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Modelling myopic responses to policy: an enhancement to the NIBAX model

by Justin van de Ven and Martin Weale

DWP Department for Work and Pensions

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Glossary

Discount factor	The price of utility enjoyed between two given periods. Related to the discount rate, dr, applied between the periods as: 1 / (1 + dr).
Discount rate	The rate at which utility enjoyed in a prospective period is reduced to reflect the time value of consumption due to impatience. Applies over a given unit of time (e.g. per annum).
Dynamic programming	A numerical approach to solving intertemporal optimisation problems.
Hyperbolic discounting	A form of discounting that applies a continuously higher discount rate in the period between any two prospective periods, as the two periods draw near.
Marginal propensity to consume	The increase in consumption consequent on a £1 increase in disposable income.
Marginal propensity to save	The increase in saving consequent on a £1 increase in disposable income.
Monte Carlo simulation	A method of generating a simulated population that involves taking random draws from well defined probability distributions.
Myopia	Time-inconsistent preferences that exhibit a present bias in consumption.
Naïve myopia	Condition where a consumer has time-inconsistent preferences that exhibit a present bias, but is unaware of their propensity to over-consume.
Sophisticated myopia	Condition where a consumer has time-inconsistent preferences that exhibit a present bias, and is aware of their propensity to over-consume.
NIBAX	A simulation model of household behaviour that has been supplied to the Department for Work and Pensions (DWP) and Her Majesty's Revenue and Customs (HMRC) by the National Institute of Economic and Social Research (NIESR).
Quasi-hyperbolic discounting	A form of discounting that applies a discontinuously higher discount rate to the first prospective period, and then a lower discount rate to all prospective periods, thereby affecting the utility price between any two prospective periods when the nearer of the two is reached.

Term to equivalence	The prospective period over which the discount factors with and without myopia are equal. For the term to equivalence to define a finite period of time in context of quasi-hyperbolic discounting, the annual rate of discount without myopia must fall between the short-run and long-run annual rates of discount applied under myopia. In this case, the term to equivalence defines the period over which the myopic preference relation applies greater impatience than the non-myopic relation.
Utility	The enjoyment that an individual experiences from consuming goods and leisure. Synonym for welfare. A utility function defines preferences between decision alternatives by indicating which alternative offers the highest measure of enjoyment.

Summary

This report describes how myopia was recently introduced into NIBAX, which is a model of behaviour in the context of uncertainty that has been developed to explore issues regarding:

- household savings;
- labour supply; and
- investment decisions.

The modelling framework – NIBAX

NIBAX has been specifically designed to be operated by people with relatively limited technical knowledge and a basic grasp of economic theory. The model runs entirely through Excel, so that no programming is required, and allows for a high degree of flexibility over the policy environment, the decisions that households make, and the preference structure.

The model generates data for the entire life course of a cohort of households strung out over the income/wealth distribution. It is possible to select a range of decisions that households make from a menu that includes:

- consumption/saving;
- labour supply; and
- investment choices between assets with a certain return, risky assets, and illiquid pensions.

NIBAX is based upon the standard economic model of decision making. The model is designed to capture the aversion to risk that people tend to display in practice.

NIBAX has been set up to reflect observations drawn from survey data.

Allowing for myopia

The amendment described in this report now allows for myopia.

In the current context myopia is more than simply impatience; it is a form of time inconsistency that reflects a present-bias in consumption. This implies that a myopic individual will tend to spend more than they would have planned to do, if they could have chosen their current consumption at some previous date.

Importantly, the model is based on the assumption that people are aware of the time inconsistency of their behaviour (so called sophisticated myopia). This implies that people who are myopic are aware that they will tend to over-consume in the future, and that they make their current decisions in light of this tendency. As a consequence of this, the myopia that is considered in the model provides an incentive for people to lock their savings away in term deposits and pension schemes.

Key insights from illustrative simulations

The illustrative simulations indicate that myopia tends to lower labour supply early in life, increase the use of unsecured debt, and delay retirement saving. The last of these effects results in reduced wealth late in the working lifetime, which motivates later retirement amongst myopic consumers.

Including a pension scheme helps to mitigate the behavioural distortions associated with myopia, by enabling individuals to commit savings for retirement. This means that welfare can be improved by the addition of pensions, where the behaviour of consumers is affected by sophisticated myopia. As noted above these responses are observed because people are assumed to be aware of their tendency to over-spend. The beneficial impact of pension schemes would disappear if it were assumed that people were not so self-aware.

The commitment mechanism that is offered by pensions in context of (sophisticated) myopia consequently tends to encourage greater voluntary participation in pension schemes, relative to a non-myopic population.

Looking forward

Procrastination has featured in contemporary policy debate, following survey evidence that decisions are influenced by framing effects.

It is commonly observed, for example, that rates of participation are higher in occupational pensions that auto-enrol new employees. This has recently influenced the move to expand access to employer-sponsored pension schemes from 2012.

It would consequently be useful to augment the current model to allow for procrastination. This would involve adding a decision cost to alternative choices, and allowing for the possibility that people are at least partially unaware of the time inconsistency of their behaviour in context of myopia (so called naïve myopia).

Both of the amendments that are mentioned above are straight-forward to implement, given the existing model structure. And each of the amendments is of potential interest in its own right.

Assuming that myopic individuals are (partially) unaware of the time inconsistency of their behaviour would result in unambiguously lower propensities to save, and eliminate the perceived benefits associated with pensions. This could provide a more accurate description of how people commonly perceive myopia to act.

Although assuming that people are naively myopic is necessary to reflect procrastination, it is not necessary to motivate behavioural inertia. The first of these terms refers to the case in which people put off doing some task on an overly-optimistic assumption about when they will perform the task in the future. Inertia, in contrast, refers only to the propensity for an individual not to take some decision – it makes no assumption about the specific reasons for the inaction. As a consequence, it is possible to reflect inertia through the assumption of a decision cost only. In this case, allowing for procrastination mitigates the scale of the decision costs that are required to reflect a given proclivity toward inertia.

Whereas empirical estimates for the terms of myopia are becoming increasingly available, the same is not true for decision costs. As the above suggests, the scale of decision costs is crucially important in determining the propensity for inertia, and it is consequently of note that this remains an issue for further research.

The principal alternative to procrastination that has been identified as a possible explanation for why people tend to respond only gradually to unanticipated changes in the policy environment is that their behaviour is affected by habits.

Allowing for habits in the current model is also reasonably straightforward, and has the particular advantage that it makes the analytical framework suitable for considering the implications of policy change over both the short and long-run. This is in contrast to the current model structure, which is most sensibly understood when it is applied to changes over the (hypothetical) long-run only.

1 Introduction

Evaluating alternative proposals for policy reform often hinges upon how people are likely to respond to changes in their decision making environment. Although the idea that the plans people make are influenced by myopia has started to feature in the contemporary policy debate, there currently exist few studies that quantify the practical implications of myopia and few analytical tools that permit such effects to be identified. NIBAX is a behavioural model that has been developed at the National Institute for use by civil servants at DWP and HMRC. This report sets out how myopia was recently included in NIBAX, and provides some illustrative examples of the influence that myopia has on the behavioural responses generated by the model.

Myopia – as it is interpreted here – is more than simply impatience. Someone who is impatient attaches little value to any costs or benefits that are realised in the future, relative to the present. Standard economic theory (Samuelson, 1937) allows for impatience through the assumption that people discount costs and benefits that are realised in the future, relative to those of the present. In practical terms, the standard economic model implies that people are time consistent, so that plans for the future can be made in the knowledge that future behaviour will be consistent with what an individual would choose to do today.

In contrast, **myopia** describes the condition where preferences change with an individual's time horizon. This variation of preferences implies that myopic individuals are essentially disappointed with the decisions that they have made or will make in every time period other than the present – they might, for example, be prone to statements such as '*if only I could go back in time, I would work harder/save more*', or '*I know I set aside this money against the risk that I am made unemployed, but on second thoughts I think I will spend the money now on a vacation*'.

There is now substantial evidence – predominantly obtained in the field of experimental psychology (Green, Fry and Myerson, 1994; Kirby, 1997) – that people tend to discount issues that bear upon their future circumstances at a higher rate when the time horizon is short. A classic example is where individuals are found to prefer a payment received immediately to a larger payment received in say a month's time, but to prefer the larger payment if the time horizon to each payments' receipt is delayed by a year. Much attention has subsequently been paid to experimental evidence that the relationship between discount rates and the time horizon is described by a **hyperbolic** functional form (first postulated by Ainslie, 1974, see Frederick, Loewenstein and O'Donoghue, 2002, for a review). This form essentially means that discount rates start out very high over short time horizons, and then fall away smoothly as the time horizon is lengthened, to level off at some value in excess of 0 in the very long run. This specification for rates of time discounting has been simplified in most economic studies to **quasi-hyperbolic** discounting, following Laibson (1997), which assumes that a higher discount rate is applied over a fixed time horizon (usually a single period), and that a lower (constant) discount rate is applied to all subsequent periods.

An important implication of (quasi) hyperbolic discounting is that it gives rise to the potential for 'conflict between the preferences of different intertemporal selves' (Diamond and Köszegi, 2003, p. 1840). This time-inconsistency of preferences can obviously give rise to interesting dynamics, particularly where individuals are assumed to be aware of their propensity to over-spend. A person may, for example, worry that if they set aside money today, then this will only encourage them to work less/spend more tomorrow. As a consequence of such considerations, myopic individuals (who realise that they are myopic) are likely to attach value to commitment mechanisms that non-myopic individuals do not. They may for example, choose to lock their money away in long-term savings accounts or pension policies in response to their propensity for over-spending, where they would otherwise choose not to.

The NIBAX model was first delivered to HMRC and DWP in December 2007. This model simulates savings and labour supply decisions for a population with heterogeneous demographic and financial circumstances, at annual intervals throughout the entire life course. Importantly, the model is designed so that decisions take explicit account of important aspects of uncertainty that people face in practice – including:

- wages;
- unemployment;
- demographics;
- investment returns; and
- the time of death.

This model was recently amended under two projects – one funded jointly by HMRC and DWP, and the other by the Leverhulme foundation – so that it now allows for quasi-hyperbolic discounting as referred to above.

Specifically, it is now possible to use NIBAX to consider the behavioural implications of assuming that people, when making decisions of an intertemporal nature, discount issues that bear upon their circumstances in the first prospective year at a higher rate than those that affect their circumstances in all subsequent years. In this regard, the model is currently based upon the assumption that, if people are assumed to be myopic, then they are aware of the time-inconsistency of their preferences, and make decisions in light of that fact (referred to as **sophisticated myopia**). This can be distinguished from the case in which individuals are myopic, and are unaware of their self-control problems – so-called **naïve myopia** – which the model does not currently account for.

The current report provides a series of descriptive analyses that are designed to indicate the effect that allowing for behavioural myopia has on the behaviour simulated by the NIBAX model. The examples that are presented indicate that allowing for myopia tends to lower labour supply early in life, increase the use of unsecured debt, and delay retirement saving. The last of these effects results in reduced wealth late in the working lifetime, which motivates later retirement amongst myopic consumers.

Including a pension scheme helps to mitigate the behavioural distortions associated with myopia, by enabling individuals to commit savings for retirement. This results in higher rates of pension participation where the population is assumed to be myopic, and an improvement in the associated effects on welfare.[1] It is important to note, however, that the beneficial effects of pensions in context of myopia are driven by the assumption that people are aware of their tendency to over-spend. The beneficial impact of pension schemes in context of myopia would disappear if it were assumed that people were not so self-aware.

Chapter 2 provides some background discussion regarding the NIBAX model, and describes the way that the model has been amended to reflect myopia. Illustrative simulations are discussed in Chapter 3, and Chapter 4 outlines potential directions for further research. Definitions for the more technical terms that are referenced in the report are provided when they are first used, and in a glossary at the beginning of the report.

1 On the welfare effects of myopia, see van de Ven (2010b), Table 11.

2 The NIBAX model and myopia

This chapter is divided into four sections. Section 2.1 explains why the life cycle framework upon which NIBAX is based is important, and what it means in practical terms. A brief description of the details of NIBAX is then provided in Section 2.2, and Section 2.3 describes the amendments to the model that have been made to allow for myopia. Section 2.4 provides analytical details that the reader may choose to skip without handicap. Further details regarding the way that the NIBAX model works, and how it has been adjusted to reflect survey data are provided respectively in Appendices A.1 and A.2.

2.1 The life cycle framework

The behavioural structure upon which NIBAX is based is the product of almost 75 years of economic development. In the mid 1930's, Keynes introduced the idea of the 'psychological law of consumption', which states that 'men are disposed, as a rule and on average, to increase their consumption as their income increases, but not by as much as the increase in their income'. As the influence of the psychological law in economic theory grew, so too did scrutiny between it and the statistical record. This scrutiny yielded a number of puzzles that the psychological law did not help to explain:[2]

- The **marginal propensity to consume**[3] out of disposable income rises as the time dimension is lengthened.
- Savings rates are (positively) correlated with income levels.
- Subgroups of the population who tend to have higher incomes on average, also tend to have lower savings rates at any given level of income.
- The **marginal propensity to save**[4] appears to be higher for income increases than for income decreases.

Modigliani and Brumberg (1955) suggested the life cycle model of decision making as a possible explanation for these puzzles, based on the same conceptual framework as developed separately by Friedman (1957) in his permanent income hypothesis. The fundamental departure of the life cycle model from Keynes' psychological law is that consumption depends not only upon current income (as in Keynes), but also upon income expectations. In the life cycle model, individuals are assumed to use saving as a way of smoothing their consumption through time, relative to fluctuations in their stream of disposable income.

The life cycle model helps to explain the four puzzles that are referred to above. As the time dimension of measurement is lengthened, temporary income fluctuations are likely to average out, so that a closer approximation is obtained to life time (or permanent) income. If individuals

[2] The discussion here draws on Attanasio and Webber (2010).

[3] The marginal propensity to consume is (approximately) equal to the additional consumption that would be undertaken if disposable income increased by £1.

[4] The marginal propensity to save is (approximately) equal to the additional saving that would be undertaken if disposable income increased by £1.

base their consumption on life time income (rather than immediate income), then we should consequently expect consumption to equate more closely to income as the time dimension of measurement is lengthened.

In context of a variable income stream, high income observations will exceed life time income. The life cycle model consequently implies that saving rates should be higher, the higher is the level of income, as the data suggest.

An individual from a disadvantaged population subgroup is likely to have lower expectations regarding lifetime income than the population mean. The life cycle model consequently suggests that individuals from disadvantaged population subgroups should spend less than others at any given income level, as observed in the data.

Finally, the fundamental hypothesis of the life cycle model is that saving is used to smooth consumption through time. Hence, it predicts the observation that people save when income is higher than usual, and dis-save when income is lower than usual.

The success of the life cycle model in explaining survey data on consumption and savings behaviour has seen it become the workhorse for economic analysis of intertemporal decision making throughout the last half century. The life cycle model does, however, have one significant drawback; it only yields analytical descriptions of decisions (closed form solutions) under a very restrictive (and implausible) set of assumptions. Under a passably realistic set of assumptions, numerical methods are required to obtain predictions from the life cycle model regarding consumption and saving. That is the purpose of the NIBAX model.

2.2 NIBAX in brief

This section provides a brief overview of the NIBAX model; for a detailed non-technical description, see van de Ven and Weale (2009), and for a technical description please refer to van de Ven (2009).

The decision unit in the model is the household, defined as a single adult or adult couple and their dependant children. NIBAX generates data for the entire life course of a population of households drawn from a single birth cohort. The life course is divided into annual increments, and data are generated for each age, from 20 to a maximum of 120. At each age, households can be 'asked' to choose their labour supply, consumption, liquid savings, pension contributions, and their portfolio allocation between safe and risky assets.

As discussed in the preceding section, the decisions that are generated by NIBAX are based upon the life cycle model of behaviour, which is the standard economic framework for analysing intertemporal decision making. There are three principal components to the life cycle model: preferences described by a **utility function** that converts observable measures of consumption and leisure into a single (unobservable) measure of **welfare**, a set of constraints that define the range of alternatives from which a decision must be selected, and expectations that define beliefs about the future. The life cycle model assumes that decisions are selected from the range of permissible alternatives to maximise expected lifetime utility, given a household's prevailing circumstances, their preferences and beliefs regarding the future.

The preferences that are adopted by NIBAX – described by the assumed utility function that is referred to above – are standard in the economic literature, and assume that people prefer averages to fluctuating extremes. As a consequence of this, the model predicts that saving and dissaving is used to average over years of plenty and years of famine (an analytical description of the assumed preferences is provided in Section 2.4). These preferences also imply that households have an aversion to risk, so that they will only choose to hold assets with uncertain returns if adequately compensated (in expectation) to do so.

