

The Effects on Consumption and Saving of Taxing Asset Returns

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EXECUTIVE SUMMARY

The aim of this study is to review what we know about how consumption and saving choices respond to tax incentives, and in particular to those taxes that change the interest rate. Whether and how much we should tax the return to saving, and whether different assets should be taxed in the same way, has been a topic of debate for both academics and policy makers. The material that we review provides a useful input to this debate by describing the likely consequences of policies that affect returns on assets.

Understanding whether and how changing the tax regime for savings is likely to alter saving behaviour requires a clear conceptual and theoretical framework. With that in mind we devote the bulk of this chapter to setting out and developing the basic model of saving over the life cycle that is the key tool economists use in thinking about why and how people save. This framework allows the analyst to specify the different incentive effects that alter saving when the return on assets changes, and to describe when the forces that increase saving will outweigh those that reduce it.

There is a large theoretical and empirical literature on the life-cycle model of consumption and saving. This literature has largely been developed separately from empirical investigations of whether changes in taxation of the return to certain assets have affected savings behaviour. A key reason is that modern versions of the life-cycle model, that explicitly incorporate uncertainty, for the most part do not tell us directly how consumption is related to factors such as present and expected levels of income, wealth, and interest rates. Quantifying this relationship is crucial for policy analysts wishing to know *how much* consumption and saving will change in response to a change in the asset return. However, ever-improving numerical techniques now provide the wherewithal to analyse precisely this type of question in increasingly realistic settings. We argue that these techniques therefore have the potential to bridge the gap between the literatures on the life-cycle model and on the observed response of saving to policy changes.

To provide a first step across this gap, in Section 7.2 we outline a specific version of the life-cycle model, which we use to simulate the behaviour of hypothetical individuals faced with different incentives to save (i.e. different interest rates). We consider an increase in the interest rate from 2% to 2.5%, a change which could be brought about by cutting the tax on interest from 40% to 25%, or from 20% to 0. For our baseline version of the model, we show that this increase in the asset return

- raises retirement wealth by almost 20%;
- increases wealth holding over the life cycle such that slightly less than 10% of the extra wealth held over the lifetime is not offset by lost tax revenue, and so can be thought of as new national saving;
- leads to an increase in lifetime welfare equivalent to that delivered by increasing consumption every period by approximately 2.1%; this is somewhat larger than the 1.9% increase in annual consumption that could be funded with the revenue from taxing the return to saving.

These conclusions are shown to be sensitive to some of the assumptions underlying our baseline. Taking account of the way in which changing family needs might shape the profile of consumption over the lifetime, or assuming that people are more reluctant to shift consumption across periods, reduce the change in savings induced by the tax change. On the other hand, a smaller change in savings does *not* necessarily indicate smaller welfare implications; in the case where people are more reluctant to shift their consumption the welfare implications of a *given change in the tax rate* increase as the response of savings gets smaller, although the revenue raised also increases.

A more general summary is that given the basic structure of the model—and the best information we have on people's willingness to shift their consumption and the way their needs and resources change over the life cycle—it is unlikely that changes in interest rates (including those brought about by tax changes) will have a big impact on the level of saving. This is consistent with our (controversial) reading of the literature on how people have responded to past changes in the taxation of assets. That is not to say that there are no behavioural effects coming from such tax changes—the empirical literature has shown that individuals do seem to respond to changes in relative interest rates by altering the mix of assets they hold.

A note of caution is that while we have been as realistic as possible in our analysis, the framework was still relatively stylized. In Section 7.3 of the chapter we outline a set of extensions to the framework that would add to its realism and to its usefulness as a tool for policy analysis. These extensions include allowing people to alter their labour supply; allowing people to hold multiple assets, perhaps including housing, other durable goods and pensions as well as a saving account; and exploring issues of habits, temptation, and procrastination that cannot be captured in the simple view of people's preferences over the life cycle.

In spite of the limitations of our analysis, we believe that our discussion illustrates why the life-cycle model is a useful—indeed, we would say

essential—tool for the analyst who wants to know how behaviour and welfare will be affected by changes in the return to saving. We hope that the simulations that we present are a useful early step for understanding how to use the model to analyse these issues.

7.1. INTRODUCTION

There are several possible reasons why policy makers might seek to reduce the taxation of the return to saving. One motivation might be given by the economic theories that, on efficiency grounds, favour an ‘expenditure tax’ that does not tax income from saving, and indeed the Meade Committee proposed an expenditure tax base (Meade (1978)). Alternatively, the aim might be to encourage more saving, if it is believed that some individuals are not building up adequate resources. Finally, the reduction may apply selectively to certain assets such as private pensions, and the aim may be to make these assets relatively attractive to potential savers.

The assessment of these rationales, and particularly of the first, which is the focus of Banks and Diamond in Chapter 6, is important for the present review of taxation and the UK tax system. While our aim is not as grand as to undertake such a sweeping assessment, the material we will be discussing is useful background to the discussion of whether these rationales are sensible or can be achieved using the policy lever of reducing the tax on the return to saving. Our purpose is to review what we know about how responsive consumption and saving choices are to tax incentives and in particular to interest rate changes.

Changes to the tax regime for saving are frequent and not always consistent. The stated reasons for such changes often refer to the second and third of the arguments mentioned in the opening paragraph. Rather than efficiency, the main motivation for changes to the taxation of interest seems to be that reducing taxes on savings will increase their total amount. Implicit in this argument is that there are good (welfare increasing) reasons for doing so—either because there are sub-optimal allocations across the life cycle or because of a perceived link between savings and investment or indeed a poorly articulated sense that thrift is good.

To understand whether changing the tax regime for savings is indeed likely to alter saving behaviour, and how, requires a clear conceptual and theoretical framework. With that in mind we devote the bulk of this chapter to setting out and developing the basic life-cycle savings model which is a key tool

of economists in thinking about savings behaviour. This choice implicitly dispenses with some of the motivations above: we will be assuming that individual households make rational choices and are not myopic or irrational in their behaviour. We justify our choice by referring to some empirical evidence that shows that the model we propose is not a bad representation of available data.

Spelling out a specific conceptual and theoretical framework to analyse the issues at hand is useful because it makes explicit the assumptions and parameters which will determine how changing the return to saving—which is obviously directly affected by the tax rate—will affect levels of saving. In a simple model we are also able to assess the welfare consequences of those changes, crucial for getting to first base in considering the appropriate salience of these issues from a policy point of view. A key point that comes out is that a small change in saving behaviour does not necessarily imply a small welfare impact from a *given change in the interest rate* (i.e. a *given rate of tax* on the return to saving). In particular, as we change the model that we analyse to reflect individuals being more reluctant to shift resources from one period to another, we find that the behavioural response to the given change in the interest rate becomes smaller but the welfare implications of the change increase.¹ On the other hand, the tax revenue raised from the given tax rate also increases.

As we discuss below, even in the simple version of the model that we present in Section 7.2, it will only be possible to quantify the impact that changes in the interest rate has on saving by using numerical simulations of some complexity. These simulations, whose use has become more and more common in the academic research on the life-cycle model, are extremely useful for rigorous policy analysis and, if one accepts a sophisticated version of the life-cycle model as a reasonable representation of reality, an indispensable tool.

A big advantage of the approach we propose is that one can deal with aggregation issues directly, by explicitly allowing for a large amount of heterogeneity across consumers, both in terms of observed determinants of consumption and saving (for instance in needs driven by changing family composition) and, possibly, in unobserved components. Our approach recognizes that heterogeneous individuals are reacting to specific incentives and determine the outcomes policy makers are interested in.

¹ In the formal model this change in preferences is a reduction in the Elasticity of Intertemporal Substitution (see Box 7.1), and the relationship between the behavioural and welfare effects is discussed in more detail in Section 7.2.1, pp. 699–702.

The approach we present is not without limitations, however. There are many important aspects that are left out of our analysis. While in what follows we discuss at some length some extensions to the model we simulate in Section 7.2, here we would like to mention four important issues that are left out of the scope of our discussion, partly to keep the length of this chapter manageable. First, the simulations we report are based on a model that assumes only a single rate of return to saving—equivalently a single asset. In fact all recent changes to the savings tax regime, whilst in general moving towards less heavily taxed status, have been applied to only some of the available savings vehicles. Therefore, these changes do not fit neatly within our exercises. Partly because of this, in Section 7.3 we review some of the empirical literature that has tried to assess the impacts of these reforms. Second, we neglect completely a bequest motive and do not discuss the issue of the taxation of bequests. We do not have a strong justification for this exclusion, which is particularly unfortunate given that there exists a lively debate among policy makers on this specific issue. A detailed and non-superficial consideration of bequests and their taxation would have increased the length of this chapter considerably. Third, we do not discuss the taxation of housing, although real estate constitutes one of the most important assets in household portfolios in the UK and other developed countries. As we explain, incorporating housing into the framework we lay out is complicated because of the transactions costs and credit constraints associated with house purchase. Finally, we do not discuss the issue of penalties to withdrawal of resources from pensions before pensionable age. These restrictions often accompany the tax privileges that are given to private pension schemes in different countries.

As well as being precise about the elements that are left out of our modelling exercises, we should also be clear that our focus is on the role of tax as it can affect the return to saving. As such we do not in general consider other levers such as the provision of information, or increased compulsory saving, that may be used to affect saving decisions (though the former is mentioned in our survey of evidence in Section 7.3). For the sake of space we also do not discuss the role of benefit withdrawal even though this is known to create large changes in the effective return to saving for some individuals:² such changes should induce similar incentive effects to those we discuss for a tax change, but limitations of data have made it hard to investigate responses to these incentives as they primarily affect lower-income individuals.

