-1 are financed by increased labour supply and lower consumption of the fourth and fifth quintiles. Consumption levels also tend to be reduced immediately after retirement. However, because people plan for a longer period of retirement, they eventually overtake the consumption paths chosen by people with low life expectancy**.** For those households that do work longer and save more, the

benefits are evident in terms of sustained consumption during the extra years of retirement. However, consumption during early retirement also takes a hit. Beyond the age of eighty consumption passes above the base run figures, falling back to them only in extreme old age when non-pension wealth is exhausted The point which emerges from this is that, although people know they are going to live longer, they are not prepared to offset the effect of this on their consumption fully by supplying more labour to build up their savings when younger. Households are not willing to give up leisure and consumption excessively during their working lives but rather choose to make sacrifices over a longer period. For the top two quintiles, leisure is reduced but not by enough to offset fully the decline in consumption which they face. For the lower quintiles the calculations are, as we have explained, complicated by the workings of means testing, making them even less keen to provide for a longer period of retirement.

**Figure 10-2 Increase in labour supply and consumption of households which expect cohort rather than period mortality rates by age and life-time income**




Panel A: effects on labour supply*




Panel B: effects on consumption

** effects on labour supply measured as percentages of the labour supply simulated using the period mortality probabilities*

# 11 Conclusion and Directions for Further Research

This report describes a model of behaviour in the context of uncertainty that has been developed to explore issues regarding household savings, labour supply, and asset allocation. The model has been specifically designed to be operated by practitioners with relatively limited technical knowledge - it runs entirely in EXCEL so that no programming knowledge is needed – and only requires a basic grasp of utility theory (i.e. income and substitution effects, inter-temporal preferences and their relationship with risk aversion etc). As the latter can easily be acquired from any good undergraduate micro-economic text book, we trust that the model will serve as a useful tool for practical evidence-based policy-making. A separate manual National Institute (2008) is available describing the operation of the model.

At the same time, the model is an advanced tool in the sense that the dynamic programming approach upon which it is based features in a range of contemporary articles in first-tier economic journals. Until now, the approach has remained the providence of economic specialists, if only because of the massive programming effort that is required in order to produce a working model. Our hope is that our current efforts will ultimately help to extend the user base of such techniques to non-specialists, and in doing so facilitate a wider understanding of their advantages as well as their limitations.

Looking forward, we recognise that the model is currently based upon a number of key assumptions that could be relaxed by further modifications. Specifically, the current version of the model assumes that intertemporal preferences are time consistent, and that there are no decision making costs in evaluating potential alternatives. Recent policy debate in the UK has, however, emphasised the importance of behavioural inertia and myopia. The issue of myopia has received extensive attention in the contemporary literature — see, for example, Laibson (1997), Diamond & Köszegi (2003), and particularly Laibson et al. (2007) and Fang & Silverman (2007) for current best practice — and is a natural consideration for development of the model in the future.

Behavioural inertia can be attributed to the existence of non-trivial decision making costs, and although this issue is intimately related to the burgeoning theory of bounded rationality (Simon (1957)), “very few explicit models of deliberation technology and

deliberation cost have appeared" (Conlisk (1996), p. 682). The most obvious way to address this issue within the context of a model such as this is to consider optimisation subject to constraints (Sargent (1993)). Failure to take up this challenge may be attributed to a number of factors, not least of which is the fact that the dynamic programming approach is only starting to gain momentum in main-stream economic research.

Alternatively — and more substantively — the unobservable nature of decision making costs complicates their inclusion in a model like the one described here. Furthermore, it is possible to argue that the existence of decision making costs should imply simpler decision-making heuristics than embodied by optimisation. This last proposition suggests that decision making costs should imply the use of different decision rules in different decision making contexts, rather than the one-size-fits-all approach embodied by unfettered optimisation (see, for example, Gigerenzer & Selten (2002)). Hence, the proper inclusion of decision making costs in a model such as this is an ambitious task, and is likely to remain a longer term goal.

Projections for behavioural responses to policy reform that are generated with the assumption of perfect and unfettered optimisation are best interpreted as showing the long-term effects of policy changes. Our current research effort is focussed upon improving our understanding of behavioural responses to policy in the shorter term and reflecting these in the model. This essentially involves augmenting the existing model to incorporate insights from the field of 'behavioural economics'. To this end the model has recently been amended to allow for myopic planning behaviour. We also hope to amend the structure to allow for non-trivial decision making costs (incurred when gathering, processing and acting upon information), which is necessary, for example, to capture procrastination. Incorporating these types of issues will improve the model's ability to reflect the immediate effects of policy reform and to address more fully the possibility that people may not be rational long-term planners.

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