A crucial aspect of the constraints that are assumed by the model concerns the access that people have to credit. In this respect, the model is designed to reflect important features of the practical reality: people can borrow up to an age specific credit limit, where the interest charged on an unsecured loan is an increasing function of the ratio of the loan value to a household's labour income.

Furthermore, NIBAX assumes that the belief structure is perfectly rational, which means that expectations are consistent with the processes that generate intertemporal variation. This assumption is made because it seems the most sensible basis upon which to evaluate policy alternatives; it would hardly seem appropriate to design policy that only functioned as planned if the decision making environment was systematically misunderstood.

The circumstances of a household are considered to be fully described by (up to) nine characteristics:

- Age.
- Number of adults.
- Number of children.
- Occupational pensions.
- Personal pensions.
- Risky liquid assets.
- Safe liquid assets.
- Time of death.
- Wage rates.

Of the nine characteristics that define the circumstances of a household, two are deterministic (age and the safe liquid asset), and up to seven can be considered uncertain. Uncertainty in NIBAX is accommodated by taking random draws from known distributions in a process that is commonly referred to as Monte Carlo simulation. Hence, two simulated households in the same circumstances will both forecast the future in the same way, and will make the same decisions as a result. But the random nature of events implies that they will have different circumstances in the following year, following, for example, different random wage draws.

In the terminology of the **dynamic programming**[5] literature, consumption, labour supply, personal pension contributions, and the portfolio allocation can be made 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.

The model is comprised of two distinct parts. The first part of the model uses numerical methods to solve for household decisions and welfare, given any feasible combination of (considered) characteristics. The way that this is achieved is described in Appendix A.1.1. Having obtained the solutions to the decision making problem that are referred to above, the model generates data for a simulated cohort, via a process that is commonly referred to as **Monte Carlo simulation** (described in Appendix A.1.2). Analyses are then based upon the data generated for the simulated cohort.

5 The NIBAX model is based upon the dynamic programming method of solving intertemporal optimisation problems.

It is important to note that the model has been set up so that it provides a close reflection to a range of observations drawn from survey data. Given the emphasis upon policy evaluation, particular care was exercised in defining the terms of tax and benefits policy that is assumed by the model, which is designed to reflect schedules set out in the Department for Work and Pensions (DWP) **Tax Benefit Model Tables**. Further details regarding the calibration of the model are reported in Appendix A.2.

2.3 Adapting NIBAX to allow for time inconsistent preferences

Amending the NIBAX model to accommodate myopia involved altering the preference structure that is the central model component used to identify decisions. Solution of the consumption decision at any given age (other than the last potential age) usually involves a trade off between utility enjoyed in the current period, and utility enjoyed in future periods. NIBAX uses **discount rates** to 'price' the utility enjoyed in these alternative periods; the higher is the price – referred to as **discount factor** – the higher is the perceived loss in current utility for a given fall in prospective utility.

As noted in the introduction, quasi-hyperbolic discounting is a simplified approximation of hyperbolic discounting. Under hyperbolic discounting, the relative price between the utility enjoyed in any two prospective periods **constantly changes** as their respective time horizons draw near, such that the price of utility in the nearer period rises relative to the latter. That is, as any given prospective period approaches, the utility enjoyed in that period is valued increasingly highly relative to utility in all other subsequent periods. Including this type of variation in the model essentially requires NIBAX to keep track of the prevailing utility prices, which adds substantially to the complexity of the computational problem involved in evaluating alternative decisions.

Under quasi-hyperbolic discounting, the relative price between the utility enjoyed in any two prospective periods **remains unchanged** until the nearer period arrives, at which time, the price of utility in the latter period falls discontinuously. The focus on quasi-hyperbolic discounting consequently helps to simplify the decision problem relative to the more general hyperbolic form, because it constrains variation of the relative utility prices of alternative time periods.

The economic literature has focused upon two forms of myopia. So called sophisticatedly myopic individuals are (at least partly) aware of the time inconsistency of their own preferences. This is in contrast to naïve myopic individuals, whose preferences are time inconsistent, but who are unaware of this fact. In keeping with the focus on a rational beliefs structure, we have included sophisticated myopia in the current specification of the model, which is the most common assumption in economic studies. This allows for a complex set of behavioural responses, as households take account of the time inconsistency of their preferences in making their decisions: they may, for example, elect to save less early in the simulated lifetime to encourage increased labour effort later in life (see Diamond and Köszegi, 2003, for a detailed discussion). The issue of naïve myopia is returned to in the conclusion.

2.4 Analytical details

The model generates behaviour by identifying decisions that maximise expected lifetime utility, as described by a given **utility function**. The utility function that is assumed for analysis is given by:

$$V_t = \frac{1}{1-\gamma}\left\{ u\left(\frac{c_t}{\theta_t}, l_t\right)^{1-\gamma} + E_t\left[\beta \sum_{i=t+1}^{T} \delta^{i-t}\left(\phi_{i,t}\, u\left(\frac{c_i}{\theta_i}, l_i\right)^{1-\gamma} + \left(1-\phi_{i,t}\right)\left(z_0 + z_1 w_i^{+}\right)^{1=\gamma}\right)\right]\right\} \quad (1a)$$

$$u\left(\frac{c_t}{\theta_t}, l_t\right) = \left[\left(\frac{c_t}{\theta_t}\right)^{1-1/\varepsilon} + \alpha^{1/\varepsilon} l_t^{\,1-1/\varepsilon}\right]^{\frac{1}{1-1/\varepsilon}} \qquad (1b)$$

where $\gamma > 0$ is the intertemporal iso-elastic parameter; E_t is the expectations operator; T is the maximum potential age; β and δ are discount factors (assumed to be the same for all households); $\varphi i,t$ is the probability of living to age *i*, given survival to age t; $c_t \in \mathrm{R}^+$ is discretionary composite consumption; $l_t \in [0,1]$ is the proportion of household time spent in leisure; $\theta_t \in \mathrm{R}+$ is adult equivalent size based on the 'revised' or 'modified' OECD scale; the parameters z_0 and z_1 reflect the 'warm-glow' model of bequests; and $w_t^+ \in \mathrm{R}^+$ is net liquid wealth when this is positive and zero otherwise. □>0 is the (period specific) elasticity of substitution between equivalised consumption (c_t/θ_t) and leisure (l_t). The constant α>0 is referred to as the utility price of leisure.

Equation (1a) makes clear that the allowance for myopia that is included in the model references prospective measures of utility, following the associated economic literature. In this regard, it is of note that myopia consequently bears upon decisions over both consumption and leisure; whereas casual introspection might suggest that it is more appropriately a consideration for the consumption/saving margin, than it is for the labour/leisure margin. This concern is mitigated in the current context by the focus upon discrete labour states (e.g. full-time/part-time/non-employment), rather than over continuous labour hours. The focus on discrete labour states limits the 'direct impact' that myopia has on labour decisions during the working lifetime, so that the most pronounced implications for employment are attributable to the impact that myopia has on accrued savings, and the bearing that this has on the timing of retirement.

If β=1, then preferences are time consistent, subject to the constant exponential discount factor δ. If β<1, then the preferences are myopic, exhibiting a present-bias. To highlight the distinction between time consistent and time inconsistent preferences, note that with β=1, we can re-write equation (1a) as:

$$V_t = \frac{1}{1-1/\gamma} u\left(\frac{c_t}{\theta_t}, l_t\right)^{1-1/\gamma} + \delta\phi_{t+1,t} E_t\left[V_{t+1}\right]$$

But if $\beta \neq 1$, then:

$$V_t = \frac{1}{1-1/\gamma} u\left(\frac{c_t}{\theta_t}, l_t\right)^{1-1/\gamma} + \beta\delta\phi_{t+1,t} E_t\left[W_{t+1}\right]$$

$$W_t = \frac{1}{1-1/\gamma} u\left(\frac{c_t}{\theta_t}, l_t\right)^{1-1/\gamma} + \delta\phi_{t+1,t} E_t\left[W_{t+1}\right]$$

and $W_t \neq V_t$. Recursive solution of the optimisation problem when $\beta \neq 1$ consequently requires W_t to be separately calculated and stored by the model: storing both V_t and W_t then permit evaluation of the full set of utility prices that are implied by quasi-hyperbolic preferences.

The implications of assuming a value of β<1 for intertemporal preferences are discussed at greater length in the following chapter.

3 Illustrative simulations

Here we report statistics drawn from two broad sets of simulations. Both sets of simulations are principally based upon the calibrated model that is designed to reflect UK survey data (discussed in Appendix A.2). In the first set of simulations, we limit household variation by omitting pensions entirely from the model; households are considered to decide only over their labour supply and their consumption. The second set of simulations then builds upon the first by extending the household decision to consider participation in an employer sponsored pension. Before exploring these simulations, however, the chapter begins by discussing an important issue of interpretation that guides the way in which behavioural responses are reported.

3.1 Distinguishing myopia from impatience

Exploring the impact of myopia on household decision making is complicated by the difficulty that is associated with distinguishing time inconsistency from impatience. As noted in Section 2.3, the preference structure upon which NIBAX is based uses discount factors to price utility enjoyed at different points in time. The standard economic model that omits myopia assumes that the discount factor applicable over any given period of time – representing the price of utility enjoyed at the end of the period relative to the beginning of the period – is independent of how far ahead in time the period begins. That is, from the perspective of an individual aged 25, the same discount factor should apply between utility enjoyed at ages 28 and 30, as between ages 38 and 40. An important implication of this pricing structure, is that it is independent of the current age of an individual, so that the individual will not have a tendency to 'change their mind' about their most preferred decision in a given context as they get older.

Myopia alters this assumption by attaching a disproportionately higher utility price to current consumption, relative to all prospective periods. For an individual aged 25, the discount factor for utility at age 27 relative to utility at age 25 is lower than the discount factor for utility at age 37 relative to utility at age 35. This has the effect of applying a disproportionately higher weight on immediate consumption, relative to consumption enjoyed in the future, so that individuals have a tendency to 'over spend'.

Raising the utility price of current consumption while holding the utility price of consumption in all prospective periods fixed increases both myopia and general impatience. To appreciate this point, it is useful to consider a concrete example. Suppose that utility is consumed at annual intervals, and that preferences are subject to a constant exponential discount rate of ten per cent per annum. Define the **annualised discount rate** as the constant exponential discount rate that would need to be applied in each year to obtain the discount factor associated with a given time horizon. For the above example, this is represented by the solid horizontal line toward the bottom of Figure 3.1.

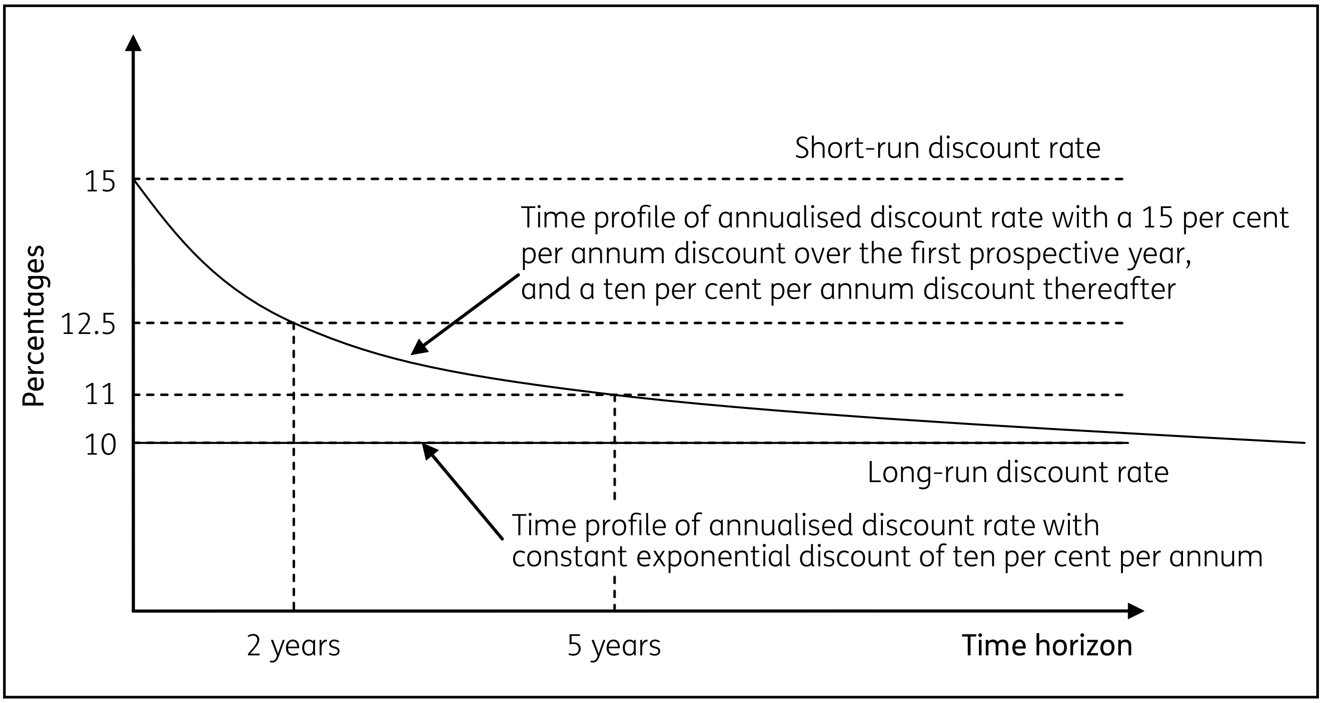
Now suppose that myopia is introduced, such that utility enjoyed in the first prospective year is subject to a 15 per cent discount relative to the current year's utility, while holding the remainder of the above example fixed (by applying a constant discount of ten per cent per annum to each subsequent year before utility is received). The discount factor associated with utility obtained in the first prospective year, relative to current utility, is then (1-0.15) = 0.85. The discount factor on utility obtained in the second prospective year is calculated in a similar fashion to compound interest: (1-0.15) x (1-0.10) = 0.765; in the third prospective year it is (1-0.15) x (1-0.10) x (1-0.10) = 0.6885; and so on.

Given this revised specification for preferences, the annualised discount rate implied by the example in the preceding paragraph is trivially equal to 15 per cent. Over the first two prospective periods, the annualised discount rate, r, satisfies the condition (1-r) x (1-r) = (1-0.15) x (1-0.10) = 0.765; this is approximately mid-way between ten per cent and 15 per cent, or 12.5 per cent per annum. As the number of prospective periods is lengthened, the annualised discount rate gradually falls from the **short-run** discount of 15 per cent per annum, toward the **long-run** discount of ten per cent per annum. This is represented by the downward sloping line in Figure 3.1.[6]

The higher is the annualised discount rate displayed in Figure 3.1, the higher is the degree of impatience over the respective time horizon. Furthermore, the greater is the variation of the annualised discount rate with the time horizon, the more pronounced is the degree of myopia. Note in Figure 3.1 that increasing the short-run discount rate above ten per cent while holding all else unchanged, results in both a higher profile for the annualised discount rate (indicating greater impatience), and a steeper downward sloping profile with the time horizon (indicating more pronounced myopia).

In the analysis that is reported below, we are interested in how myopia affects the decisions generated by the NIBAX model. This is complicated by the fact that it is not possible to alter the degree of myopia without also altering the degree of impatience. The analysis reported below is designed to respond to the inherent connection between the degree of myopia and impatience by introducing the concept of the **term to equivalence**.

Figure 3.1 Quasi-hyperbolic discounting and the annualised discount rate



[6] In analogy, if 15 per cent per annum interest were applied to the first year of a fixed term savings account, and ten per cent per annum were applied to all subsequent years, then as the term of the savings account was lengthened, the average annual rate of return on the investment would fall from 15 per cent per annum down toward ten per cent per annum.

By construction, it is not possible to replicate the downward sloping profile of the annualised discount rate associated with myopia with the horizontal profile described by a (time-consistent) constant exponential discount rate. The best that we can do is to compare the situation with myopia to a situation with a constant exponential discount rate: we refer to the period where the two discount rates meet as the term to equivalence. Setting a constant exponential discount rate to 12.5 per cent per annum will obtain a term to equivalence of two years to the myopic specification that is reported in Figure 3.1, as indicated by the associated dashed lines in the figure. Similarly, setting a constant discount of 11 per cent per annum will obtain a term to equivalence of five years, relative to the previous example with myopia.

The term to equivalence is a useful concept because it indicates the way in which the myopic and time-consistent preference structures relate to one another. Specifically, the longer is the term to equivalence, the longer is the time horizon over which myopia applies a higher annualised discount rate, relative to time-consistent preferences. Put another way, as the term to equivalence is lengthened, so too is the period over which the myopic specification for preferences implies greater impatience, relative to the time-consistent specification for preferences.