We structure our main discussion in two sections. In Section 7.2, we provide a simple theoretical framework that allows us to organize the discussion

² See Wakefield (2008), and section 3.2 of Blundell, Emmerson, and Wakefield (2006).

of the effect of taxation on saving and consumption. To illustrate the insights that this framework can provide, we use it to simulate the behaviour of hypothetical individuals faced with different incentives to save. While the model we use in this section is quite a bit more realistic than the textbook version which is often thought of when referring to the ‘life-cycle model’, it is necessarily stylized and simplified. Section 7.3 surveys what we know about the empirical relevance of the life-cycle model, with a particular emphasis on its application to considering how consumption and saving respond to changes in the interest rate. We consider both evidence on the validity of the model and estimates of some of its parameters. We then go on to discuss the relevance of more complex versions of the model. While some of these complications are bound to be relevant for our discussion, we will stress that our quantitative knowledge of these extensions is very limited. Therefore, in the last part of the section we also discuss some more direct (and less structural) evidence on the response of savings to changes in its theoretical determinants. Section 7.4 concludes.

7.2. THE LIFE-CYCLE MODEL AND THE RESPONSE OF SAVING TO TAXATION

In this section we provide a simple theoretical framework that allows us to organize the discussion of the effect of taxation on saving and consumption. The behavioural model we use, the so-called life-cycle model of Modigliani and Brumberg (1954), is not meant to be a literal description of reality but can capture some important features of individual households’ behaviour. It also constitutes a useful benchmark against which we can contrast the implications of more complex and possibly more realistic models. Before we delve into the specifics of the model, we want to emphasize *why* we think it is important to understand this framework if one wants to analyse the effects on consumption and saving of taxing asset returns.

The life-cycle model is a workhorse of modern macroeconomics and public finance. Proposed by Modigliani and Brumberg (1954) in a seminal contribution, it shares with the Permanent Income Hypothesis of Friedman (1957)³ the idea that individuals allocate resources over time (and therefore determine current consumption and saving—or, equivalently, present and future consumption) taking into account the resources available over a long

³ Unlike the permanent income model, which is usually thought of as a model with an infinite horizon, the life-cycle model focuses explicitly on a finite horizon and is therefore particularly useful for studying retirement saving and related issues.

period of time and the possibility of moving them over time. The latter might mean saving to move purchasing power from the present to the future, or borrowing to shift purchasing power from the future to the present. The attractiveness of the life-cycle model and of the permanent income hypothesis is that they treat the allocation of consumption over time (saving) in a manner analogous to that of the allocation of a certain amount of expenditure among several commodities. This powerful intuition is behind some of the optimal taxation results that Banks and Diamond discuss in Chapter 6.

The conceptual framework provided by the life-cycle model makes clear that a change in the interest rate changes the relative price of consumption between time periods. Thus a measure of how much an individual will shift consumption from one time period to another (by saving or borrowing) in response to a change in the relative price of consumption in those two periods becomes crucial for understanding the effects on consumption and saving of a change in the interest rate. Precisely such a measure is provided within the model by a parameter known as the ‘elasticity of intertemporal substitution’ (EIS—for a fuller discussion see Box 7.1). As this elasticity gets smaller, so the increase in saving when the interest rate increases gets smaller. Indeed, when the EIS is very small saving may actually fall when the interest rate increases (Section 7.2.1, pp. 686–7, discusses the mechanisms through which this may happen). Despite the clear relevance of the EIS, a remarkable feature of the sizeable recent literature on the effect of the preferential taxation of retirement wealth on personal and national saving is that it never refers to the literature that has studied the life-cycle model and estimated preference parameters, including the EIS.

One possible reason for this neglect might be the feeling that the life-cycle model constitutes a poor approximation of reality. An alternative reason for the disjuncture of the two literatures, however, could be that modern versions of the life-cycle model that explicitly incorporate uncertainty, for the most part do not deliver a closed form solution for consumption. That is, one can write down optimality conditions that can be used in the empirical analysis, but cannot use them to solve for an expression for consumption as a function of, say, present and expected future income, current wealth, and the level of current and future (expected) interest rates. This lack of a consumption function that could be used for policy analysis has led public finance economists to neglect the consumption literature. The exercises in this chapter start to fill this gap, and demonstrate the potential for progress in this area through the use of ever-improving computational techniques.

We begin by providing a more specific outline of a simple version of the life-cycle model, which we then use to simulate the behaviour of hypothetical individuals faced with different incentives to save. This exercise will give

us the theoretical effect that one would observe in response to changes in the taxation of saving if individuals behave according to the stylized model. We then show that different effects are obtained when additional factors are added to the model. One point we will make is that the life-cycle model is a potentially very rich structure that can encompass and explain different types of behaviour. The issue of which version of the model is relevant is ultimately therefore an empirical question and in Section 7.3 we discuss the available empirical evidence.

Box 7.1. Formalizing the model, the Euler equation and the Elasticity of Intertemporal Substitution

Formalizing the life-cycle model

We interpret the life-cycle model as one in which an individual maximizes lifetime utility derived from consumption using her lifetime resources and taking into account the available inter-temporal trades. Using the assumption that utility is additively separable across periods—i.e. that consumption today does not directly affect the marginal utility from consumption tomorrow—we can write this down as:

$$\max_{\{c_t\}} U(c_0) + E_0 \sum_{t=1}^T \beta^{-1} U(c_t).$$

Subject to an inter-temporal budget constraint:

$$A_{t+1} = A_t(1 + r) + y_t - c_t$$

where $U(\cdot)$ is the within period utility function, c is consumption, β is the subjective discount factor, A is the level of assets, r is the interest rate, y is income, and E is the expectations operator.

The Euler equation

In general, apart from very special assumptions about the utility function and/or the nature of uncertainty, this problem does not have a known closed form solution—that is, there is no known form for the consumption choice as a function of resources.

However, there are certain well-known features of the solution for a more general case. Under certain regularity assumptions for the utility function, and abstracting from factors such as credit constraints, the solution will satisfy the following condition for the evolution of the marginal utility of consumption (the rate of change in utility when there is a small change in consumption).

This is the ‘Euler equation’:

$$U_{c_t} = (1 + r)\beta^{-1} E_t\{U_{c_{t+1}}\}.$$

(cont.)

Box 7.1. (cont.)

Where U_{ci} is the marginal utility of consumption at period i (i.e. the first derivative of the utility function with respect to consumption), and the interest rate and discount factor have been assumed to be certain and fixed.

This condition may be interpreted as saying that consumption will be chosen such that the marginal utility of consumption evolves smoothly over the life cycle. In the case with no uncertainty, the condition says that the marginal utility of consumption will grow at a rate determined by the excess of the interest rate over the rate at which individuals discount the future. With a standard, time-invariant utility function, this will involve consumption declining steadily over the life cycle when the discount rate exceeds the interest rate, or growing steadily when the interest rate is larger than the discount rate.

For more details on the Euler equation and its interpretation see, for example, Attanasio (1999).

The Elasticity of Intertemporal Substitution

We are interested in the responsiveness of consumption and saving choices to a change in the interest rate. A change in the interest rate represents a change in the relative price of consumption at different points in time, and the Elasticity of Intertemporal Substitution (EIS) plays a crucial role in determining the responsiveness of consumption choices to such relative price changes. The larger is the EIS, the larger will be the shift in consumption from one period to another following a change in the relative price of consumption in those two periods, and for a very small EIS consumption will be almost unaffected by such relative price changes.

Formally, the EIS measures the proportional change in the ratio of consumption levels between two periods, divided by the proportional change in ratio of marginal utilities from changing consumption in these periods:

$$EIS = \frac{\partial(c_i/c_j)}{c_i/c_j} \bigg/ \frac{\partial(U_{ci}/U_{cj})}{U_{ci}/U_{cj}} = \frac{\partial \ln(c_i/c_j)}{\partial \ln(U_{ci}/U_{cj})}.$$

Where i and j are time periods, and U_c is the marginal utility of consumption. In our simulations we use the constant relative risk aversion utility function:

$$u(c) = (1 - \gamma)^{-1} c^{(1-\gamma)} \quad (*)$$

This functional form implies that the EIS is equal to the inverse of the relative risk aversion parameter, i.e. $EIS = 1/\gamma$.

Using the Euler equation to provide evidence on the EIS

The relationship between the *EIS* and the way consumption changes in response to changes in the interest rate is neatly seen within the Euler equation mentioned

above. With the utility function in equation (*), the Euler equation can be written as follows:

$$\Delta \log(c_{t+1}) = k_t + \frac{1}{\gamma} r_{t+1} + \varepsilon_{t+1} \quad (\dagger)$$

where the left-hand side of the equation is the consumption growth rate, the term k_t represents a variety of observable and unobservable factors, and the term ε_{t+1} is a residual term that represents expectational errors, that is, factors affecting consumption at $t + 1$ that were not known to the consumer at t . The EIS ($1/\gamma$) is seen directly to capture how much consumption at $t + 1$ changes relative to consumption at t in reaction to a change in the interest rate.

The simplicity of this final representation of the Euler equation makes it a useful basis for empirical analysis aimed at providing evidence on the plausibility of the life-cycle model and/or at estimating the value of the EIS.

7.2.1. A specific life-cycle model

The life-cycle model as we have so far described it is a rather general framework. In order to bring it to bear on reality, we need to make a number of assumptions about the details of the various components of the model. We therefore introduce the version of the model that we use to simulate the behaviour of hypothetical individuals, by discussing some of the key assumptions that we need to make in order to operationalize the model. This discussion highlights why the model is useful, but also awkward to use, for analysing the tax policy and public finance questions we are interested in. The results that we present in this section at pp. 690–702 are intended to provide an accessible introduction to using the model to think about how individuals respond to incentives to save.

Before going into the details of the model it is worth stressing that the model is one of *individual* behaviour. As such it is easy to incorporate various forms of observed and unobserved (by the researcher) heterogeneity in it. This can take the form of heterogeneity in parameters or, more conveniently, heterogeneity in some of the determinants of individual choices, such as needs, income processes, tastes, and so on. As we shall see, once we have the basic model, it is easy to introduce these aspects into the picture.

Features of the model

The basic version of the model that we use corresponds to that formalized in Box 7.1. In the simplest version of the model we consider a single decision

unit, that is, an individual whose utility depends on consumption over her life cycle. While we will maintain the assumption of a single and monolithic decision unit that maximizes a single utility function, in a more complicated version of the model that we consider below we consider a household whose composition might change over time as children are born and eventually leave the parental home. In this chapter we do not consider models where different individuals in the households might have different utility functions.

Individuals maximize expected utility, and utility each period is derived from consumption in that period and is not affected by consumption in other periods. Future utility is discounted at a geometric rate.

The resources that individuals use to fund their consumption arrive as an income stream which is exogenous in the sense that we do not model a labour supply choice and so the level of income does not depend on any choice made by the individual. The income process is modelled as being made of a deterministic component, assumed to be known perfectly by the individual, and a stochastic (or risky) component. Our individuals are assumed to be aware of the process that generates it. After a certain age, individuals are assumed to retire and to be entitled to benefits that are a fixed proportion of the last earnings of their working life.

We assume that life has a fixed duration which is known to individuals and that there is no bequest motive. Moreover, individuals are not allowed to die in debt. In terms of the inter-temporal trades available to the individual, we assume that individuals have a single asset that pays a fixed interest rate to move resources in to the future. We also restrict the amount individuals can borrow.⁴

In the simplest version of the model, we assume that the individual/household whose consumption we study has constant consumption needs throughout the life cycle. We then introduce more realistic settings where household size, and therefore the needs households have, vary deterministically with age.

Some of the assumptions we make are very stark and unrealistic. However, many of them can be relaxed in a relatively simple fashion and/or have minimal effect on the main results we obtain concerning consumption choices and how consumption and saving respond to changes in the interest rate. A good example of such an assumption is that of certain life length. One can introduce the possibility that an individual dies with some known probability

⁴ Under certain assumptions on preferences, individuals will never want to borrow. This occurs when the marginal utility of consumption goes to infinity at a very low level of consumption. Individuals will not want to borrow if this induces a positive probability of having extremely low levels of consumption.

(possibly increasing in age) without much complication—a probability of not reaching the next period of life essentially has the same effect on current behaviour as an increase in the discount rate.

Other assumptions, however, are crucial for the results we will be discussing and cannot be relaxed without substantially changing the nature of the model⁵ and the implied results. One such assumption is that of intertemporal separability, which implies that consumption at a certain date does not affect the marginal utility derived from consumption at different dates. This assumption rules out the existence of durable goods which deliver consumption services for more than one period, and of habit formation whereby current utility is affected by the level of consumption to which the agent has become accustomed. A second such assumption is that labour income arrives without being affected by a labour supply choice. This exogeneity assumption is strong, and the implications for consumption and saving choices will be particularly pronounced if labour supply choices directly affect the utility derived from consumption—because consumption and leisure are either complements or substitutes. We briefly discuss models with labour supply, and models with durable goods or habits, in Section 7.3.2.

Some of the basic insights of the life-cycle model we will be analysing are well known and do not need to be discussed in detail here. Consumption at any point in time depends not only on current income, but also on the total amount of resources available to an individual over her life cycle. Consumption should react to the interest rate, although it is well known that, at least theoretically, the effect on consumption of changes in interest rates is ambiguous. This is because there are several mechanisms by which a change in the interest rate will affect current consumption. We describe these mechanisms considering the case of an increase in the interest rate; the same mechanisms would lead to consumption shifting in the opposite direction following an interest rate decrease. The increase in the interest rate represents a decrease in the price of future consumption relative to current consumption, and this induces a ‘substitution effect’ of a decrease in current consumption and a commensurate increase in current saving. This would be counteracted by an ‘income effect’ since with a higher interest rate a given target level of future consumption is achieved with less saving. As noted by Summers (1981), wealth effects concerning the amount that expected future incomes are discounted tend to reinforce substitution effects and also lead to a decrease in consumption or increase in saving when the interest rate goes

⁵ When the nature of the model is changed, this can quickly increase computational complexity of the numerical solution.

up. These wealth effects tend to be stronger when the time period that the individual cares about is longer. Ultimately, which of these forces dominates depends on preference parameters and is, therefore, an empirical issue.

The computations we provide have to be obtained by numerical methods. These, however, have become increasingly standard and affordable, both because of the increased power of computers and because of a small literature that, starting with Deaton's (1991) contribution, has looked at the solution of life-cycle models of increasing degree of complexity and realism. Much of the existing literature has been devoted to the plausibility of the standard LC-PI and of slightly different models, such as the so-called buffer-stock model. Here what we do is to simulate some versions of the standard model to show two things. First, we want to see how the responsiveness of savings to the interest rate varies with preference parameters and other features of the model, including the institutional set-up in which the behaviour of our consumers is embedded. Second, we want to compute saving and wealth elasticities to the interest rate implied by parameters estimated from micro data for some realistic versions of the model that is not rejected in an obvious way by the same data.

Details of the model

Having described the key assumptions that we need to make to operationalize the model, we must now be precise about the parameters that we impose when simulating the behaviour that the model predicts. Table 7.1 reports the key parameters of the baseline model and of the alternatives we simulate.⁶

As discussed above, a key preference parameter is the EIS, which is set to 1 for our baseline results.⁷ This is at the high end of the range of values that have been estimated for this parameter (see Section 7.3.1, pp. 708–10), and we also conduct analyses for values of $1/2$ and $1/4$. The discount rate is set at 2.5%, which is equal to the larger of the two real interest rates for which we simulate behaviour.

The process generating income is also important to our results. There is a deterministic component of income which is hump-shaped during working life and assumed to be known perfectly by the individual. The parameters that determine the shape of the profile of this component of income are set to match profiles observed for family incomes in the British Household Panel

⁶ We would like to thank Hamish Low for help with the initial set-up of the simulated life-cycle model used here, though we are solely responsible for any errors in the simulations or their interpretation.

⁷ The EIS = 1 implies that the utility function has the logarithmic form.

Table 7.1. Model parameters

Parameter	Baseline	Variants
Utility Parameters		
EIS	1	1/2, 1/4
Discount rate	2.5%	
Income process		
Initial income growth rate (expected)	3.4%	
Age at peak expected income	50	
Ratio of peak income to initial income	1.6	
Variance of permanent shock (to log income)	0.030	0, 0.060
Variance of transitory shock (to log income)	0.030	0, 0.060
Replacement rate in retirement	0.5	0.25, 0.75
Retirement age	65	
Others		
Real interest rate	2%	2.5%
Lifespan	60 yrs (21–80)	

Survey (BHPS).^{8,9} Income is expected to grow at approximately 3.4% per year at the beginning of the working life, and the expected growth rate then gradually declines until the expected income peak of approximately 1.6 times initial income is reached at age 50. There is also a stochastic component of income and individuals are assumed to be aware of the process that generates this. It is made up of a transitory shock,¹⁰ and a permanent (random walk) component. The variances of the shocks to these components are set approximately to match values estimated by Meghir and Pistaferri (2004),¹¹ and are similar to the values imposed by Low (2005) in his simulation exercises. Income in retirement is certain, and in our baseline run is equal to half the final income of the working life. As Table 7.1 indicates, we conduct analyses with alternative values of the variances of the income shocks, and of the retirement income replacement rate.

A final factor that we consider in our model is how varying consumption needs affect our results. In the baseline version of the model, we assume that

⁸ We use a measure of income that excludes investment income, and data from the years 1991–2002.

⁹ Data from the BHPS were made available through the UK Data Archive <<http://www.data-archive.ac.uk/>>, which is now incorporated within the Institute for Social and Economic Research at the University of Essex. Neither the original collectors of the data nor the Archive bear any responsibility for the analyses or interpretations that are presented here.

¹⁰ The transitory shocks are independently and identically distributed across time and individuals.

¹¹ Meghir and Pistaferri (2004) use US data, and we take their estimates of the unconditional variance of these shocks. The main discussion of their paper has implications for whether the values of these unconditional variances can be sufficient to characterize the evolution of earnings shocks.

the individual's consumption needs are constant over the life cycle. If, instead of a fictitious individual we consider a household, we can compare this version of the model to one in which consumption needs are increased between the ages of 22 and 58 due to the presence of children in the household. In this version of the model, utility is defined in terms of consumption per adult equivalent, and consumption is scaled down in the utility function during the years when children live in the parental home. The scaling factors are set to match the average number of children of couples of each age in the BHPS in 2002,¹² and family size and consumption needs are assumed to peak in the late 30s.

Model results

(a) Profiles of consumption and asset holding

Probably the best way to introduce our results is to present some pictures of life-cycle profiles for consumption and wealth under different scenarios. For example, in Figure 7.1, we plot the life-cycle profile for consumption in our baseline run. This picture, as the others reported below, is obtained by simulating the life cycle of 10,000 individuals who each receive a particular realization of the assumed income shocks¹³ and averaging the relevant variable of interest. The figures report plots of these averages.