It is important to stress, however, that the term to equivalence does not indicate the extent of myopia. In context of quasi-hyperbolic discounting, the degree of myopia as described by the variation of the annualised discount rate with the time horizon depends upon the degree of disparity between the short-run and long-run discount rates. In contrast, the term to equivalence is defined by how a given constant (exponential) discount rate divides between the short-run and long-run discount, rather than the disparity between the two. Furthermore, the term to equivalence is a descriptive statistic that relates only to the period required to equate discount factors under alternative models of discounting. This is a separate issue from whether or not an individual ever actually lives long enough to ensure that they survive to see the term to equivalence met.

The analyses that are reported below compare behaviour simulated under the assumption of myopic quasi-hyperbolic discounting, relative to behaviour simulated under the assumption of time-consistent (non-myopic) exponential discounting. In the case of quasi-hyperbolic discounting, the short-run discount rate is set to 18.4 per cent per annum, and the long-run discount rate to four per cent per annum. These rates are based upon econometric estimates calculated on UK data that are reported in van de Ven (2010a).[7]

Given the short-run and long-run discount rates that are assumed for quasi-hyperbolic discounting, four alternative constant exponential discount rates are considered for comparison, which were specified to reflect four terms to equivalence: five years (7.0 per cent exponential discount rate), ten years (5.5 per cent), 15 years (5.0 per cent), and the very long-run (infinity, 4.0 per cent). This last option sets the exponential discount rate equal to the long-run discount rate, so that the term to equivalence is never actually reached (the downward sloping line in Figure 3.1 tends towards but never actually touches the horizontal line at ten per cent).

Holding the discount rates assumed for quasi-hyperbolic discounting fixed ensures that the degree of myopia is constant throughout the analysis. The alternative terms to equivalence that are considered for analysis then provide a means of comparing the responses to myopia using alternative controls for impatience. Given the novelty of the 'term to equivalence' that is discussed above, some readers may appreciate the following analytical description. The discussion that follows can, however, be omitted without handicap.

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7 van de Ven (2010a) reports econometric estimates for the excess short-run discount rate, and the (long-run) exponential discount rate. The long-run exponential discount rate that is considered here is set to four per cent, based upon the model calibration that is reported in the Appendix. The analysis then assumes an excess short-run discount rate of 15 per cent, based upon the estimates reported in van de Ven (2010a): (1-0.04)*(1-0.15) = 0.816.

The standard model of decision making is based upon exponential discounting. Suppose, as in NIBAX, that time is divided into annual increments. In this context, exponential discounting implies that the discount factor that is used to deflate utility enjoyed in t years time for comparison with utility that is enjoyed today is given by:

$$D_t = \delta^t \qquad (2)$$

with the per period discount factor $\delta < 1$. Under quasi-hyperbolic discounting, the discount factor is amended to:

$$Q_t = \beta\delta^t \qquad (3)$$

where the per period short-run discount factor $\beta\delta$ is set discontinuously lower than the per period long-run discount factor δ for any $\beta < 1$.

Note that, if $\beta < 1$, then, for any given δ, $Q_t < D_t$. This indicates that introducing myopia by reducing the value of β below 1 results in lower discount factors over all time horizons, unambiguously reducing incentives to work and to save. But, if all we were interested in was an unambiguously lower discount factor, then we wouldn't have to go to the trouble of introducing myopia; we could just reduce the per period exponential discount factor δ.

To understand how myopia influences savings and labour supply decisions, it is useful to partially off-set the reduction in Q_t that is implied by a reduction in β, through a coincident increase in δ.

The specification of equations (2) and (3) given above reveal that, if $\beta < 1$, then it is not possible to set $Q_t = D_t$ for all potential time horizons t. It is always possible, however, to set $Q_t = D_t$ at any given time horizon t. When $\beta < 1$, and $Q_s = D_s$ for some given time horizon s, then $Q_t < D_t$ for all $t < s$, and $Q_t > D_t$ for all $t > s$. In words, quasi-hyperbolic discounting will discount utility enjoyed in periods prior to s by more than the model of exponential discounting, in periods following s by less than exponential discounting, and the two models of discounting will apply the same discount factor to utility enjoyed during period s.

3.2 The influence of myopia on consumption and labour supply

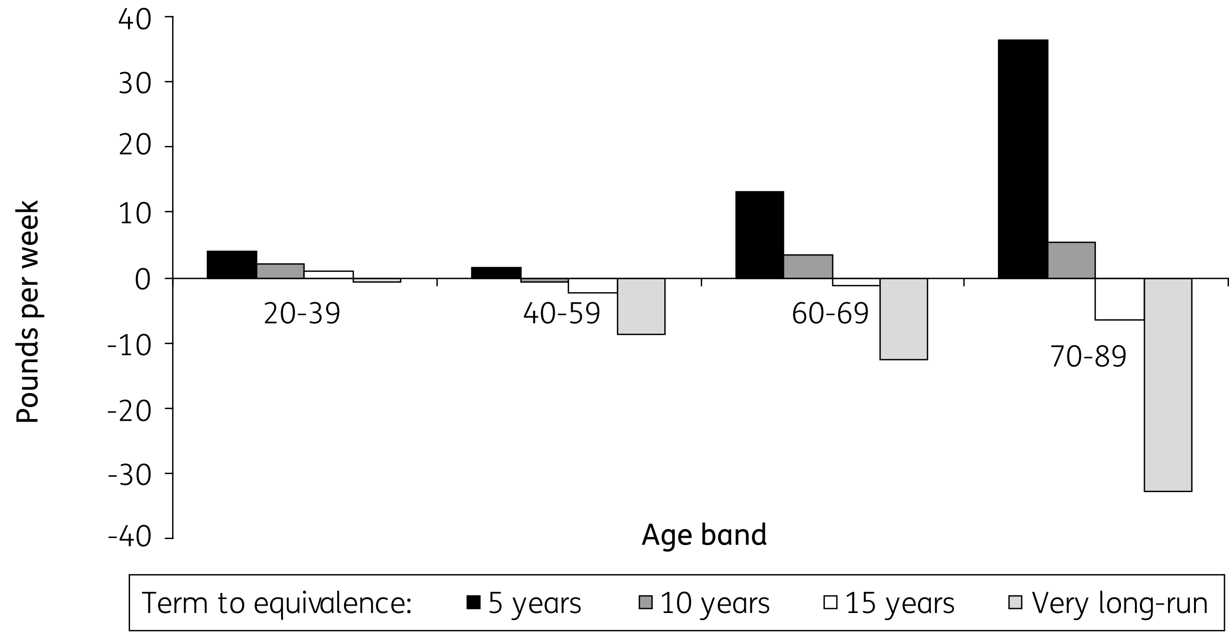
To simplify, we begin by reporting the impact of myopia on household behaviour where decisions are limited to choosing over annual consumption and labour supply.

The effects on average consumption by age of the various alternative specifications considered for intertemporal discounting are reported in Figure 3.2. The first thing to notice in this figure is the bearing that the term to equivalence has on consumption. As the term to equivalence is increased – implying relatively greater impatience in context of myopia – consumption tends to fall away under the myopic preferences, particularly at later ages. When preferences reflect a high degree of patience under myopia (five year term to equivalence), then consumption tends to rise throughout the lifetime relative to exponential discounting, and vice versa when myopic preferences reflect a high degree of impatience (the very long-run term to equivalence).

The effects reported for consumption early in life may appear counter-intuitive: shouldn't impatient households spend more when they are young, and patient households spend less when they are young? In fact, relative to households simulated under exponential discounting in the 'very long-run' behavioural scenario, households simulated under myopia (who are relatively impatient) do consume more on average between ages 20 and 31, but this is obscured by the ten year averages that are reported in Figure 3.2 (see Table 3.1 for associated results). The observation that consumption early in life responds in a somewhat counter-intuitive way is, however, principally attributable to the influence that impatience has on labour supply. Relative to exponential discounting with a five year term to equivalence, households simulated under myopia supply more labour throughout the working lifetime in consequence of their relatively high patience, so that their lifetime income is higher as a result. This enables them to finance higher consumption even at younger ages.

The effects on consumption of the two alternative terms of ten and 15 years that are reported in Figure 3.2 fall between the extremes that are discussed above. It is of note that averaging over the consumption effects reported for the ten and 15 year terms obtains a value around zero for the entire lifetime. This can be interpreted as balancing out the effects of impatience that are referred to above, and as we are more concerned here with the effects of myopia than with impatience *per se*, the average between the ten and 15 year terms forms a useful frame of reference in the discussion that follows.

Figure 3.2 Effects of myopia on consumption in the absence of a pension asset



Source: Authors' calculations on output from the NIBAX model.
Notes: Figure reports population averages simulated under the assumption of myopic quasi-hyperbolic discounting subject to a short-run discount of 18.4 per cent per annum and a long-run discount of four per cent per annum, less population averages simulated under the assumption of a non-myopic constant discount rate adjusted to obtain the respective term to equivalence.
The term to equivalence represents the period over which myopic preferences imply a higher degree of impatience, relative to the non-myopic preferences that are used as the basis for comparison.

An important aspect of NIBAX is that it extends beyond a simple representative agent, to consider the circumstances and decisions of households throughout the income/wealth distribution. To explore the distributional implications of myopia, Table 3.1 breaks down the population average statistics that are reported in Figure 3.2 into quintile groups distinguished by lifetime disposable income.

Table 3.1 Effects of myopia on consumption in the absence of a pension asset and by lifetime income quintile (per cent changes)

Age band	Lowest quintile	2nd quintile	3rd quintile	4th quintile	Highest quintile
5 year term to equivalence					
20-29	0.7	0.8	0.9	1.0	0.6
30-39	1.2	1.3	1.5	1.8	-1.0
40-49	1.0	1.0	1.7	2.2	-3.0
50-59	1.5	0.7	0.6	1.4	-0.7
60-69	1.0	0.5	1.1	2.0	2.8
70-79	0.8	2.0	4.7	7.7	6.5
80-89	0.8	2.8	7.1	12.3	12.4
90+	0.4	1.4	4.7	10.5	13.4
Average absolute difference	0.9	1.3	2.8	4.9	5.1
10 year term to equivalence					
20-29	0.6	0.9	0.8	0.7	0.4
30-39	0.5	0.1	0.3	0.5	-0.2
40-49	0.0	-0.5	0.0	1.0	-1.0
50-59	0.8	0.5	-0.2	0.1	-0.2
60-69	0.4	0.1	0.2	0.6	0.7
70-79	0.1	0.2	0.7	1.3	0.9
80-89	0.1	0.3	1.1	2.2	1.8
90+	0.0	-0.1	0.1	0.7	0.3
Average absolute difference	0.3	0.3	0.4	0.9	0.7
15 year term to equivalence					
20-29	0.5	0.9	0.9	0.7	0.4
30-39	0.0	-0.4	-0.3	-0.2	0.0
40-49	-0.5	-1.2	-0.6	0.7	-0.5
50-59	0.4	0.4	-0.4	-0.4	-0.5
60-69	0.0	0.0	-0.1	-0.1	-0.4
70-79	-0.2	-0.5	-1.0	-1.3	-1.0
80-89	-0.2	-0.7	-1.5	-2.0	-2.1
90+	-0.2	-0.8	-2.0	-3.9	-4.8
Average absolute difference	0.3	0.6	0.8	1.2	1.2

Continued

Table 3.1 Continued

Age band	Lowest quintile	2nd quintile	3rd quintile	4th quintile	Highest quintile
Term to equivalence in the very long-run					
20-29	0.6	1.2	1.2	0.8	0.3
30-39	-1.0	-1.5	-1.2	-1.3	0.4
40-49	-1.4	-2.3	-1.9	-1.2	-0.3
50-59	-0.6	0.2	-0.3	-0.5	-2.1
60-69	-0.8	-0.2	-0.9	-1.9	-3.0
70-79	-0.9	-2.1	-4.9	-7.1	-4.8
80-89	-1.1	-3.2	-7.7	-11.9	-10.2
90+	-0.7	-2.6	-7.8	-15.5	-16.0
Average absolute difference	0.9	1.6	3.2	5.0	4.6

Source: Authors' calculations on output from the NIBAX model.

Notes: Table reports population quintile averages simulated under the assumption of myopic quasi-hyperbolic discounting subject to a short-run discount of 18.4% p.a. and a long-run discount of 4% p.a., less population averages simulated under the assumption of a non-myopic constant discount rate adjusted to obtain the respective terms to equivalence. The term to equivalence represents the period over which myopic preferences imply a higher degree of impatience, relative to the non-myopic preferences that are used as the basis for comparison.

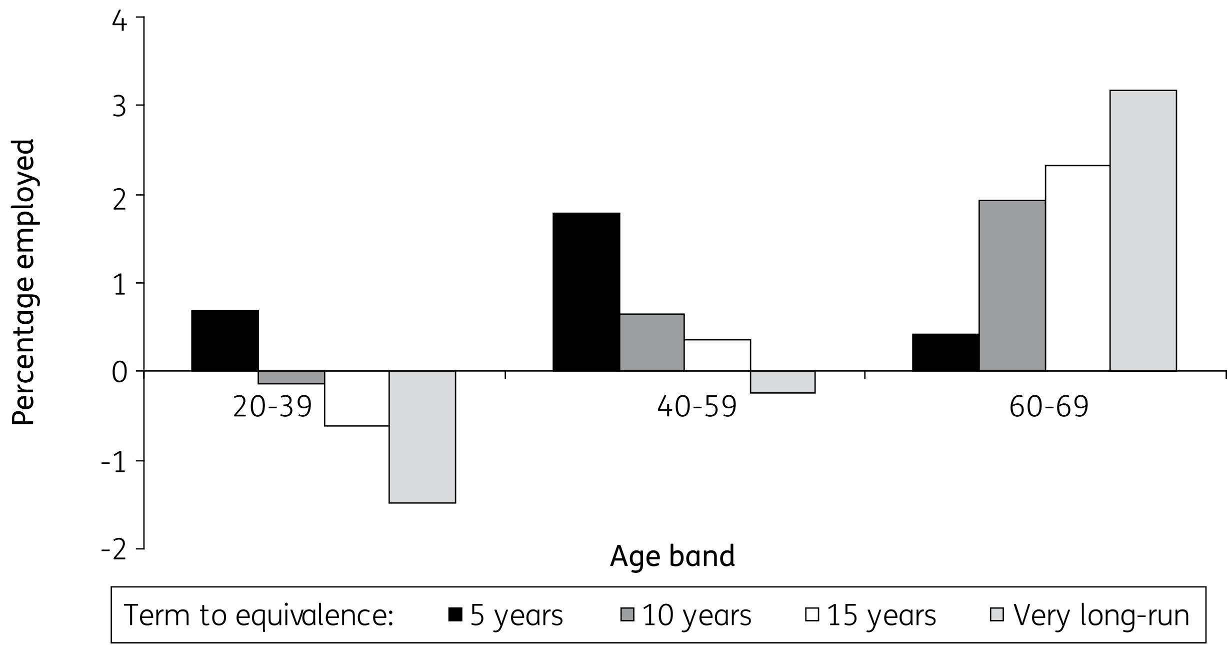
Table 3.1 indicates two interesting results beyond those that are reported in relation to population averages. First, the effects of myopia on behaviour are qualitatively similar between quintile groups throughout the simulated lifetime. And second, the magnitude of the responses to myopia tends to increase with household affluence, which is most clearly observable in the average absolute differences that are reported at the bottom of each panel in Table 3.1. This second observation is attributable to the fact that the responses of more affluent households are less affected by liquidity constraints than those of households lower in the wealth distribution. The result that households higher in the wealth distribution respond more readily to changes in incentives is very common in empirical economic studies.

Given the qualitative similarity of the effects observed throughout the wealth distribution, the remainder of the study focuses exclusively upon population averages. Tables that report associated statistics for quintile groups are provided in the Appendix.

Employment effects are reported in Figure 3.3. This figure indicates that the present-bias implied by myopic preferences implies lower employment (greater leisure taking) early in life, and later retirement relative to exponential discounting for all but the five year term to equivalence. Focusing upon the average of the statistics reported for the ten and 15 year terms reveals almost half a percentage point fall in the proportion of adults employed between the ages of 20 and 39 under myopia, relative to time consistent preferences. This is followed by an approximately equivalent rise in employment rates in the middle of the working lifetime, and a relatively substantial increase of two per cent employed later in life: myopia in this context suggests later retirement. Over the course of the entire lifetime, the incidence of employment rises under myopia, relative to all of the alternatives considered for exponential discounting: from five per cent under the five year term to equivalence, to 0.3 per cent under the 'very long-run' scenario.

This last observation may appear somewhat counter-intuitive: why would a present bias encourage people to work longer? The answer is that people who have self control problems, and who have no means of committing savings for retirement, tend to save far less early in life. As a consequence of this, they have fewer savings toward the end of their working lives, motivating a delay in retirement to make up the savings short-fall.

Figure 3.3 Effects of myopia on adult employment in the absence of a pension asset

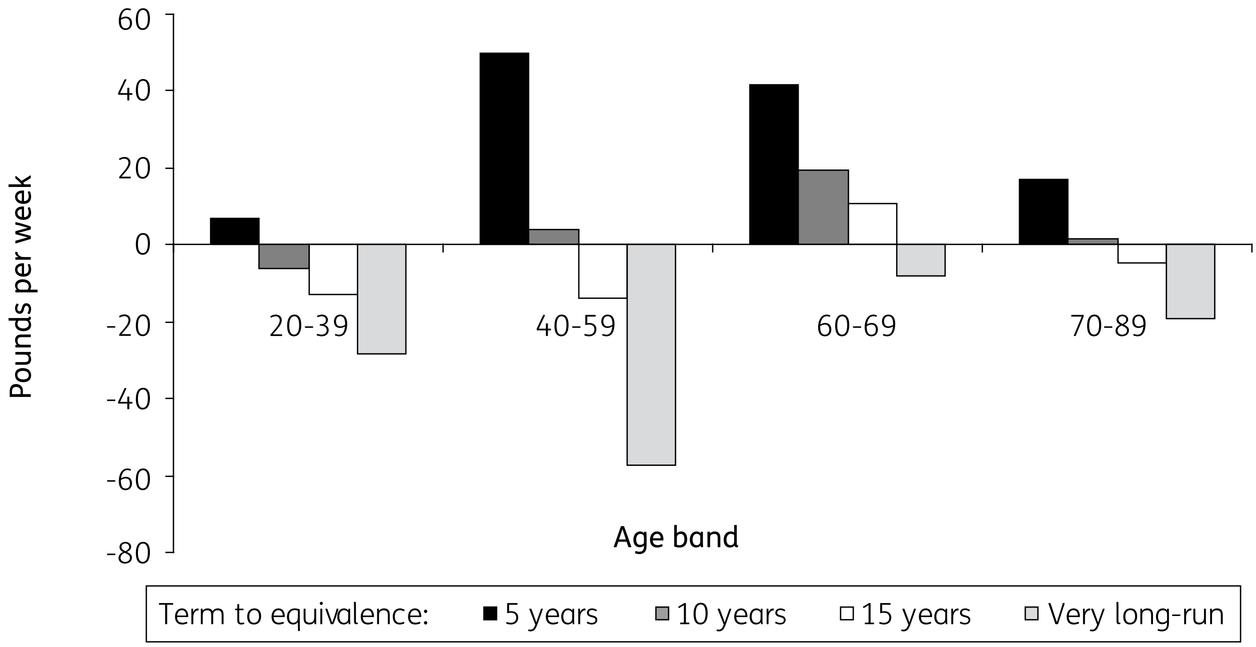


Source: Authors' calculations on output from the NIBAX model.
Notes: Figure reports population averages simulated under the assumption of myopic quasi-hyperbolic discounting subject to a short-run discount of 18.4 per cent per annum and a long-run discount of four per cent per annum, less population averages simulated under the assumption of a non-myopic constant discount rate adjusted to obtain the respective term to equivalence.
The term to equivalence represents the period over which myopic preferences imply a higher degree of impatience, relative to the non-myopic preferences that are used as the basis for comparison.

The labour supply responses that are discussed above are important determinants of the effects of myopia on disposable income that are reported in Figure 3.4; and the reported effects on disposable income underlie the consumption effects that are reported in Figure 3.2. It is interesting to note that, despite the substantial increase in labour supply observed late in the working life under myopia in the very long-run scenario, disposable income nevertheless falls.

This is due to two factors, both of which are a response to the relatively high impatience under myopia that is assumed in the 'very long-run' simulation scenario. First, the reduced labour supply that is reported early in the working lifetime in Figure 3.3 depresses labour income due to the effect that work experience is assumed to have on wages. Second, and more importantly, households simulated under myopia choose to accrue fewer savings relative to those simulated under exponential discounting in the very long-run scenario, which depresses disposable income through the impact that it has on investment income.

Figure 3.4 Effects of myopia on disposable income in the absence of a pension asset

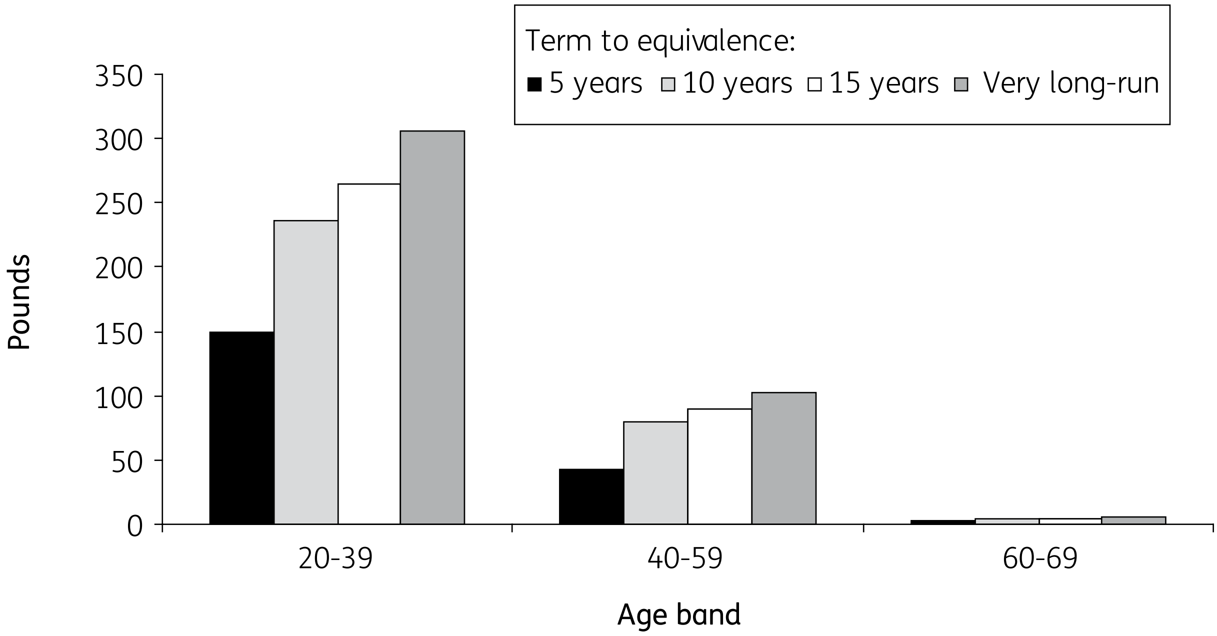


Source: Authors' calculations on output from the NIBAX model.
Notes: Figure reports population averages simulated under the assumption of myopic quasi-hyperbolic discounting subject to a short-run discount of 18.4 per cent per annum and a long-run discount of four per cent per annum, less population averages simulated under the assumption of a non-myopic constant discount rate adjusted to obtain the respective term to equivalence.
The term to equivalence represents the period over which myopic preferences imply a higher degree of impatience, relative to the non-myopic preferences that are used as the basis for comparison.

The impact of alternative assumptions regarding intertemporal discounting on indebtedness is reported in Figure 3.5. That indebtedness should rise as a general implication of myopia is of little surprise. What may be less clear, however, is why average indebtedness rises under all of the simulated scenarios, including the five year term to equivalence, which also involves a substantial increase in saving under myopia (as is indicated by the increase in consumption enjoyed late in life reported in Figure 3.2).

The observation is due to two factors. First, the increase in labour supply observed under the five year term scenario implies a substantial increase in lifetime income. This motivates higher consumption throughout the lifetime, as reported in relation to Figure 3.2, and this consumption is part-funded early in life through higher indebtedness. Secondly, increased saving can co-exist with increased indebtedness because of heterogeneous circumstances of different households within the simulated population.

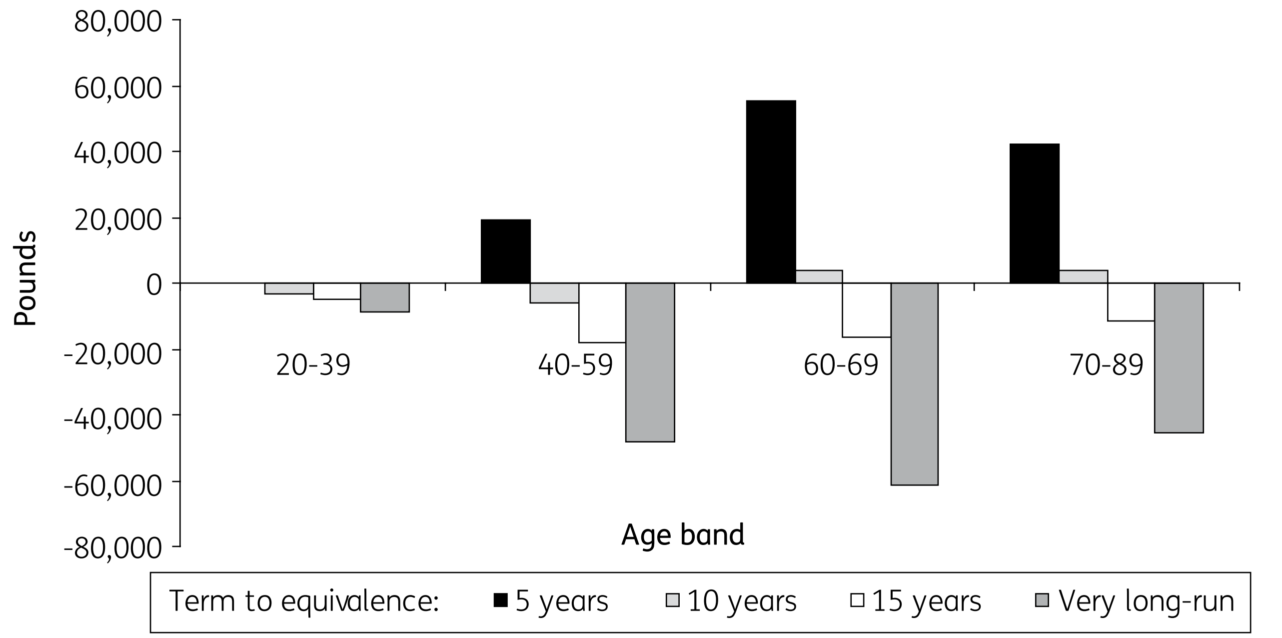
Figure 3.5 Effects of myopia on unsecured debt in the absence of a pension asset



Source: Authors' calculations on output from the NIBAX model.
Notes: Figure reports population averages simulated under the assumption of myopic quasi-hyperbolic discounting subject to a short-run discount of 18.4 per cent per annum and a long-run discount of four per cent per annum, less population averages simulated under the assumption of a non-myopic constant discount rate adjusted to obtain the respective term to equivalence.
The term to equivalence represents the period over which myopic preferences imply a higher degree of impatience, relative to the non-myopic preferences that are used as the basis for comparison.

Figure 3.6 reports the impact of myopia on aggregate savings. This figure indicates that myopia tends to result in lower aggregate savings for all but the five year term to equivalence scenario. This is consistent with the fact that myopic individuals, who realise that they are myopic (as is the case in the current analysis) will take into account the fact that money that is set aside for retirement too early in the lifetime is likely to be spent prematurely. As a consequence of this, saving for retirement is delayed, resulting in lower wealth and a delay in the timing of retirement between ages 60 and 69. Figure 3.6 reveals that saving never fully recovers, despite the delay in retirement, where the term to equivalence exceeds ten years.

Figure 3.6 Effects of myopia on total net worth in the absence of a pension asset



Source: Authors' calculations on output from the NIBAX model.
Notes: Figure reports population averages simulated under the assumption of myopic quasi-hyperbolic discounting subject to a short-run discount of 18.4 per cent per annum and a long-run discount of four per cent per annum, less population averages simulated under the assumption of a non-myopic constant discount rate adjusted to obtain the respective term to equivalence.
The term to equivalence represents the period over which myopic preferences imply a higher degree of impatience, relative to the non-myopic preferences that are used as the basis for comparison.

3.2.1 Summary

In the absence of a pension scheme, the simulations reported here indicate that myopia implies higher consumption and reduced labour supply early in life, resulting in a delay to saving for retirement. This results in lower aggregate household savings and higher indebtedness throughout the working lifetime. Reduced provisions for retirement tend to increase labour supply in the middle of the working life, and to delay the timing of retirement. Nevertheless, on balance, the additional saving that is consequent on delayed retirement is insufficient to make up for the foregone savings accrued early in life, resulting in marginally lower consumption during retirement. This last finding is, however, dependant on the terms that are assumed for comparison.

3.3 The influence of myopia with private pension decisions[8]

As noted previously in this report, the illiquidity of pension savings has an interesting bearing on the incentives perceived by (sophisticatedly) myopic decision makers. On the one hand, pension fund illiquidity is undesirable because it means that pension savings cannot be accessed in the event of an adverse financial shock. On the other hand, the illiquidity of pension savings enables myopic

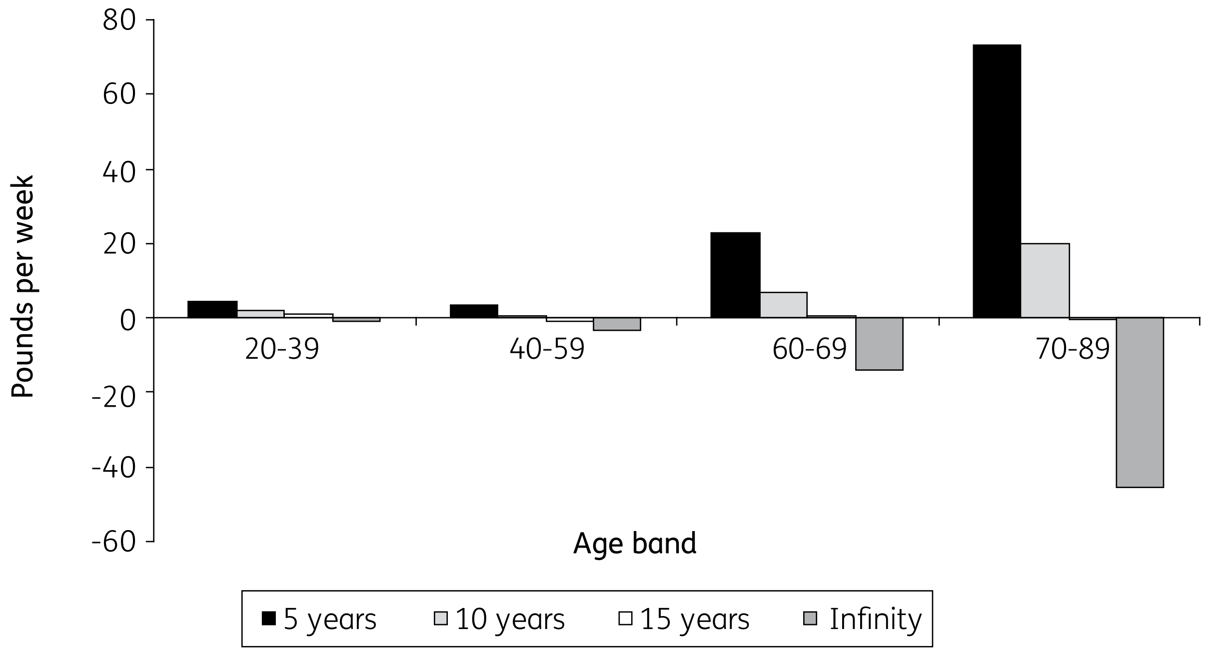
8 The private pension schemes that we model here are structured to reflect the typical terms offered by occupational pensions in the UK.

individuals to off-set the propensity to over-spend by committing savings for retirement. This second consideration implies that saving through pensions tends to be more desirable to a population that is myopic than to one that is not, which is reflected in the results that are reported here.

Before jumping into the statistics regarding pension saving, it is useful to begin – as in Section 3.2 – with the associated effects generated for consumption, which help to distinguish impatience from time inconsistency in the subsequent analysis. Associated statistics are reported in Figure 3.7.

Comparing Figures 3.2 and 3.7 reveals that very similar consumption responses to myopia were obtained, with and without access to private pensions. One of the most interesting developments in Figure 3.7 is the observation that consumption is almost unchanged by the allowance made for myopia under the 15 year term to equivalence scenario. Given that we are principally concerned with the influence of time-inconsistency of preferences that is described by myopia, rather than on impatience in aggregate, the discussion that follows focuses exclusively on the 15 year term. Results to the alternative terms to equivalence are reported in Appendix A.3.

Figure 3.7 Effects of myopia on consumption with a pension asset



Source: Authors' calculations on output from the NIBAX model.
Note: Figure reports population averages simulated under the assumption of myopic quasi-hyperbolic discounting subject to a short-run discount of 18.4% p.a. and a long-run discount of 4% p.a., less population averages simulated under the assumption of a non-myopic constant discount rate adjusted to obtain the respective terms to equivalence. The term to equivalence represents the period over which myopic preferences imply a higher degree of impatience, relative to the non-myopic preferences that are used as the basis for comparison.