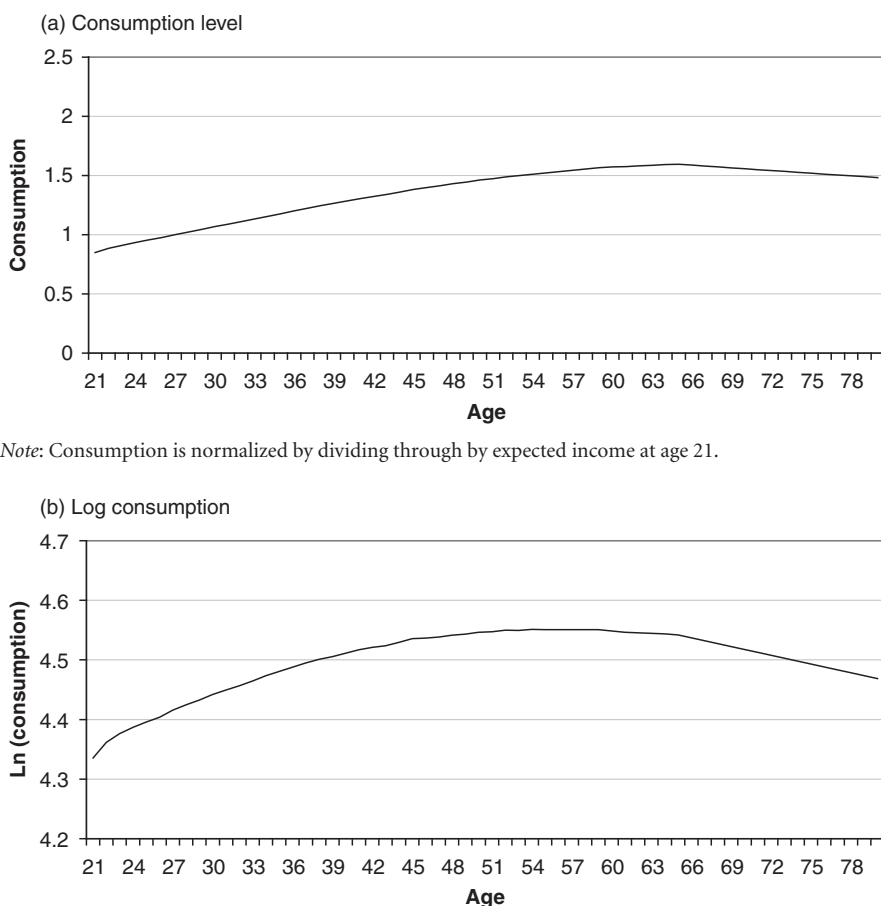
The profile for average consumption in Figure 7.1(a) is shaped both by the savings motives that determine individuals' consumption choices and by the ability individuals have to transfer resources over time and, in particular, the presence of credit constraints. In addition, in our specific example, the shape of the consumption profile is also driven by the assumptions made about the stochastic component of income and its variability.¹⁴ To get a clearer picture of the influence of constraints and the motives for saving, in panel (b) of the figure we also plot the mean of log consumption.

The individuals modelled are impatient in the sense that the subjective discount rate on utility received in the future (2.5%) is greater than the

¹² The scaling factor is such that in utility the consumption of a couple with one child is scaled down by a factor of 1.35 relative to that of a couple, for a couple with two children the factor is 1.7, and so on. In order to smooth out the data, we fit a quartic regression through the values of the average number of children at each age, and use the predictions from this regression to compute our scaling factors. We also adjust the equivalence scale equally at all ages so that the discounted value of equivalized income in the model with family needs is equal to the discounted value of income in the baseline version of the model.

¹³ The shocks are assumed to be independent across individuals.

¹⁴ Shocks to the permanent component of income are assumed to have a log-normal distribution. The variance of individual income will therefore increase with age. When we average across individuals the *level* of income, Jensen's inequality will imply that the mean of income will also increase.



Note: Consumption is normalized by dividing through by expected income at age 21.

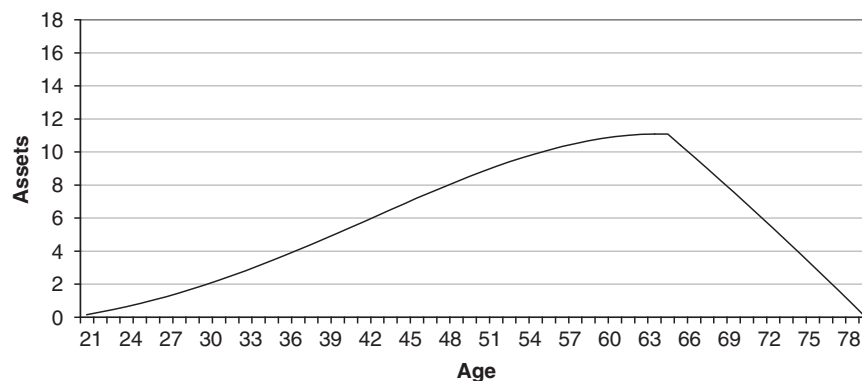
Figure 7.1. Average consumption by age: baseline case

rate of interest (2%). Therefore, as discussed in the section on ‘The Euler equation’ in Box 7.1, in a certain and unconstrained world these individuals would like consumption to decline steadily throughout the life cycle. This profile is not achieved because of credit constraints and what has been defined ‘precautionary saving’. The former prevent the individuals from borrowing to bring consumption forward to the early years of life when income is low relative to expected lifetime resources. Precautionary saving arises because, given the shape of the utility function (technically a convex marginal utility), the presence of uncertainty encourages the holding of assets as a form of insurance against shocks. These factors outweigh the impatience for most of the working life and so the profile for mean log consumption is upward sloping until the late 50s. At the point of retirement (age 65) all uncertainty

ceases and individuals have built up stocks of retirement wealth so that they are no longer credit constrained. At this age the consumption growth rate kinks downwards and remains constant for the remainder of the lifetime as individuals achieve the steady downwards drift in consumption that is optimal in the unconstrained, certain scenario.

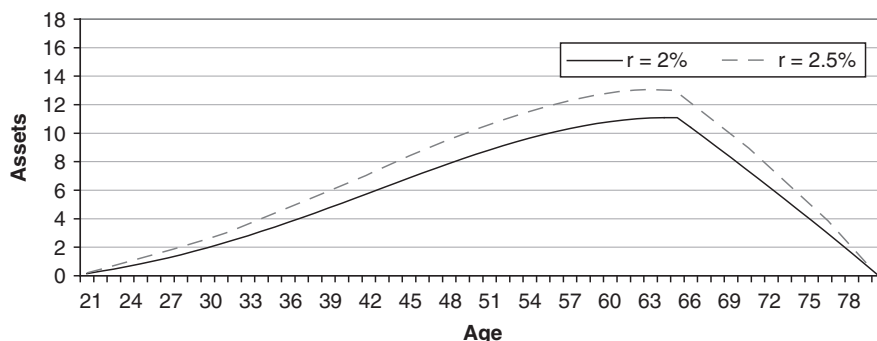
The factors shaping the average consumption profile also show up in the profile of average asset holdings across the life cycle, which is plotted in Figure 7.2. In this picture, the level of assets is scaled by expected income at age 21, so the peak level of asset holdings at age 65 is equal to approximately eleven times expected initial income. Assets are seen to increase fairly steadily throughout the working life, although most rapidly between the ages of 35 and 50 when income is, on average, high relative to expected resources and so individuals engage in retirement saving. There is a decrease in the rate of increase in assets as retirement approaches and income falls, and a subsequent running down of assets after age 65.

Our main interest is to determine how the profile of asset holding changes when the real interest rate is increased from 2% real to 2.5%. This would roughly correspond to a case in which the pre-tax interest rate is 3.3% and the tax rate on saving is reduced from 40% to 25%, or alternatively we might think of the tax rate being reduced from 20% to 0 when the pre-tax rate of return is 2.5%. In Figure 7.3, we plot two average profiles of asset holdings, corresponding to these two different values of the interest rate. Figure 7.4 shows how the level of accumulated assets changes, on average, in each period of life, which may be thought of as the average effect of the change in the interest rate on asset holdings. Under the assumption about the EIS in our baseline



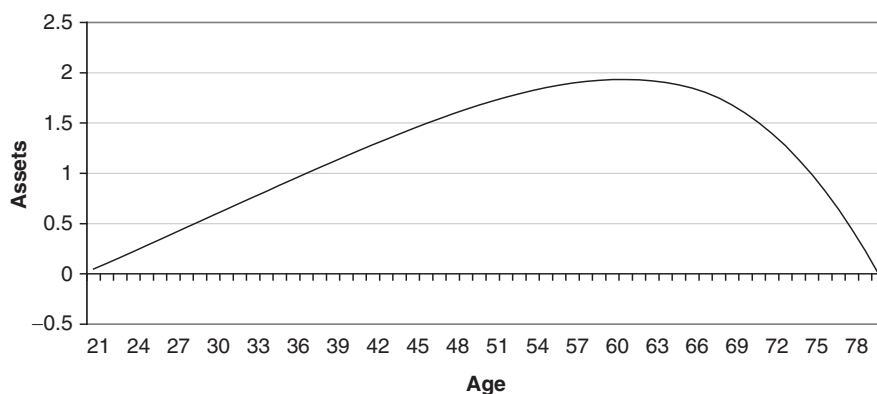
Note: Assets are normalized by dividing through by expected income at age 21.

Figure 7.2. Average asset holdings by age: baseline case



Note: Assets are normalized by dividing through by expected income at age 21.

Figure 7.3. Average asset holdings by age: baseline case, different interest rates

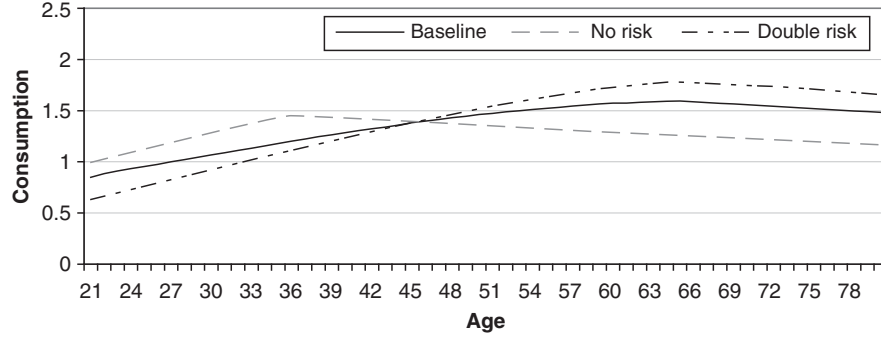


Note: The change in assets is normalized by dividing through by expected income at age 21.