We now turn to the effects of myopia on saving and the portfolio decision between pension and non-pension wealth. Figure 3.8 indicates that myopic preferences imply stronger incentives to invest wealth in pensions. This is a direct response to the observation, made in Section 3.2, that myopia results in a delay to retirement saving where pensions do not exist. Here, myopic individuals take advantage of the commitment mechanism offered by pensions to circumvent their propensity to prematurely spend accrued savings.

Panel C of Figure 3.8 indicates that total wealth tends to fall in context of myopic preferences and given a pension asset by around £4,000 on average throughout the life course. This compares with approximately £6,500 in the absence of a pension asset (reported in Section 3.2). Hence, the addition of the pension asset helps to offset around 40 per cent of the reduction in total wealth associated with the myopic preferences.

Figure 3.9 indicates that the allowance for myopia has a very similar impact on indebtedness and employment, with or without private pensions. In the case of unsecured debt, allowing for myopia increases average indebtedness to an extent that is almost identical to that observed without private pensions. Similarly, allowing for myopia tends to result in higher leisure taking early in life and lower leisure taking later in life, consistent with the general results reported in Section 3.2.

Finally, we consider the sensitivity of the results that are reported above to the degree of impatience that is assumed under exponential discounting. In this regard, it is particularly interesting to explore the implications of myopia that describes a high degree of patience, relative to exponential discounting, as this serves to exaggerate the tension between a bias toward immediate consumption and the desire to save. Figure 3.10 consequently reports observations over aggregate wealth and employment derived in respect of the simulations that impose a five year term to equivalence (the most patient myopic preference structure relative to the specification of exponential discounting).

Figure 3.8 Effects of myopia on wealth with a pension asset – 15 year term to equivalence

Panel A Effects on pension saving

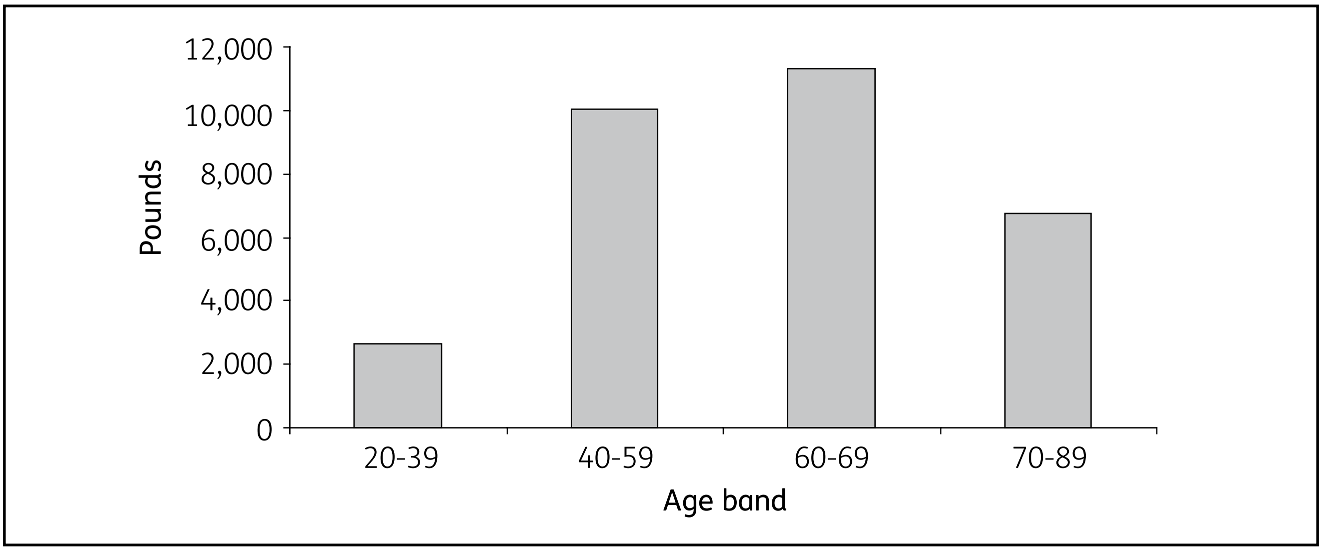
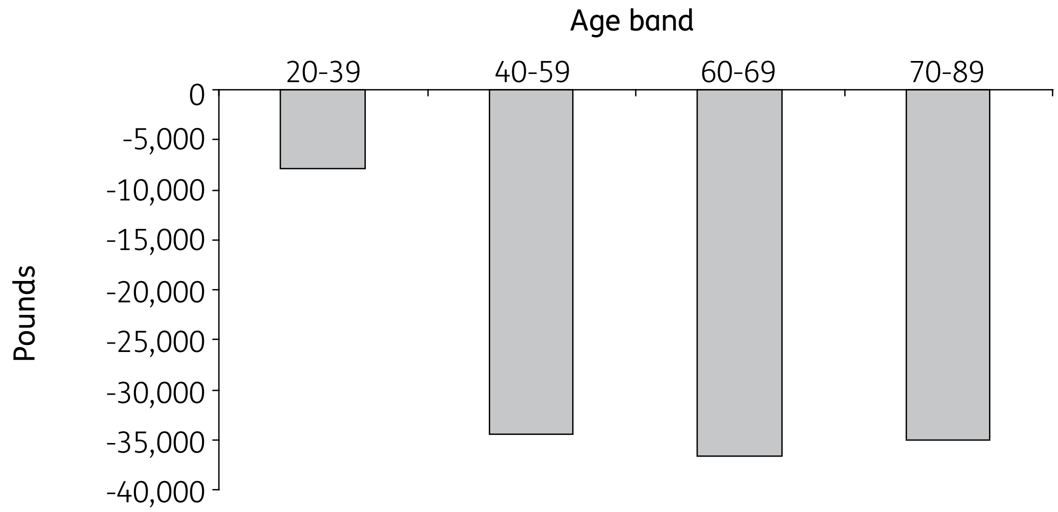
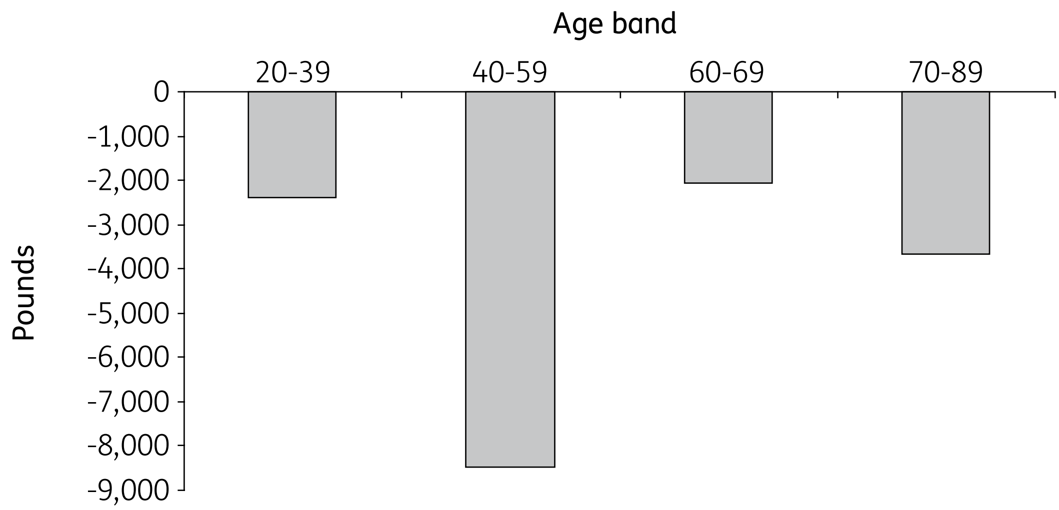


Figure 3.8 Continued

Panel B Effects on non-pension saving



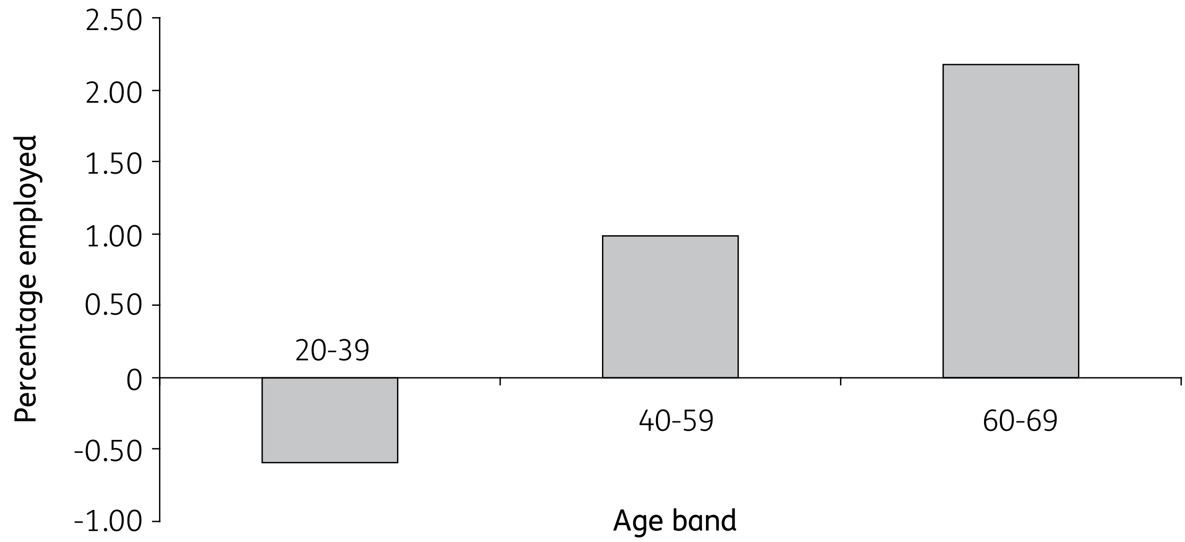
Panel C Effects on total wealth



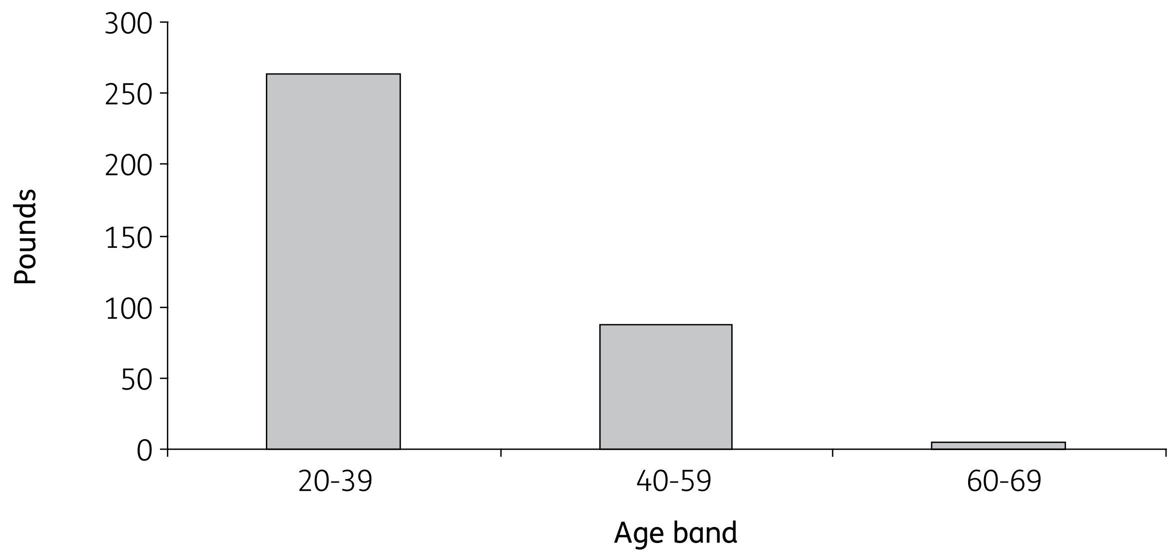
Source: authors' calculations on output from the NIBAX model.
Note: Figure reports population averages simulated under the assumption of myopic quasi-hyperbolic discounting subject to a short-run discount of 18.4% p.a. and a long-run discount of 4% p.a., less population averages simulated under the assumption of a non-myopic constant discount rate adjusted to obtain the respective terms to equivalence. The term to equivalence represents the period over which myopic preferences imply a higher degree of impatience, relative to the non-myopic preferences that are used as the basis for comparison.

Figure 3.9 Effects of myopia on employment and indebtedness with a pension asset – 15 year term to equivalence

Panel A Effects on proportion of adults employed



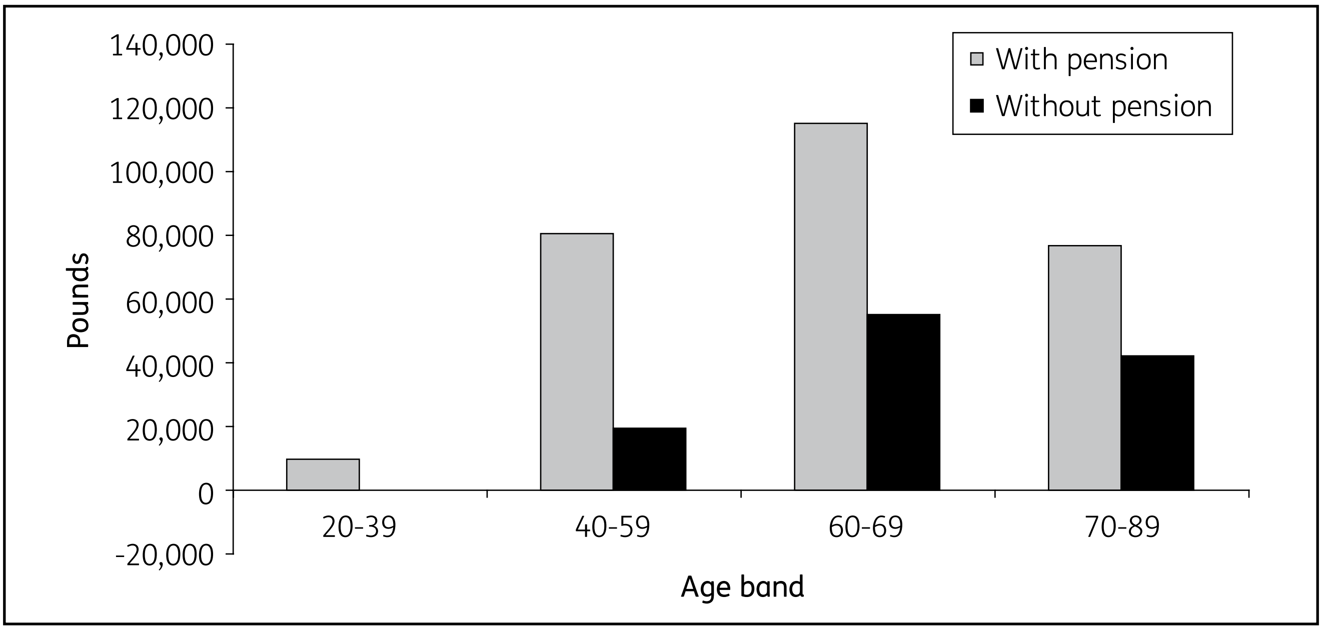
Panel B Effects on indebtedness



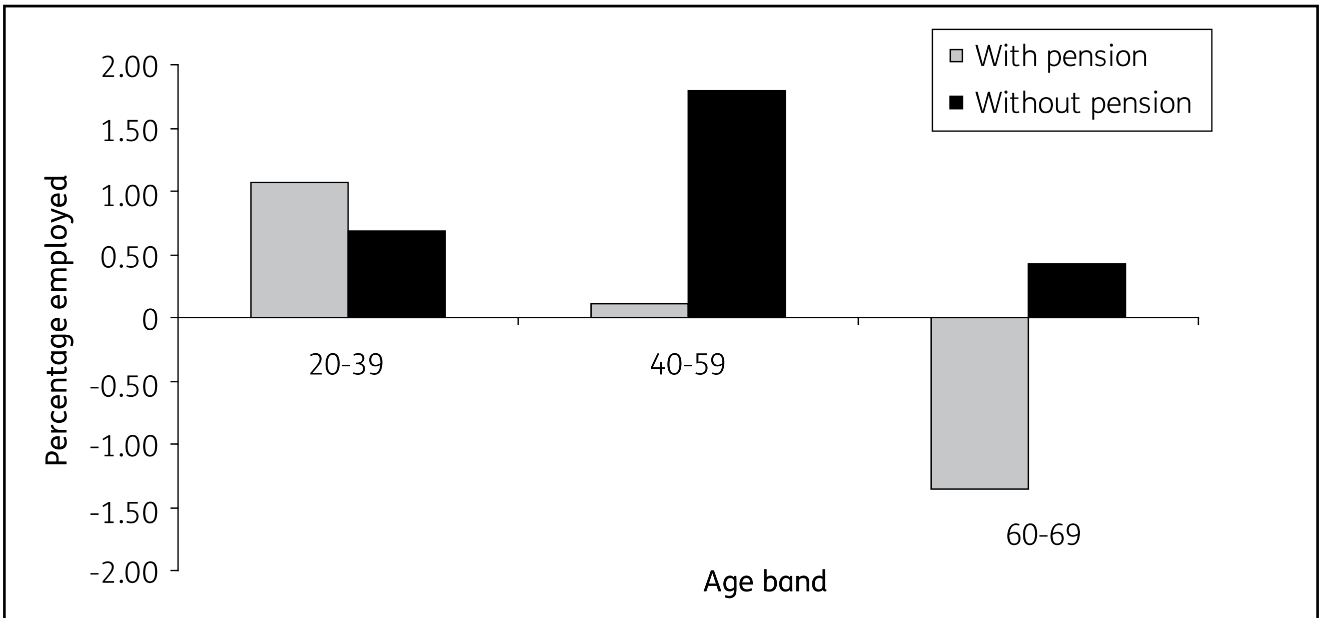
Source: Authors' calculations on output from the NIBAX model.
Notes: Figure reports population averages simulated under the assumption of myopic quasi-hyperbolic discounting subject to a short-run discount of 18.4 per cent per annum and a long-run discount of four per cent per annum, less population averages simulated under the assumption of a non-myopic constant discount rate adjusted to obtain the respective term to equivalence.
The term to equivalence represents the period over which myopic preferences imply a higher degree of impatience, relative to the non-myopic preferences that are used as the basis for comparison.