Figure 7.4. Average change in asset holdings by age when r changes: baseline case

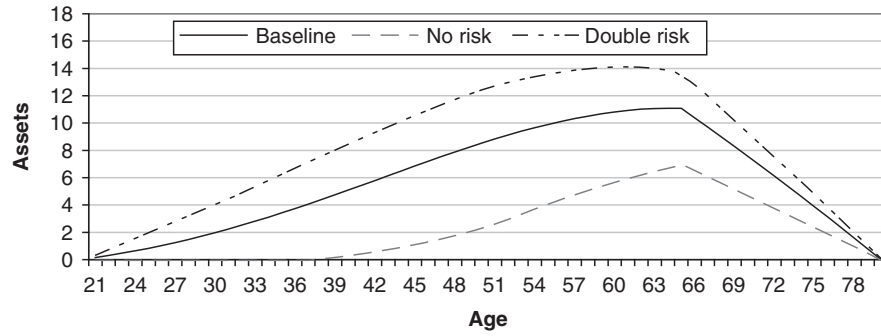
run ($EIS = 1$), the average change in assets induced by the higher interest rate is non-negligible and increases steadily through most of the working life. The average effect on asset holdings is largest around age 61 when assets are increased by approximately 1.9 units (i.e. 1.9 times average initial income), or 18%, in the high interest rate regime compared to the low interest rate regime.

To examine the extent to which the results in Figures 7.1 to 7.4 are driven by the assumptions we have made concerning the level of income risk, in Figures 7.5 to 7.7 we show results for different levels of risk. In order, the figures show average consumption profiles, average asset holdings, and the average change in asset holdings when the interest rate is changed, for three different assumptions about the variance of shocks to income. In each figure,



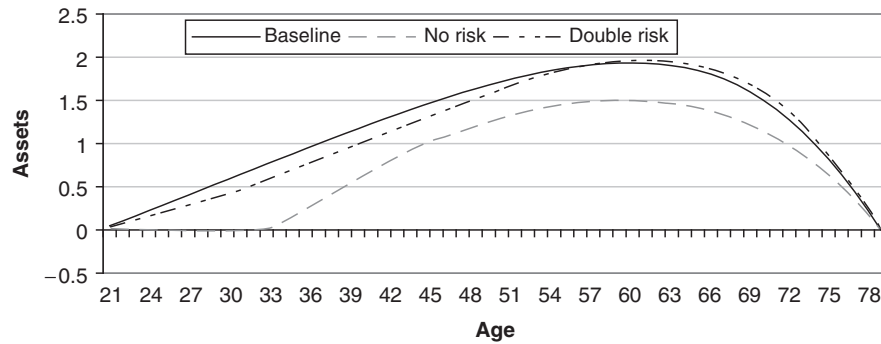
Note: Assets are normalized by dividing through by expected income at age 21.

Figure 7.5. Average consumption by age: different levels of income risk



Note: Assets are normalized by dividing through by expected income at age 21.

Figure 7.6. Average assets by age: different levels of income risk



Note: The change in assets is normalized by dividing through by expected income at age 21.

Figure 7.7. Average change in asset holding by age when r changes: different levels of income risk

the continuous line is for the baseline case which we have already discussed, the line made up of alternating dashes and dots is for the case of no income risk,¹⁵ and the dashed line is for a case in which the variances of the shocks to (log) income (both permanent and transitory shocks) are doubled compared to the baseline run.

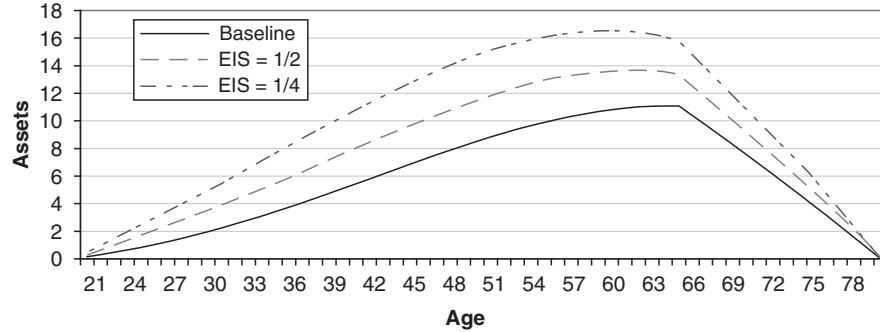
The plots for the case with no risk are a particularly useful benchmark against which to compare our baseline run, since with no risk in the model the plotted profiles are effectively for a single individual facing a lifetime income profile that is fixed at the mean level in the model. The consumption profile for the individual facing this profile with certainty is initially upward sloping as credit constraints force a consumption profile that tracks income. Once income is sufficiently high that the credit constraint no longer binds, the consumption profile follows the downward sloping path that is preferred by the agent. Figure 7.5 shows that relative to this certain case, average consumption in our baseline case is lower in early life, and higher at later ages, and this pattern is more pronounced when this amount of risk in the economy is increased. The relative shapes of these profiles are reflections of the fact that average saving is higher when there is more uncertainty (Figure 7.6).

When we consider in Figure 7.7 the average change in asset holding induced by the change in the interest rate, we see that the two uncertain cases have rather similar profiles which are higher than the profile for the individual facing certainty. However, as we shall see, this difference between the certain and uncertain cases, is small relative, for example, to those that are due to changing the EIS while holding the level of risk constant.

To see how the EIS affects the results, we repeat the exercise that yielded Figures 7.6 and 7.7 for three different levels of the EIS. We report the graphs corresponding to this exercise in Figures 7.8 and 7.9. In Figure 7.8 we plot the average level of assets corresponding to three different levels of the EIS (1, $\frac{1}{2}$ and $\frac{1}{4}$), while in Figure 7.9 we report the effect of the change in interest rate corresponding to these same three levels of the EIS. Assets are in general higher for lower levels of the EIS because the lower value of this parameter implies that the individual wants to achieve a smoother path of consumption across the life cycle, and in the set-up we are modelling this requires extra retirement saving. On the other hand, the effect on asset holdings of a change in the interest rate is considerably *smaller* for lower levels of the EIS.¹⁶ For

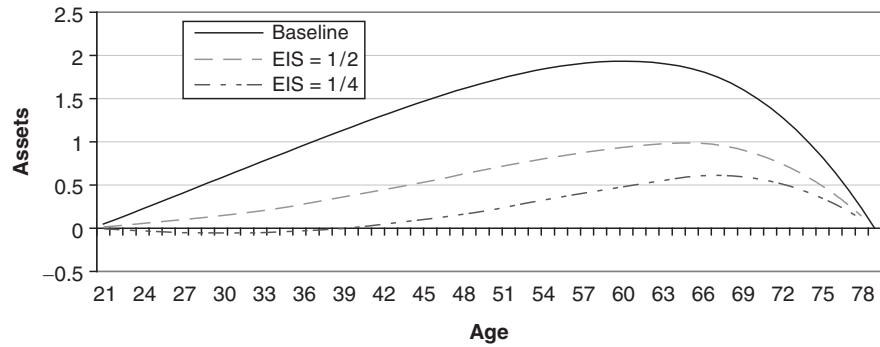
¹⁵ With no risk in the model the plotted profiles are effectively for a single individual facing a fixed lifetime income profile.

¹⁶ Indeed, in the case with the EIS = $\frac{1}{4}$, the average change in assets is very slightly negative during the early years of the life cycle. This illustrates how income effects—which tend to reduce saving when the interest rate goes up—become more important relative to substitution effects as the EIS is reduced.



Note: Assets is normalized by dividing through by expected income at age 21.

Figure 7.8. Profile of average asset holdings: baseline case, different preferences

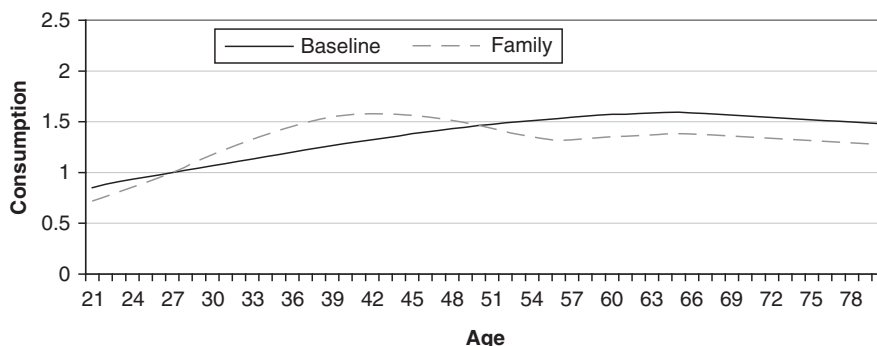


Note: The change in assets is normalized by dividing through by expected income at age 21.

Figure 7.9. Average change in asset holdings when r changes: baseline case, different preferences

instance, halving the EIS from 1 to $1/2$ reduces the peak effect of the interest rate change on asset holdings from about 1.9 units to approximately 1 unit. The decline in this effect clearly illustrates that the EIS is a measure of the responsiveness of consumption choices to relative prices of consumption at different points in time (see Box 7.1): this responsiveness declines as the EIS declines.

The model we have considered so far is unrealistic in that it does not consider changes in consumption needs over the life cycle. Our first extension to the basic model is to introduce such needs. As mentioned at the end of Section 7.2, pp. 689–90, this involves defining utility in terms of consumption per adult equivalent, so that a given level of consumption delivers less utility during the years when children are living in the parental home. Note that



Note: Consumption is normalized by dividing through by expected income at age 21.

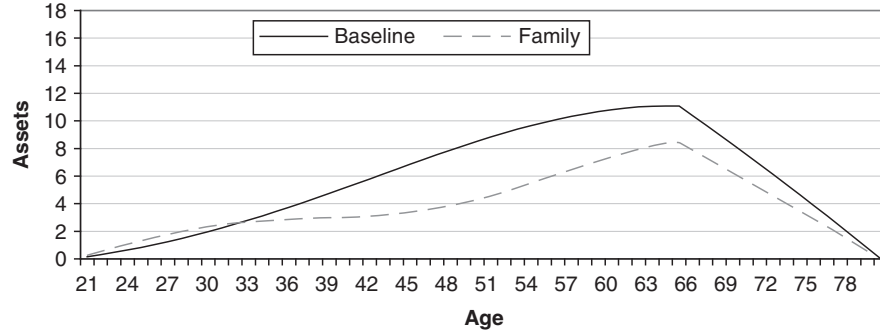
Figure 7.10. Profile of average consumption, with and without family

when we introduce family needs, we do this in such a way that the expected present discounted value of equalized lifetime resources at the start of life is set equal to the present value of lifetime resources when family needs are not modelled.¹⁷ The thought experiment is thus to see how our results changed due solely to the introduction of family needs.