Figure 3.10 Effects of myopia on employment and aggregate savings – five-year term to equivalence, with and without a pension asset

Panel A Effects aggregate savings



Panel B Effects on proportion of adults employed



Source: Authors' calculations on output from the NIBAX model.
Notes: Figure reports population averages simulated under the assumption of myopic quasi-hyperbolic discounting subject to a short-run discount of 18.4 per cent per annum and a long-run discount of four per cent per annum, less population averages simulated under the assumption of a non-myopic constant discount rate adjusted to obtain the respective term to equivalence.
The term to equivalence represents the period over which myopic preferences imply a higher degree of impatience, relative to the non-myopic preferences that are used as the basis for comparison.

Figure 3.10 throws into sharp contrast the importance of pensions in context of myopic preferences. The two panels of the figure indicate that – where myopic preferences reflect a relatively high degree of patience, the addition of pensions motivates higher labour supply early in life, and increased saving. Late in the working lifetime the substantially higher stocks of wealth that households accrue in context of pensions allow them to retire early, relative to the case in which pensions do not exist.

3.3.1 Summary

The option to invest in private pensions helps to mitigate the behavioural distortions that are associated with time inconsistent preferences (if agents are aware of their time-inconsistency). Myopic individuals consequently tend to invest more heavily in (illiquid) pension schemes than do otherwise similar individuals with time consistent preferences, and less in liquid assets. Myopia tends to have a similar impact on labour supply and indebtedness, with or without pensions. Relative to a population of time consistent decision makers, a myopic population can be expected to work less early in life, to take on more unsecured debt, and to delay retirement saving. This last factor implies that myopia tends to result in delayed retirement.

Finally, it is important to stress that the beneficial impact of pensions in context of myopia that is identified here is a direct result of the assumption that people are aware of their propensity to over-consume, and make their decisions in light of this fact. If households were assumed to be naively unaware of their self-control problems, then they would attach no value to the commitment mechanism offered by a pension scheme, and the associated benefits that are identified here would vanish as a consequence.

4 Conclusion and directions for further research

Much attention has been paid in the contemporary policy debate to the view that at least some people are influenced by myopia when making decisions of an intertemporal nature. In the policy debate regarding the extension of access to employer sponsored pension schemes, for example, myopia was cited as one of the factors motivating state involvement in retirement provisions (e.g. Pensions Commission, 2005, pp. 68-69, and the Department for Work and Pensions (DWP), 2006, p. 31). In this regard, it appears that the public debate has gotten slightly ahead of the economic literature, as there currently exist very few studies that consider the practical implications of myopia for behavioural responses to policy alternatives. Recent amendments to the NIBAX model have been made to help meet this information gap, making the necessary analytical tools directly available to policy makers.

The practical examples that are reported in this study reveal that myopia can have very profound – and sometimes surprising – effects on behaviour in a realistic policy environment. We find that a myopic population is likely to retire later than an otherwise similar population that is not affected by myopia. This is because the myopic population makes fewer provisions for retirement early in the working lifetime, and must work longer to make up (some of) the short-fall. In the ant and the grasshopper parable, the grasshoppers must toil their way later into autumn, and possibly into winter, to stave off material hardship. Our analysis also provides statistical support for the hypothesis (cited above) that myopia provides a justification for the existence of a pension scheme.

There are a number of directions in which the current version of NIBAX could be amended in an effort to obtain a more realistic reflection of the practical reality. We start with those that are simple extensions of the amendment with which this report is concerned, before discussing more ambitious objectives.

The current version of the model is limited to considering so-called sophisticated myopia, in which decision makers are assumed to be fully aware of their propensity to over-consume. However, the proposition that some people may be naïvely unaware of their myopia does not appear to us improbable, and is likely to have important implications for associated decision making – as noted in the above text, the welfare benefits of commitment mechanisms as offered by pension fund illiquidity only apply if individuals are aware of the time inconsistency of their preferences.

Furthermore, even if one rejects the idea that people may be naïvely myopic, accommodating such behaviour would help to interpret results generated under the assumption of sophisticated myopia by separating out the influence of the present bias in consumption from the dynamic game between different intertemporal selves. This is a relatively straightforward problem to implement – equivalent to approximately two week's work – and would not affect the computational burden associated with the model.

Relaxing the assumptions of the quasi-hyperbolic preference structure upon which the current model is based is also a trivial numerical exercise – likely to account for around three week's work. Unlike the preceding issue, however, it is likely to have a pronounced effect on the computational burden required to run the model, with associated implications for the time that the model will take to calculate a simulation.

To explain this further, it is of note that the computation time of the model will increase in approximate proportion to the number of times the discount rate is assumed to change over the prospective time horizon. Hence quasi-hyperbolic discounting involves one alternative discount rate, and so involves a computation time that is similar to that involved in the absence of myopia. If the discount rate is assumed to change over two prospective periods, then this implies that the time required to run a simulation using NIBAX would approximately double, and so on for more flexible specifications of the discount rate. Of course, the required computational time could be managed by omitting alternative household characteristics from the simulations.

An additional aspect of potential interest is to allow for additional heterogeneity in the range of household types that is currently permissible under the model. This could be implemented with a small amount of effort – accounting for approximately three week's work. It should be remembered, that – as in the case of relaxing the model of quasi-hyperbolic discounting the run time required for the model would increase in proportion to the number of household 'types' considered for analysis.

More substantively, the attention that is now being paid to the issue of procrastination in the policy debate suggests that future development could focus upon the allowance of decision making costs and naïveté. The idea here is that, if people have myopic preferences, but are unaware of their myopia, then they may delay an undesirable task on an unrealistically optimistic assumption about when they will perform the task in the future. O'Donoghue and Rabin (1999) have shown that very small decision costs can motivate indefinite delay of a task, even if the task is associated with a significant financial gain in expectation.

The issues involved in addressing naïveté have already been discussed. Regarding the issue of decision costs, these provide a plausible explanation for a number of observed behavioural phenomena, including supply side labour market rigidities, and the importance of default options (in, for example, the terms of pension schemes). Including decision costs into the model is, however, complicated by the fact that it is difficult to identify the scale of the costs that best reflect the practical reality. As such, close collaboration with practitioners would be required to identify those areas where decision costs are likely to play the most important role, and how such costs should be most appropriately structured.

The current version of NIBAX is designed explicitly to consider long-run responses to policy counterfactuals. While this is an important aspect to take into account in the process of policy design, it is also clearly limiting. Perhaps the most substantive, and exciting question is consequently how to make the model an appropriate basis for considering the short-term effects of policy reform. A similar difficulty has long been considered by macro-economic modellers. One of the most convincing solutions identified in the macro-context is to assume that there is intertemporal persistence in behaviour that explains the 'excess-smoothness' observed for private responses to economic shocks. In the context of NIBAX, this involves allowing for **habits** in the preference relation. The incorporation of habits in the preference structure assumed for NIBAX is a non-trivial task – from a computational perspective, and in relation to the associated parameterisation of the model – but appears to be a task well worth taking on!

Appendix

A.1 Modelling approach

This section describes the way in which NIBAX simulates household behaviour. Two discrete stages are involved. We describe the first stage before moving on to the second.

A.1.1 First stage of a simulation

In the first stage of a simulation, a numerical structure is constructed to describe the decisions and welfare of a household with any permissible combination of characteristics. For example, suppose a simple specification of the model was selected that only considered consumption and labour supply, taking into consideration a household's:

- age;
- number of adults;
- potential wage rate (should it choose to work); and
- accrued wealth (assumed to be liquid and to accrue a risk free rate of return).

Then, given any household's age (say 36), its relationship status (single adult), its potential wage rate (£315 per week), and its accrued wealth (£21,232), the first stage of the model should predict the household's consumption (£253 per week), its labour supply (full-time employment), and its welfare.

This may sound like an implausible undertaking. Nevertheless, it is made possible by modern computing technology. The first stage of a simulation proceeds by dividing all of the permissible characteristics that a household may have into a series of grids. In the above example this would involve constructing a four dimensional grid in age (single years between ages 20 and 120), number of adults (1 or 2), the range of permissible wage rates (£0-£10,000 per week), and wealth (£0-£5,000,000). Solutions are then obtained for utility maximising decisions at each intersection of the grid via a process known as backward induction.

Starting at the last possible age (120), there is no probability of a household surviving to the subsequent period (age 121). This simplifies the problem of solving for utility maximising decisions, because the impact of current decisions on future circumstances is made irrelevant. It is consequently fairly straight forward to solve for decisions and welfare at all of the intersections of the grid in the last possible age simulated by the model.

The model solution then proceeds to the penultimate potential age considered by the model (119). Solving for utility maximising decisions at the penultimate age is made more complicated than solving for decisions at the last potential age, because such decisions often affect both utility in the penultimate period, and circumstances (and therefore utility) in the following period. For example, increasing consumption at age 119 increases the utility enjoyed at age 119, but reduces wealth, and therefore the consumption that can be enjoyed at age 120. The trade-off between current utility and expectations regarding future utility is evaluated by referencing the measures of welfare previously calculated for the grid in the last possible age simulated by the model. This permits utility maximising decisions and expected lifetime welfare to be evaluated at all points of the grid in the penultimate age.

Solutions for decisions in all preceding ages are then obtained recursively in a similar fashion to that described for the penultimate age.

A.1.2 Second stage of a simulation

In the second stage of a simulation, NIBAX generates panel data at annual intervals over the entire life course for a population of 10,000 households representing a single birth cohort. This involves ‘running households forward through the grids’ that are evaluated in the first stage of the simulation.

At the youngest age simulated by the model (20), the characteristics of the population are randomly allocated by taking random draws from a joint distribution. Given the characteristics of each household, the grids that are constructed in the first stage of the simulation are used to evaluate the decisions that each household will make and their respective measures of expected lifetime utility. Each household is then projected forward one year, given their simulated decisions, and the processes that are assumed to govern the intertemporal evolution of the characteristics.

Where the evolution of a characteristic is deterministic, projecting forward through time is straightforward. In the case of liquid wealth, for example, next period’s wealth is simply equal to this period’s wealth, plus disposable income, less consumption. Where the evolution of a characteristic is uncertain, then projecting forward through time involves taking a new random draw for each individual. In the case of wages, for example, the wage next period is described as a function of age, wage in the current period, labour supply, and a random ‘innovation’ that is assumed to have a log-normal distribution. Projecting wages forward through time consequently involves taking a new random draw at each period for each individual from the assumed log-normal distribution.

Having ‘aged’ the population one year, the process begins again, and is repeated until the final age that is considered by the model, or until the household is identified as dying (which ever comes first). The panel data that are derived from this process form the basis for secondary analysis.

A.2 Model calibration

The parameters of NIBAX have been calibrated to match age specific moments of a population generated by the model to the associated moments estimated from survey data. A detailed discussion of the various issues involved in calibrating the model is provided in van de Ven (2009). This section gives a brief account, focusing on the match obtained between the model and survey data.

The specification of the model that was used to calibrate the parameters imposes both hard and soft constraints on credit, includes:

- uncertainty over relationship status;
- the possibility of a low wage offer;
- allowing households to choose their labour supply from up to five alternative options; and
- decisions to participate in personal pensions.

Importantly, risky assets were omitted from this model specification to reduce computation times.

The data used to calibrate the model are principally drawn from the 2007 waves of the Family Resources Survey (FRS) and the Expenditure and Food Survey (EFS), adjusting all monetary statistics to reflect real wage growth of 1.3 per cent per annum. The tax and benefits structure between ages 20 and 64 was specified to reflect Department for Work and Pensions’ (DWP) Tax Benefit Model Tables from June 2007. Similarly, the tax structure from age 65 was specified to reflect the Basic State Pension and the Pension Credit, as they stood in 2007.

The mortality rates that were imposed are calculated from the cohort expectations of life published by the Office for National Statistics (ONS). These data were used to calculate the age specific probabilities of survival for a couple, where both members of the couple were aged 20 in 2005, and take into account official expectations regarding the prospective evolution of mortality rates.

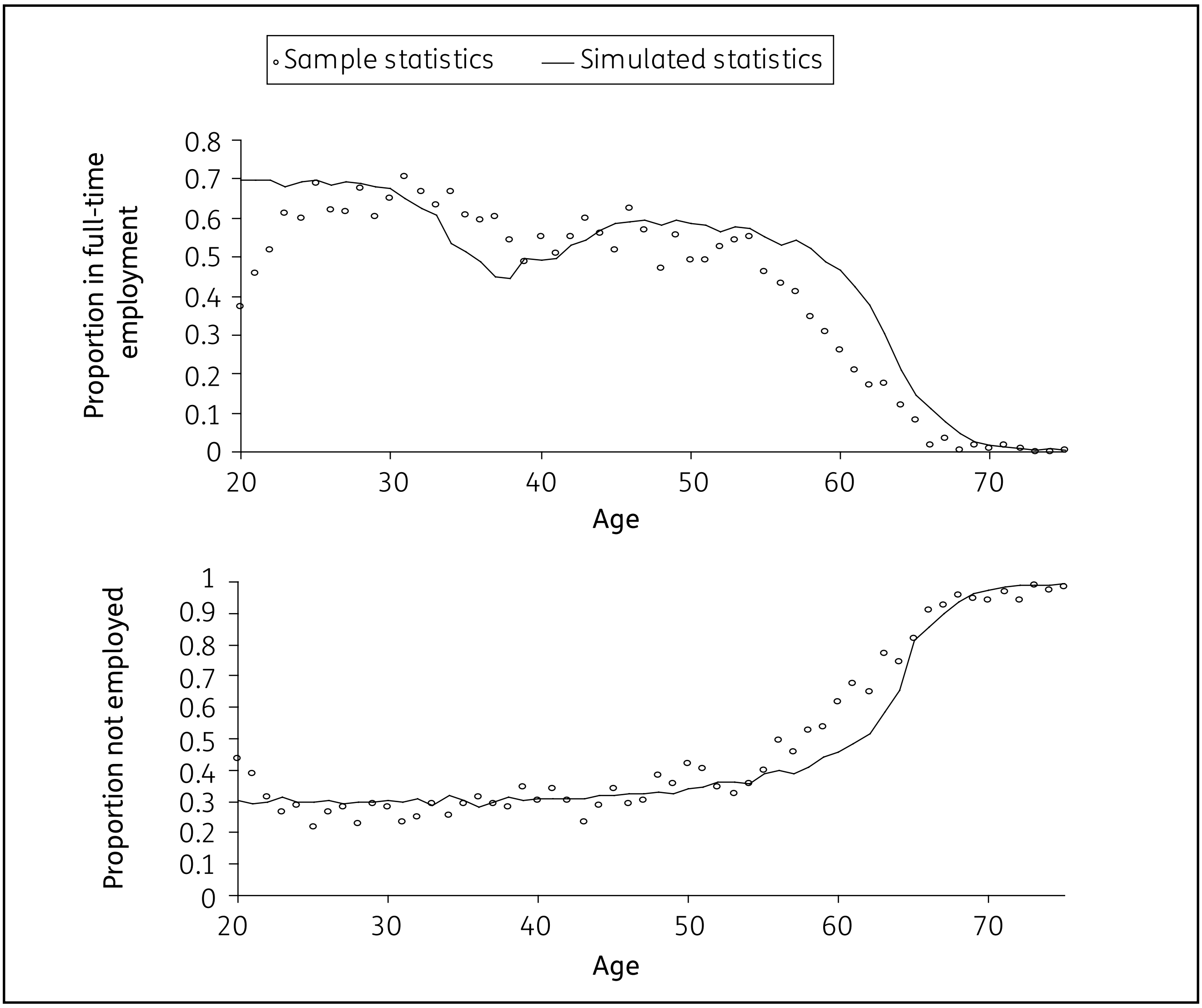
With regard to credit, a £2,000 upper limit on unsecured debt was imposed, subject to the condition that debt is repaid in full by age 65. The (real) variable interest charged on unsecured loans was set to vary between 11.5 per cent and 19.8 per cent per annum, based upon historical data on the charges levied on personal loans and credit cards reported by the Bank of England. These compare with 2.7 per cent per annum that was assumed to accrue to positive balances of liquid wealth, and four per cent per annum on pension wealth.