In Figure 7.10, we plot, together with the baseline consumption profile plotted in Figure 7.1, the consumption profile implied by a model with changing consumption needs. As noted in Attanasio and Browning (1995) and Attanasio, Banks, Meghir, and Weber (1999), the explicit consideration of changing family size and composition generates a hump-shaped life-cycle consumption profile. This hump shape follows from the hump-shaped nature of the profile of adult equivalents over the life cycle, and can clearly be seen in Figure 7.10 which contrasts the profile of average consumption when family needs are modelled to that in the baseline run.

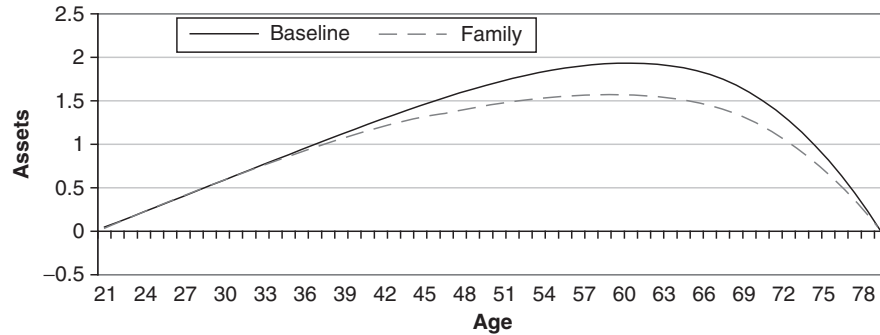
In Figure 7.11, for the same two cases, we plot the implied level of assets. In the changing needs model, the level of accumulation for retirement is reduced, a direct consequence of the hump-shaped profile of consumption being closer to the profile for income than was the case when constant consumption needs were assumed. Finally, for the case of changing needs, we also perform the comparative static exercise of increasing the interest rate. As shown in Figure 7.12, the absolute size of the effect of the change in the interest rate is somewhat reduced, at least for the years after the mid-thirties. The peak average effect on asset holdings is now approximately 1.6 units at

¹⁷ This involves dividing the equivalence scale by a factor of 1.2426. In the absence of perfect credit markets to transfer resources across time this is not quite the same as holding expected welfare constant, though in practice it turns out to be very close.



Note: Assets is normalized by dividing through by expected income at age 21.

Figure 7.11. Profile of average asset holding, with and without family

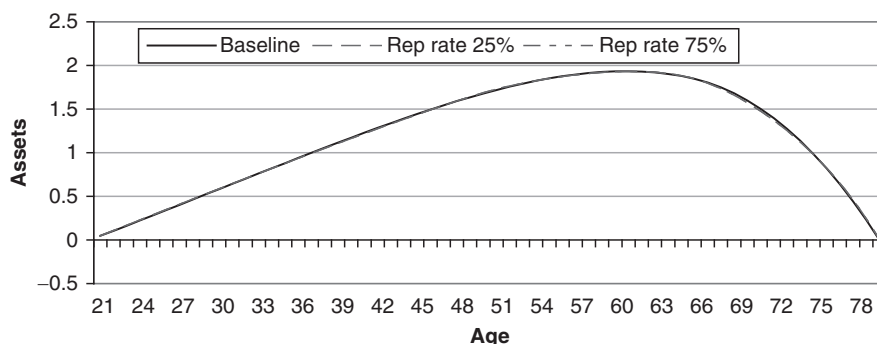


Note: The change in assets is normalized by dividing through by expected income at age 21.

Figure 7.12. Profile of average change in assets, with and without family

age 61, though this still represents approximately 18% of peak average asset holding.

Finally, we consider how our results are affected by the extent to which retirement consumption needs can be funded from 'pension income'. The pension replacement rate is given by the level of pension income relative to the final income received during the working life, where both pension and labour incomes are measured excluding completely interest income. In the base case retirement income is half the final working-age income, and in the comparison cases is set to 25% or 75%. To ensure that this increase (decrease) in retirement income does not represent a direct increase (decrease) in the amount of lifetime resources that can be enjoyed by our individuals, it is accompanied by a commensurate scaling down (up) of lifetime income stream in such a way that the present discounted value of expected lifetime



Note: Change in assets is normalized by dividing through by expected income at age 21.

Figure 7.13. Average change in asset holdings due to change in the interest rate from 2% to 2.5%: different replacement rates

resources is held constant.¹⁸ This may be thought of as funding the change in pension payments through a change in proportional payroll tax (or social security contributions).

Given that the wealth-preserving nature of the reform to the pension is effectively increasing or reducing forced saving for retirement, it is unsurprising that individuals almost fully offset this change by adjusting their saving behaviour. That this offset is not exact reflects the fact that moving income away from retirement and towards the working period serves to alleviate credit constraints and allows consumption to be shifted very slightly towards the first years of the working life (the relevant plots of consumption and saving are available from the authors on request). Nonetheless, since the level of saving is affected by changing the pension, it is of interest to check how the changes induced by changing the interest rate are affected by different replacement rates. In Figure 7.13, we plot again the changes in asset holding induced by the higher interest rate for the baseline case, together with the same changes in the two new comparison cases. As can be seen, changes in the replacement rate have almost no effect on the changes in asset holdings that are induced by the change in the interest rate.

(b) Financial implications and welfare consequences of changing the interest rate

We motivated the results presented above on the grounds that the behavioural implications of an increase in the interest rate can be thought of as the

¹⁸ This involves a decrease (increase) in exogenous income each year of 3.6% (3.3%) when the pension is increased (decreased), and the present values are calculated at the low tax interest rate of 2.5%.

implications of a cut in the tax on the return to personal savings. Beyond these behavioural implications the policy maker will also want to know whether cutting the tax on the return on assets is a cost-effective way to encourage saving, and about the implications of the tax for individual welfare. We address these issues in this subsection, and it is important to realize that it is only by having a framework such as the life-cycle model that we can make welfare assessments.

In our baseline version of the model, an increase of the interest rate from 2% to 2.5% resulted in an average increase in wealth holdings at retirement of approximately 18% (see Figure 7.4), and the proportionate increase in wealth holdings was similar (though on a smaller base) when we introduced family needs into the model (Figure 7.12). By contrast, when needs were held constant but the EIS was reduced to $\frac{1}{4}$ (Figure 7.9) the proportionate increase in wealth at retirement was approximately 4%.

To think about whether it seems to be cost effective to cut the tax on the return to saving to achieve these increases in wealth, we can compute the tax revenue foregone due to the tax cut, and compare this to the increase in retirement wealth. The cumulative amount of tax revenue foregone up to the retirement age can be computed from the model with behaviour simulated under the lower (2%) interest rate. This is done by taking the sum across ages of the difference between the gross of tax return on savings paid at a 2.5% interest rate, and the amount actually paid to the individual who receives a 2% net of tax interest rate. It turns out that in our baseline version of the model the foregone tax represents around 93% of the expected increase in personal retirement wealth, or, in other words, 7% of the increase in personal wealth is not offset by exchequer cost and so is new national saving.^{19, 20} In the case with family needs the pattern of saving, and therefore of accumulated tax revenues, is altered and this results in a threefold increase in the proportion of retirement wealth that is new national wealth, to 22%.²¹ In these cases, and particularly the latter, the policy change does ‘buy’ more new personal wealth than it costs in tax revenue foregone. This conclusion is, though, sensitive to the assumptions of the model: if we reduce the EIS to $\frac{1}{2}$ then the tax revenue

¹⁹ In calculating the cumulated tax foregone, we assume that a return on tax receipts of 2.5% accrues in the public sector. If we instead ignore any return on tax receipts, then the 7% number would increase to 35%.

²⁰ Instead of calculating this number for a given age, we could have taken an average across all ages to represent total new saving in an economy in which every generation had been affected by the tax cut: this calculation would have suggested a 10% increase in national wealth.

²¹ If returns to public funds are ignored, new national wealth would be approximately half of the extra personal wealth.

Table 7.2. Compensating variation in consumption required to make an agent indifferent between a 2% real interest rate with this compensation, and a 2.5% real interest rate

Case	A: CV (% increase in consumption)	B: % increase in cons available from tax	A-B
Baseline	2.13	1.90	0.23
EIS $\frac{1}{2}$	2.95	2.65	0.30
EIS $\frac{1}{4}$	4.17	3.44	0.72
No risk	0.70	0.61	0.09
Double risk	3.36	2.87	0.49
Family needs	2.11	1.31	0.80
Replacement rate 0.25	2.46	2.28	0.18
Replacement rate 0.75	1.84	1.56	0.27

foregone by the time of retirement is 2.5 times the amount of extra personal wealth held²² and this factor increases as the EIS falls.

The preceding analysis suggests that the lower the EIS, the less cost effective is the policy of cutting the tax on the return to saving as a means of encouraging wealth accumulation. On the other hand, we have not so far considered the effect of the interest rate change on the well-being of individuals. To quantify this, we convert the change in expected lifetime utility at the beginning of life that results from the interest rate change, into a ‘compensating variation’ (CV) consumption value. This is the proportionate increase in consumption each period that would be required to make the individual indifferent between accepting the lower interest rate with this boost to consumption, or accepting the higher interest rate. Column A of Table 7.2 displays such CV values for several of the different examples that are described in the above pictures. Alongside these compensating variation values, column B of the table records the percentage increase in consumption per period that could be funded from the tax raised through taxing interest income. The final column in the table records the difference between columns A and B, which is the excess of the amount of compensation required over the amount that can be funded from the tax revenue.²³

Column A of Table 7.2 shows that, for most of the cases considered, the change in welfare due to the hypothetical tax cut is equivalent to that deriving

²² Ignoring returns on public funds reduces this factor to 1.75.

²³ It is unsurprising the CV always exceeds the tax revenue: the interest rate change represents a price distortion that is not corrected by the envisaged proportional adjustment to consumption each period.

from increasing consumption in the low interest rate regime by between 2% and 3% each period. The notable exceptions are the case with no risk, where the welfare change is equivalent to slightly less than 1% of consumption, and the case with a low EIS where a 4% increase in per period consumption is required.

Examples that might be considered practically important modifications of our baseline model are that with changing family circumstances (since these are an important part of many people's lives), and those with a reduced EIS (since, to anticipate Section 7.3.1, empirical evidence suggests this parameter may take a value of slightly less than the level of 1 that we use in our baseline and most of our simulations). As we saw in our analyses above, the reduction of the EIS and the introduction of family needs both reduce the response of savings behaviour to the change in the interest rate, relative to our baseline run (see, respectively Figures 7.9 and 7.12). However, Table 7.2 indicates that smaller behavioural responses do not necessarily reflect smaller welfare consequences of the change in the interest rate. This is particularly clear for the reduced EIS, where the CV increases substantially as the EIS falls, and although the tax raised increases at the same time this increase is not sufficient to fund the extra CV.²⁴ For the case of family needs, the implications are different: the compensating variation required is almost the same as in the baseline case, but since the presence of a family reduces saving and therefore the tax revenue over the life cycle, less of this payment could be covered from the tax revenue than is the case when family needs are not an issue.

Reflections on model results

We have seen that by using numerical techniques to solve and simulate a life-cycle model, we can analyse how much consumption and saving will respond to a change in the interest rate, and think about the welfare consequences of this change. For example, in the case analysed above that incorporated family needs (Figures 7.10–7.12), we found that increasing the interest rate from 2% to 2.5% raised retirement wealth by almost 20%. Assuming that the increased return had been due to a cut in the tax on interest income, we found that slightly more than 20% of the extra wealth held over the life cycle was not offset by lost tax revenue, and so was new national saving. Additionally, we were able to show that if the tax raised from cutting the asset return had been used to provide extra consumption, this would have provided about 60% of

²⁴ It is important to realize that this analysis is for a given tax *rate*, and the tax revenue will be changing across different versions of the model. If we had analysed constant tax *revenue*, then the welfare costs of taxing the return to assets would *increase* with the EIS.

the extra consumption required to compensate the family fully for the welfare lost due to taxing the asset return.

We should emphasize that this welfare conclusion is not sufficient to justify a policy of not taxing the return to savings. Given the need to raise revenue to fund public services, we must have distortionary taxes. The framework we have analysed does not provide us with knowledge of whether the welfare consequences of distortions induced by taxing saving are smaller or larger than those induced by other tax instruments (though see Banks and Diamond, Chapter 6).

Nonetheless, knowledge of how consumption and saving would respond to changes in the interest rate is clearly of interest to a policy maker wondering whether changing the rate of return is a good way to encourage saving. To illustrate why analysis of welfare consequences is a useful complement to this for the policy maker, the case of changing the EIS provides a useful example. The analysis suggested that the lower the EIS, the less cost effective is the policy of cutting the tax on the return to saving as a means of encouraging wealth accumulation. On the other hand, the welfare analyses showed that the welfare consequences of taxing saving *at a given rate* are more severe when the EIS is lower, notwithstanding that the response of saving to the change is also smaller. Thus, simply thinking about behavioural responses does not seem to give us sufficient information for evaluating a policy and the potential of our model to facilitate welfare analyses is a clear virtue of the framework in this context.

The potential of numerical techniques to provide specific predictions from a life-cycle model about saving behaviour and welfare is, then, what makes us optimistic about the potential for research to bridge the gap between the literatures that aim to build our knowledge of the life-cycle model, and to analyse whether tax privileges to certain assets achieve discernible increases in saving. The analyses of this section provide an early, small step across this gap. It should be emphasized that our analyses have been for a particular set-up of the life-cycle model, and slight modifications to it. Changes to the set-up could alter the conclusions and so to make analyses of the kind we have conducted relevant for considering actual or proposed policy reforms, it is important that the model is as realistic as possible. This requires accurate knowledge of key parameters such as the EIS and fortunately, as we argue in the next section, we do have quite convincing evidence about this parameter. The next section also surveys ongoing research on extensions such as the addition of labour supply, or of durable goods or habit formation, which are designed to increase the realism of the framework considered here. In considering this research, we will place particular emphasis on what is known

about how such extensions modify the conclusions of the stylized model used in this section. A growing understanding of such extended versions of the life-cycle model will only add to its value as a flexible tool for thinking about how tax policy affects saving behaviour, and for interpreting existing evidence on responses to past tax reforms.

7.3. THE LIFE-CYCLE MODEL: WHERE DO WE STAND?

The model that we have used to perform the simple exercises in Section 7.2 is obviously, even in the most complicated version we have used, a fairly simple and to some extent unrealistic framework. Nonetheless we would argue that it constitutes a useful framework to address the issues we have been discussing. Such a stand must be justified on two grounds: first, the model is, at some level, an appropriate conceptualization of individual behaviour; second, the many simplifications we have introduced do not constitute a fundamental drawback of the structure we have used and the latter can provide useful insights. In this section, we will start by discussing the evidence on the plausibility of the life-cycle model. We will first consider structural estimates and tests of the model. We will then move on to consider indirect evidence on the relevance of some implications of the model that can be obtained from the reaction of individuals or groups of individuals to policy reforms. Finally, we will discuss some important aspects that were not included in the model used in Section 7.2 as well as some important alternatives to the life-cycle model.

7.3.1. The evidence on the life-cycle model²⁵

In our opinion, since its initial formulation of the 1950s, there have been two important developments in the literature on consumption and the life cycle. First, since the 1970s, economists have learned to introduce uncertainty in a rigorous fashion in the theoretical framework. The assumption of rational expectations has had some important applications in the consumption literature, as we will discuss. While this has made the analytical properties of the model much harder, it has also revealed some important issues. While the precautionary saving motive was discussed already in Dreze and Modigliani

²⁵ Some of these issues are discussed in Attanasio (1999) and, more recently, in Attanasio and Weber (2009).

(1972), its implications have only been extensively explored much later (see, for instance, Carroll (1997)). Second, household level data have been brought to bear on the empirical relevance of the model and a number of contributions have made a serious attempt at complex specifications of preferences that could be brought to the data. From an empirical point of view, therefore, the first issue to confront is whether it is possible to write a plausible version of the model that is not rejected by individual level data. If the answer to this first question is positive, then one can estimate, using individual level data, the parameters that are crucial for policy analysis. In what follows, we first consider tests of the life-cycle–permanent income model. The aim is to answer the question: is the model we discussed in Section 7.2 at all relevant from an empirical point of view? We then discuss evidence on the size of the parameters that are important from a policy point of view.

Testing the model

Since Hall (1978), Sargent (1978), and Flavin (1981), the empirical analysis of the life-cycle model has taken two main strategies. Some contributions have used the so-called ‘Euler equation’ for consumption. This equation was discussed in some detail in Box 7.1 and expresses one of the main implications of the model: the consumer will choose consumption and saving so that at the optimum the ratio of expected marginal utilities of consumption at different dates is equal to the ratio of relative prices, that is, the interest rate. Given an assumption about the nature of expectations, the equation incorporates uncertainty in a relatively simple fashion. It is extremely useful for empirical analyses because it implies a relationship among observable variables (notably the interest rate and consumption growth—again see Box 7.1) that can be used to estimate preference parameters and to test the model.

The first focus of this literature, starting with Hall (1978), was on testing the model. In that first paper, the implication tested was that, conditional on current consumption (which under some preferences coincides with marginal utility), other current variables, including income, do not help in predicting future consumption. Subsequent papers (see, for instance, Campbell and Mankiw (1989)) tried to interpret rejection of this strong hypothesis in terms of market failures (liquidity constraints that force some individuals who would like to borrow against future income to consume no more than current income), or rationality failure (‘rule of thumb’ consumers who consume a fraction of their current income). Most of these papers (an exception being Hall and Miskin (1982)) used aggregate level data and completely neglected aggregation issues.

The life-cycle model is, of course, a theory of *individual* behaviour, and in the late 1980s and in the 1990s, some contributions started to fit the Euler equation to individual level data. Some of the relevant papers were Attanasio and Weber (1989, 1993, 1995), Blundell, Browning, and Meghir (1994), Banks, Blundell, and Preston (1994), Attanasio and Browning (1995). A short and definitely subjective and not unbiased summary of these results is that a rich version of the life-cycle model can fit the available data, especially if one focuses on households headed by prime aged individuals.

The datasets used in this literature contained a large amount of information on household characteristics as well as on consumption expenditure, and this meant that the empirical specification could be rich as well as theory consistent. It could allow, for instance, for a flexible role of demographics and family composition in preferences to reflect changes in needs (our analysis in Section 7.2 indicated how important family composition might be). Flexibility also meant that the specifications adopted in several of these papers were robust to the possibility that labour supply choices directly affect the (marginal) utility derived from consumption, because leisure and consumption are either complements or substitutes. Finally, most of these papers restricted the sample to households headed by prime aged individuals, excluding households headed by very young individuals and households headed by individuals around or past retirement ages.

Formal statistical tests, derived from theory, generally failed to reject versions of the model that were flexible enough and that were estimated on individual level data, and apparent violations of predictions of the model in aggregate data were often no longer evident. For example, with controls for demographics and labour supply, these papers based on individual level data typically found no evidence of 'excess sensitivity' through which, contrary to the predictions of the life-cycle model, consumption responds to predictable changes in income. Attanasio and Weber (1993) also showed that aggregation biases could explain some of the results in the literature based on aggregate data, such as the celebrated Campbell and Mankiw (1989) paper: when 'wrongly' aggregated, the micro data delivered estimates that were very similar to those obtained by Campbell and Mankiw (1989).