The logit model that is assumed to govern relationship transitions was estimated on pooled data from waves 1 to 17 of the British Household Panel Survey, and the specification of personal pensions was structured to broadly reflect common terms applied by Occupational Pension schemes.

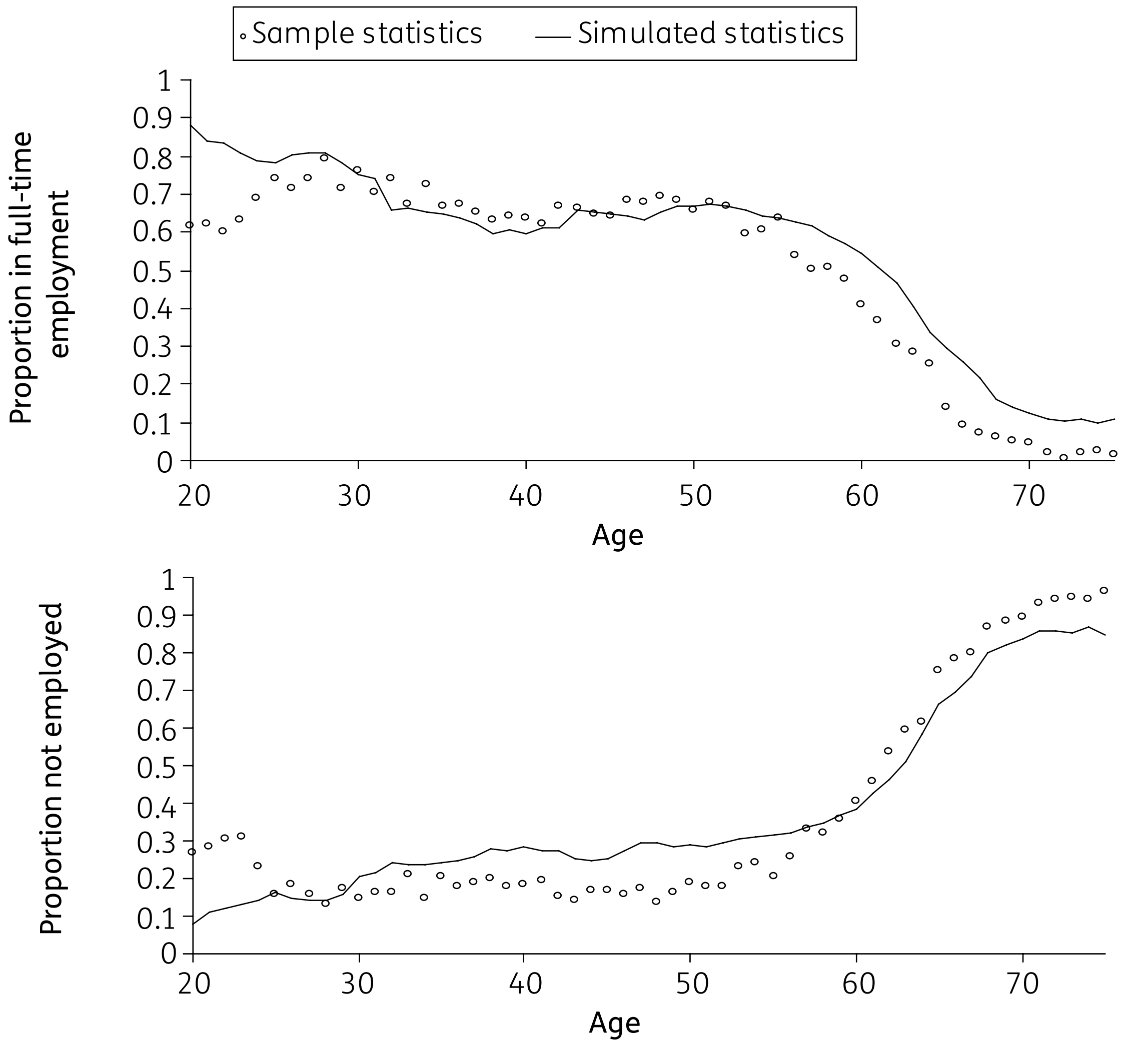
The match obtained between the model and survey data is reported in Figures A.1 to A.4, which suggest that the model does a good job of reflecting the associated survey data. Starting with Figure A.1, the two panels of the figure indicate that, not only does the model do a good job of capturing the rate of departure from the workforce into retirement, but it also manages (particularly for single adults) to capture the dip in employment that is observed around peak child-rearing years. This second issue is captured through three alternative aspects of the model's construction. First, the model allows for variation in the number of children in a household, based on age specific averages observed in FRS data. Second, consumption needs increase with household size because the consumption argument that enters the utility function is defined in **equivalised and not absolute** terms. Equivalisation means that the utility gain from any absolute measure of consumption falls as household size increases. And thirdly, the model is designed to reflect the impact that childcare costs have on disposable income in practice.

Figure A.1 Employment rates by age and relationship status

Panel A Employment rates for singles



Panel B Employment rates for couples



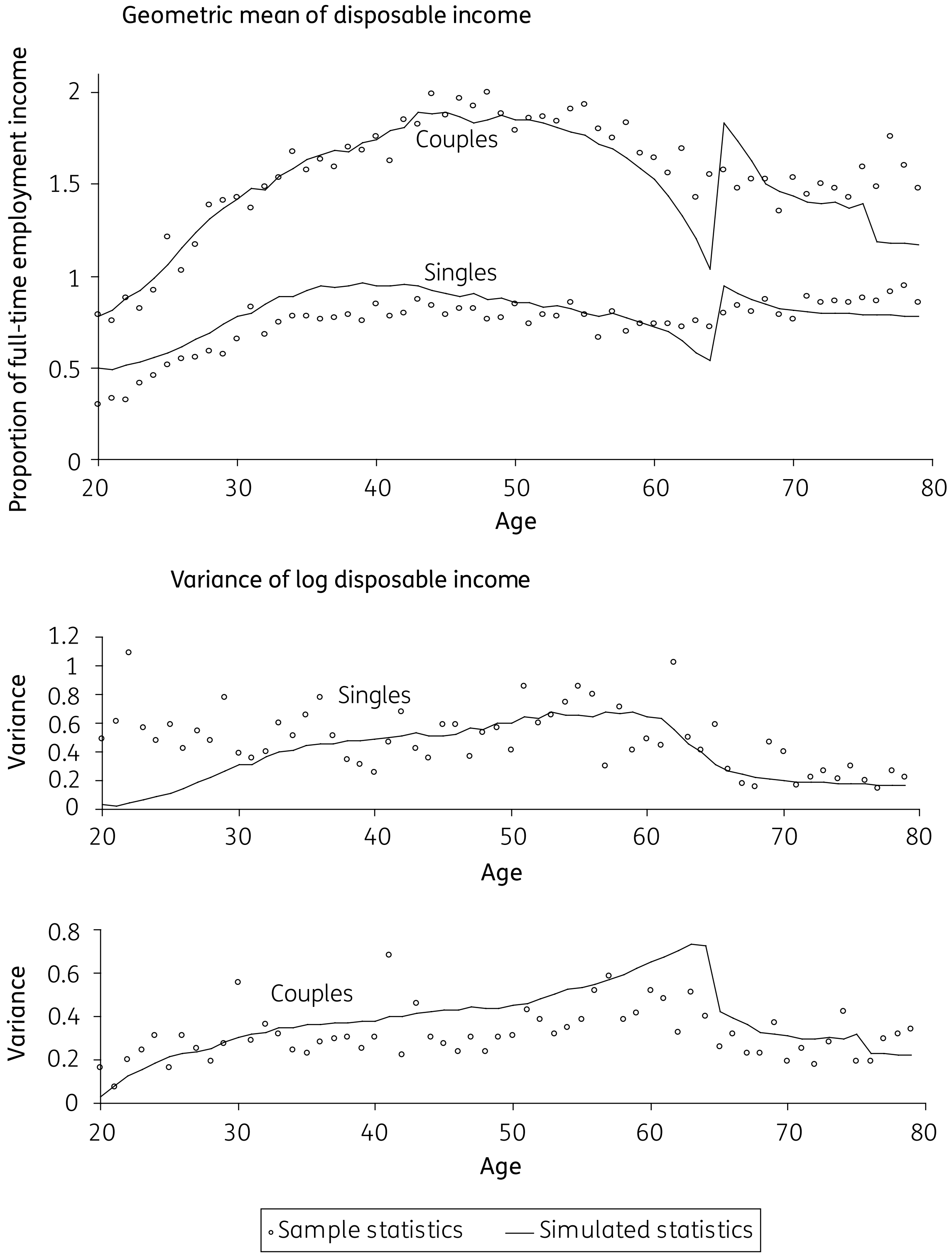
Source: FRS 2007/08 wave, and NIBAX simulations.

Figures A.2 and A.3 reveal that the model does a good job of capturing the humped shape profile that is evident for geometric means of income in survey data. This fact on its own is of little surprise, given that the model includes a full set of dummies that determine the age profile of employment income. What is more interesting is that a decent match is obtained to both private and disposable income. As the difference (wedge) between these two is predominately attributable to taxes and benefits, Figures A.2 and A.3 taken together suggest that NIBAX obtains a reasonable approximation to the tax and benefits structure applied in the UK. Nevertheless, it is of note that it was not possible to match the respective variances of both measures of income simultaneously. The calibration consequently focused upon matching to the variance of disposable household income, as this can be expected to have a more immediate bearing on consumption decisions.

Figure A.2 Moments of private non-property income by age and relationship status

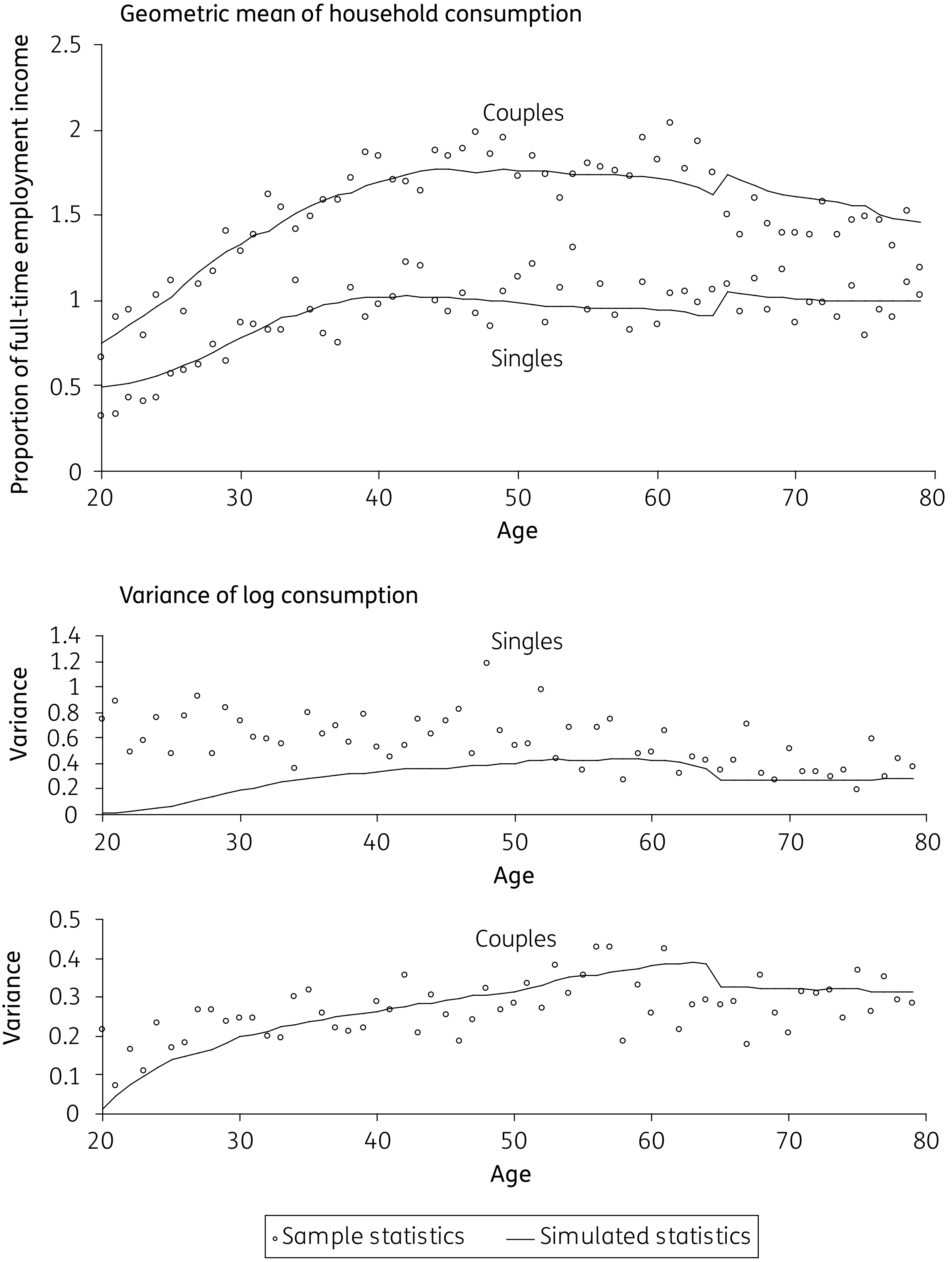
Source: FRS 2007/08 wave, and NIBAX simulations.

Figure A.3 Moments of disposable income by age and relationship status



Source: FRS 2007/08 wave, and NIBAX simulations.

Figure A.4 Moments of consumption by age and relationship status



Source: FRS 2007/08 wave, and NIBAX simulations.

Finally, the consumption moments that are reported in Figure A.4 reveal that the model obtains a close match to the geometric means observed for singles and couples, and to a slightly lesser extent the associated variances also.

A.3 Supplementary results

The supplementary results reported in this section were obtained for the model that excludes pensions, and applies no adjustment to the exponential discount factor following an (excess) reduction in the short-run discount factor – the 'very long-run' term to equivalence referred to in Section 4. Full details are available from the authors upon request.

Table 7.1 Effects of myopia on percentage of adults employed by age band and lifetime income quintile

Age band	Lowest quintile	2nd quintile	3rd quintile	4th quintile	Highest quintile
20-29	-0.6	-0.4	-0.4	-0.8	-1.7
30-39	-0.6	-0.8	-2.1	-4.3	-3.0
40-49	-1.1	0.0	-0.5	-2.7	-3.3
50-59	0.8	1.9	2.5	0.7	-0.7
60-69	2.1	1.6	2.8	7.0	2.4
70-79	-0.7	-0.8	-0.5	1.5	3.2

Table 7.2 Effects of myopia on disposable income by age band and lifetime income quintile (per cent change)

Age band	Lowest quintile	2nd quintile	3rd quintile	4th quintile	Highest quintile
20-29	-0.82	-0.95	-1.84	-3.57	-3.86
30-39	-1.73	-4.01	-6.64	-8.26	-5.44
40-49	-1.84	-3.87	-6.00	-6.99	-6.99
50-59	-1.09	-1.12	-3.97	-7.56	-5.78
60-69	-1.19	-2.09	-2.81	-0.82	0.11
70-79	-0.90	-1.53	-3.78	-6.23	-4.21
80-89	0.01	-0.27	-2.47	-9.63	-11.80
90+	-0.02	-0.25	-1.38	-4.95	-9.54

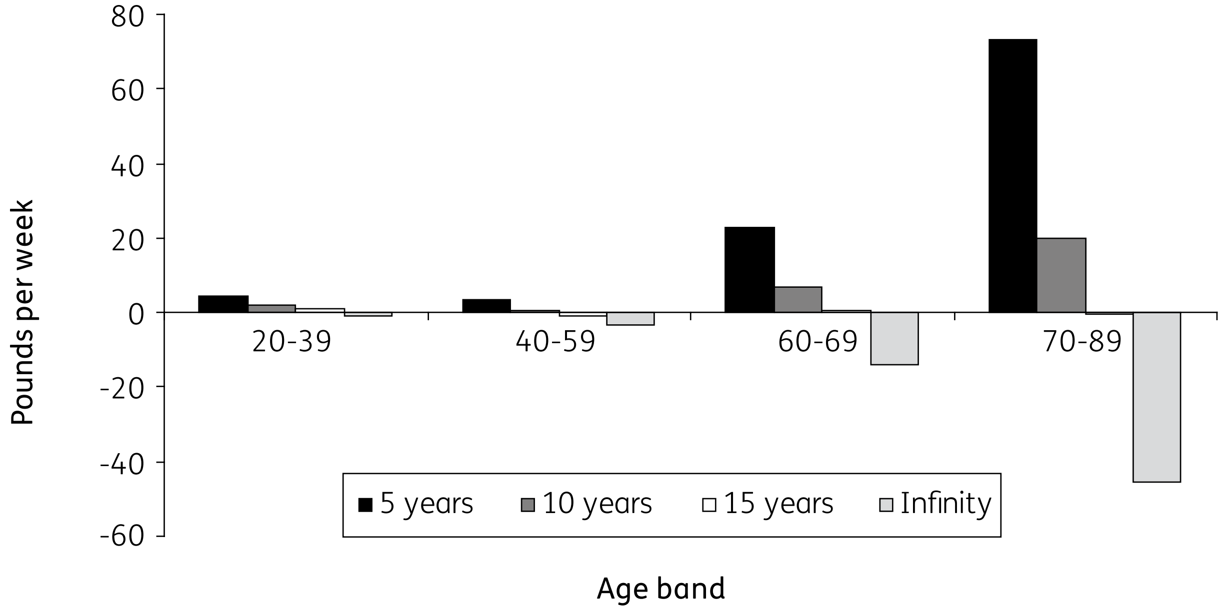
Table 7.3 Effects of myopia on unsecured debt by age band and lifetime income quintile (per cent of average annual consumption)

Age band	Lowest quintile	2nd quintile	3rd quintile	4th quintile	Highest quintile
20-29	2.18	1.23	0.86	0.58	0.31
30-39	5.17	2.52	0.96	0.36	0.09
40-49	2.60	1.91	0.35	0.06	0.01
50-59	0.24	0.13	0.02	0.00	0.00
60-69	0.13	0.02	0.00	0.00	0.00

Table 7.4 Effects of myopia on total net worth by age band and lifetime income quintile (per cent of average annual consumption)

Age band	Lowest quintile	2nd quintile	3rd quintile	4th quintile	Highest quintile
20-29	-6.13	-7.33	-7.59	-7.93	-5.91
30-39	-15.52	-32.97	-53.16	-64.20	-48.83
40-49	-15.11	-45.39	-114.42	-160.76	-135.42
50-59	-17.86	-52.78	-152.30	-272.47	-264.23
60-69	-17.03	-63.82	-178.06	-288.72	-238.09
70-79	-23.35	-70.94	-166.98	-248.69	-196.05
80-89	-14.74	-44.42	-109.07	-175.46	-144.22
90+	-4.59	-14.71	-39.45	-73.80	-71.65

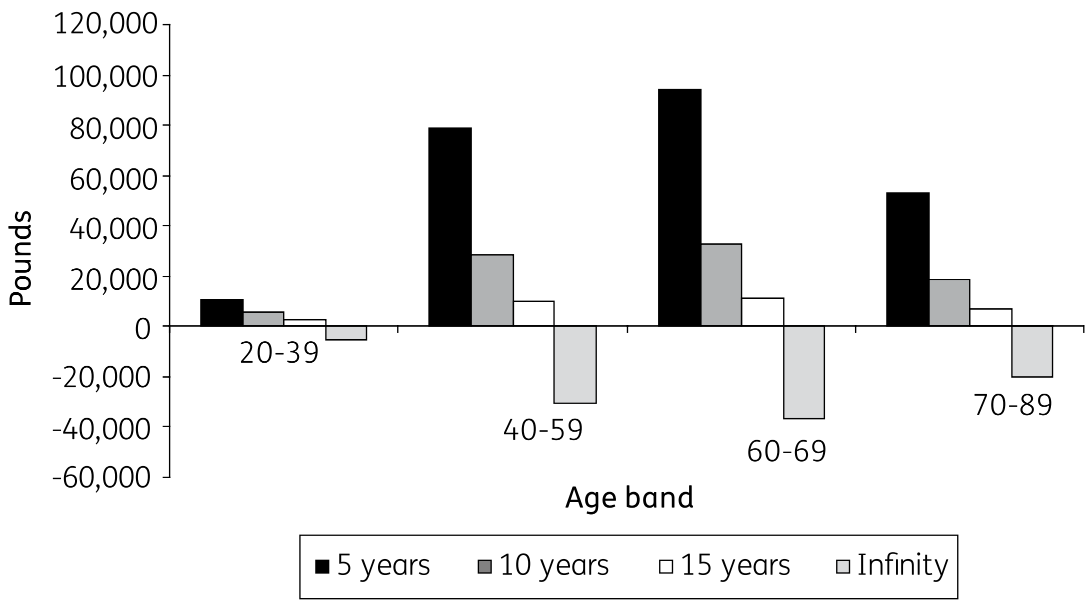
Figure A.5 Effects of myopia on consumption with a pension asset by age band and term to equivalence



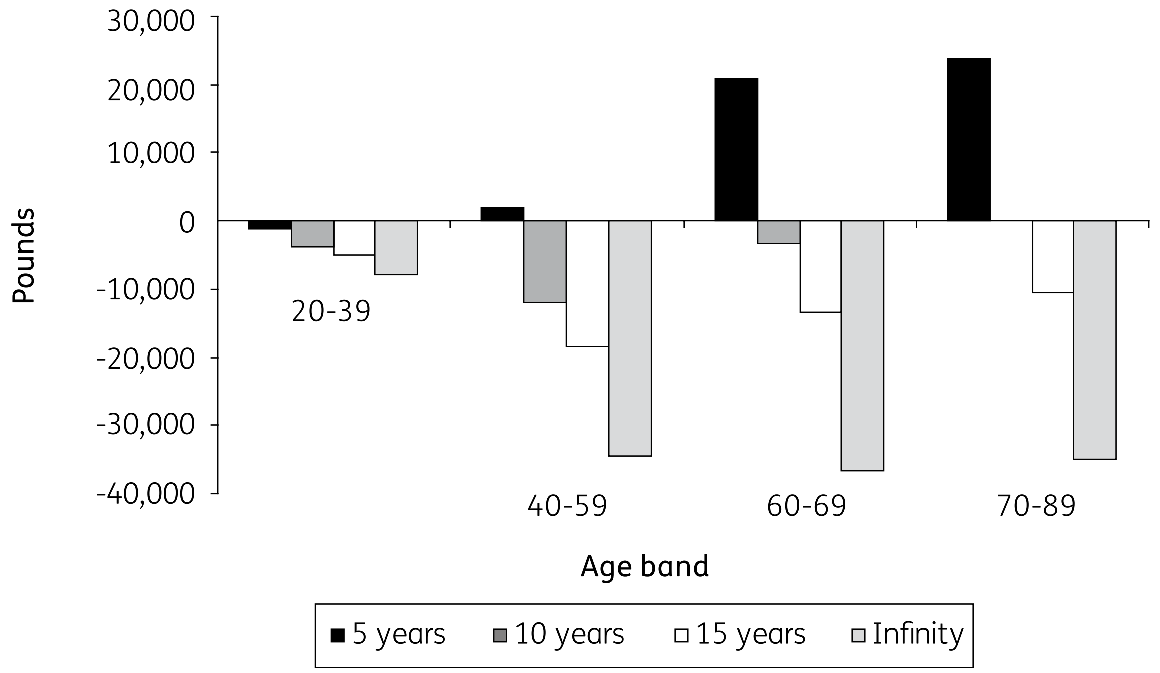
Source: Authors' calculations on output from the NIBAX model.
Bars indicate terms to equivalence, with infinity referred to as the 'very long-run' in Chapter 3.

Figure A.6 Effects of myopia on household wealth with a pension asset by age band and term to equivalence

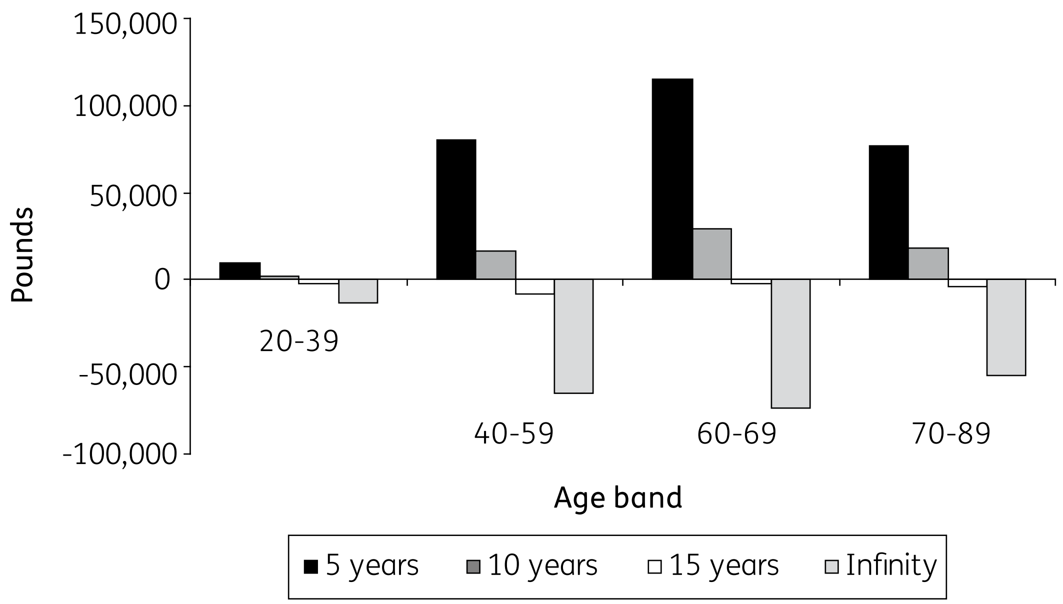
Panel A Effects on pension saving



Panel B Effects on non-pension saving



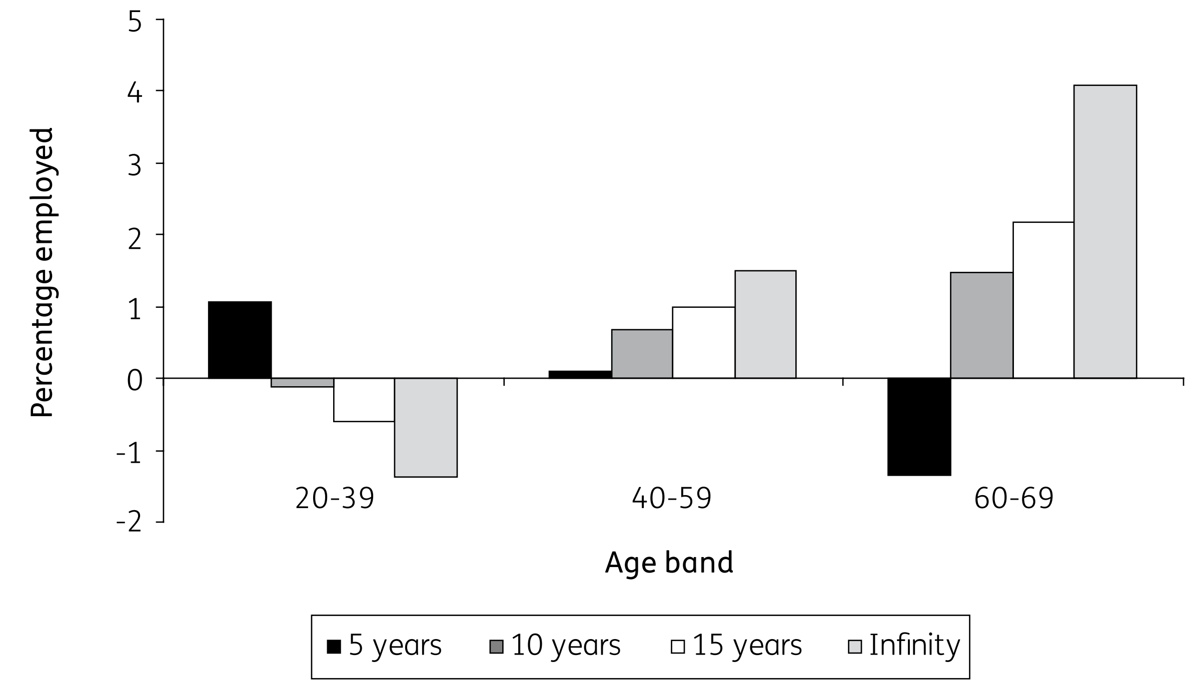
Panel C Effects on total wealth



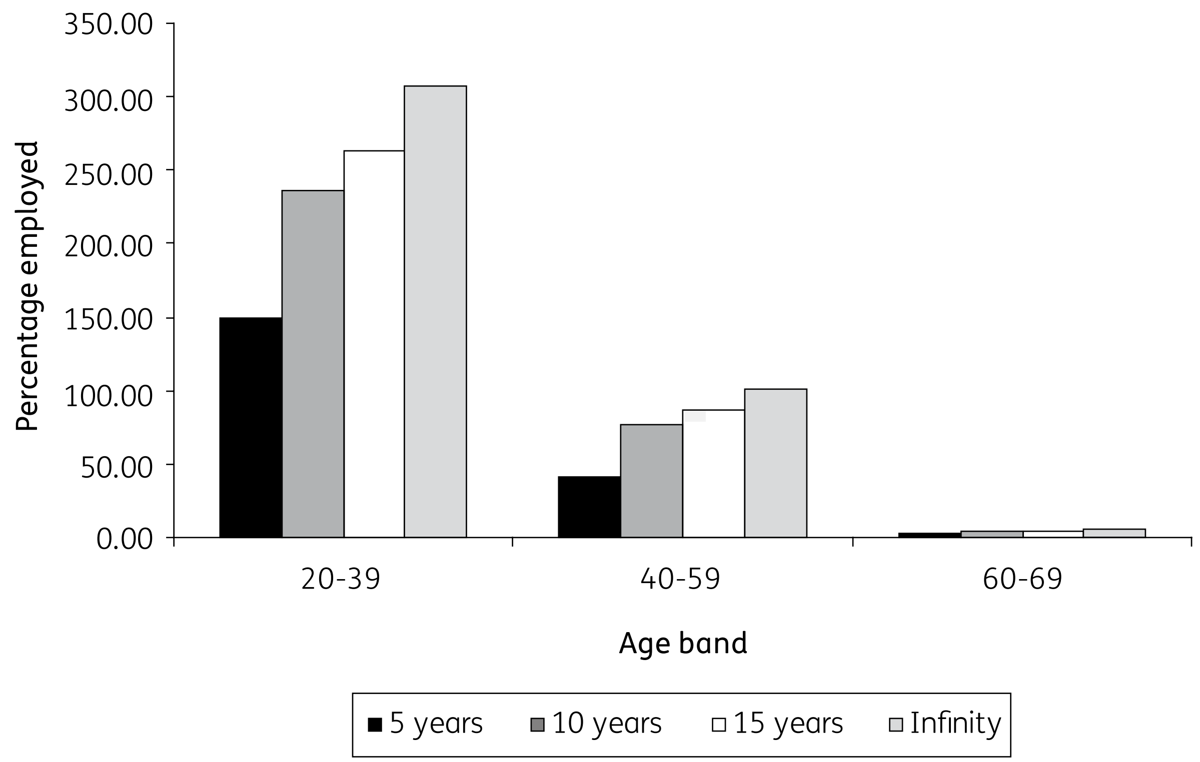
Source: Authors' calculations on output from the NIBAX model.
Bars indicate terms to equivalence, with infinity referred to as the 'very long-run' in Chapter 3.

Figure A.7 Effects of myopia on employment and indebtedness with a pension asset by age band and term to equivalence

Panel A Effects on proportion of adults employed



Panel B Effects on indebtedness



Source: Authors' calculations on output from the NIBAX model.
Bars indicate terms to equivalence, with infinity referred to as the 'very long-run' in Chapter 3.

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Although the view that at least some people are myopic has featured in contemporary policy debate, little is currently understood about the practical implications of short-sightedness in a realistic policy setting. This report publishes the results of work conducted by the National Institute of Economic and Social Research (NIESR) to help meet the information gap. The report describes analytical routines that were developed to explore the influence of myopia on savings and labour supply decisions, and which have been supplied to civil servants within DWP and HM Revenue and Customs. Illustrative simulations produced by the analytical routines indicate that myopia can have very profound – and sometimes surprising – behavioural implications. The simulations suggest that myopia will tend to reduce labour supply early in life, increase the use of unsecured credit, and depress aggregate savings. We also find that myopia tends to *increase* the age of retirement, as individuals attempt to make up for some of their savings short-fall. The simulations also suggest that allowing people to invest in pensions tends to mitigate the behavioural effects of myopia.

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