The big attraction of the Euler equation approach is that it can deliver an empirically treatable specification without necessarily making very strong assumptions. The approach is robust to the presence of several imperfections in different markets in which the individual acts, it is possible to control for possible interactions between choices concerning leisure and consumption, it can control in a reasonably flexible way for unobserved heterogeneity between individuals and, above all, it is not necessary to specify the whole

stochastic environment in which the individual operates. The price one pays for this is that the approach does not deliver a 'consumption function'. It is therefore not possible to establish how consumption or saving will change in reaction to changes in the various variables faced by the individual. This is obviously an important limitation for policy analysis and probably explains the dichotomy mentioned above between the empirical consumption literature and the public finance literature. There are three possibilities to overcome this difficulty. One is to impose enough simplifying structure on the model that a consumption function can be derived; a second is to use numerical methods to obtain consumption functions; the third is to use approximations to the consumption function. We will now briefly discuss the first two.

One of the few cases in which a consumption function can be derived is that in which utility is quadratic and the only uncertainty comes from income. In such a case, Flavin (1981) and subsequently Campbell (1987) and Campbell and Deaton (1989) derived the cross equations restrictions implied by the model on the time series representation of income and consumption. Most of the papers that used this type of approach (including West (1988) and Hansen, Roberds, and Sargent (1991)) used time series aggregate data; one exception that looked at this type of restrictions on micro data is Nalewaik (2006). While the approach can be useful for empirical analysis, the assumptions required still seem difficult to sustain for policy analysis where the focus is on variation in the interest rate as well as fluctuations in income.

These considerations lead us back to the use of numerical methods (or approximations) to address this problem. And, indeed, starting with Deaton (1991), Hubbard, Skinner, and Zeldes (1995), Attanasio, Banks, Meghir, and Weber (1999) and others have developed methods to solve these models. The simulations presented in Section 7.2 are, in effect, an application of this approach.

The big difficulty of this approach, if it wants to be realistic and of policy relevance, is that one needs to specify all of the details of the stochastic environment in which the consumer lives. And, as should be clear from even the simple exercises reported in Section 7.2, some of these details are quantitatively and qualitatively important for the results one obtains. Moreover, even simple modifications of the basic model may introduce considerable complications at the numerical level. This was evident in some of the subsequent papers that have taken this approach, such as Palumbo (1999), who looked at health and consumption, Low (2005), who introduced endogenous labour supply choices, Diaz, Rios-Rull, and Pijoan-Mas (2003), who introduced habits, Gomes and Michaelides (2003), who looked at portfolio

choices and habits and, more recently, Attanasio, Bottazzi, Low, Nesheim, and Wakefield (2007), Sanchez-Marcos and Rios-Rull (2006), and Bottazzi, Low, and Wakefield (2007), who introduce endogenous housing choices and, in the case of the last paper, housing and labour supply choices.

These computational difficulties notwithstanding, a remarkable recent paper by Scholz, Seshadri, and Khitatrakun (2006) has demonstrated the potential of the numerical approach. They construct a life-cycle simulation model that they use to predict the saving behaviour of a large set of individuals for whom they have data on earnings over a period of forty years. In the model they try to be as realistic as possible in terms of the institutional factors that might affect saving and consumption choices (taxation, government transfers, medical expenses, uncertainty, and so on), although they do acknowledge that constraints of data and computational feasibility mean that some features of the model, such as the treatment of housing wealth and of bequests and inheritances, remain stylized. They argue that the model 'accounts for more than 80% of the 1992 cross-sectional variation in wealth' and that 'fewer than 20% of households have less wealth than their optimal targets, and the wealth deficit of those who are undersaving is generally small'. While sensitivity to assumptions means that such results must be interpreted with caution, these results do challenge the popular wisdom, and some interpretations of a strand of literature discussed in Section 7.3.3, that many individuals are 'under saving'.

The difficulty in getting numerical solutions of even modestly realistic models implies that this approach can be used only with great difficulty for the estimation of parameters. A possibly more productive approach, which is effectively the one used in Section 7.2 and in the Scholz et al. (2006) paper just discussed, is to obtain estimates for some of the parameters from formal estimation, possibly using robust methods such as Euler equations, and others possibly from matching specific data moments. Key parameters having been retrieved in this way, numerical simulations can then be used to understand the policy implications of the realistically parameterized model.

Estimates of structural parameters: how substitutable is consumption over time? How impatient are consumers?

To simulate a model of the kind sketched in Section 7.2, one needs to specify a utility function and give a value to each of its parameters. As mentioned in the previous subsection, the specification of utility that has been extensively used in the literature that has estimated Euler equations on micro data is of the isoelastic type, with utility defined over consumption per adult equivalent.

Adult equivalent schemes are typically estimated in a flexible fashion and account for the role played by demographic variables in the Euler equation. In this context, the two crucial parameters to determine the size of the effects of changes to the economic environment faced by the agents (such as changes in the interest rate or in expected income) are the elasticity of intertemporal substitution and the discount factor. The former determines by how much consumption shifts between periods when its relative price in those periods changes (see Box 7.1). The latter determines how impatient consumers are and whether, given a certain level of the interest rate, consumption will be increasing or decreasing over time. We now discuss the empirical evidence on the size of these two parameters.

In his famous 1988 paper, Hall argued that, on the basis of aggregate time series data, there are strong reasons to believe that the elasticity of substitution of consumption is close to zero or very small. This is because relatively large (predictable) movements in interest rate do not seem to be associated with movements in (predictable) consumption growth. However, the EIS is a parameter that describes an individual's preferences, and in the late 1980s and 1990s several papers, starting from Attanasio and Weber (1989, 1993), used individual level data to estimate it.²⁶ These papers typically obtained larger estimates of the EIS than the value of 0.1 suggested by Hall: the values obtained typically ranged from 0.65 to figures slightly above 1. The implications of these much higher estimates for the taxation of saving are obvious, as showed by the simple computations in Section 7.2. And yet these findings have not been consistently used in the public finance literature.

Our choice of different sizes for the EIS in the simulation exercises presented in Section 7.2 should be indicative of what we think are plausible estimates that come out of the empirical literature on the topic. If one wants to fit an isoelastic utility function like the one in equation (*) in Box 7.1, micro data from both the US and the UK indicate that a plausible range of values for the EIS is 0.5 to 1. We would view values of the EIS below 0.4 as very low and values above 1, as too high.

Of course, the assumption of isoelastic preference is analytically and theoretically very convenient. However, there is some evidence that the EIS might change with the level of consumption (see Attanasio and Browning (1995), for instance). Given the discussion in Section 7.2 on the importance of the EIS for the size of the saving response to changes in tax policy, specifications

²⁶ These are essentially the same set of papers we mentioned at the top of p. 706, when discussing estimation of the Euler equation. As discussed in Box 7.1, a log-linear regression of consumption growth on the interest rate (the form of many empirical Euler equations) identifies the EIS.

of preferences that allow for a non-constant EIS should be an important item on the research agenda.

The second important preference parameter is the discount factor. Its size, relative to the size of the interest rate, defines whether a consumer is 'impatient' in the sense of Carroll (1997). Little evidence exists on the size of this parameter, especially based on micro data. The reasons for this paucity of evidence are many. Probably the most important is the difficulty in identifying such a parameter with any precision. Much of the empirical evidence on Euler equations from micro data comes from log-linearized versions of the equation. In such a situation, the discount factor gets buried into the intercept of the equation and cannot be identified. However, the lack of strong evidence on the size of this parameter might not be too important. As we mentioned above and perhaps not surprisingly, demographic effects have been shown to be very important in explaining variations in consumption over the life cycle. These variables typically enter preferences so that they act as a time varying discount factor. Therefore, possible variations in the level of consumption induced by changes in the discount factor can be dwarfed by changes in demographics and, possibly, the probability of surviving. Whether a consumer shows 'impatience' over the life cycle, consuming at levels close to her current income and saving little, might be driven more by the dynamics of her family size than the relationship between the interest and discount rates.

An indirect piece of evidence on the size of the discount factor and its heterogeneity in the population can be found in Attanasio, Banks, Meghir, and Weber (ABMW) (1999). In that paper, the authors present simulations of a life-cycle model with plausible preference parameters, including the effect of demographics on the utility of consumption, and show that variation in the timing of childbearing can help to explain variation in the shape of the life-cycle profile of consumption of different groups of households, defined in terms of the educational attainment of the household head. The one aspect of the data that the simplest version of the model presented by ABMW does not fit is the fact that consumption profiles peak at different ages for different education groups. A fit to this feature of data is achieved with different discount factors on top of different patterns of family size changes, assuming that less educated individuals are slightly more impatient.

7.3.2. When the simple model does not work

As we have mentioned several times, the model presented in Section 7.2 makes some very stark assumptions. In this subsection we analyse the

implications of relaxing some of these assumptions with a focus on the issue of the effects of savings taxation. We start with relaxation of preference assumptions, then move on to assumptions about market structure and availability of intertemporal trades.²⁷ We conclude this subsection with a brief discussion of preference specifications that might be considered as substantial deviations from the standard model. It is worth noting that with all of these extensions, the factors that we discussed in Section 7.2 as determinants of how consumption and saving will respond to a change in the interest rate will still apply: the shift in the relative strength of income and substitution effects as the EIS changes will, for example, still be pertinent. However, some of the extensions we discuss (such as limits on borrowing that impose constraints on consumption) may restrict the extent to which these previously discussed factors can influence behaviour, while others (such as the modifications of the preference specification that we consider in this section at pp. 716–18) will add a further set of preference effects that must be taken into account.

Labour supply

An important assumption in the simulations we reported was that the income process was exogenous. As we mentioned above, this assumption can be justified with the assumption of ‘separability’ between leisure and consumption in the utility function, which says that labour supply choices have no direct effect on the (marginal) utility of consumption. Alternatively, the assumption could be justified if one can argue that labour supply is virtually fixed irrespective of the wage so that total income is effectively exogenous. Unfortunately, both these justifications are quite weak. While the second might be justified for men, female labour supply elasticities, both at the intensive (hours) and extensive (participation) margin can be sizeable. Moreover, as measured consumption often includes many items directly related to labour supply behaviour (from transport, to clothing, to home energy consumption), the hypothesis of separability is even conceptually difficult to defend. This has considerable implications for the dynamics of life-cycle consumption and saving, as well as for the response of individual savings to specific incentives.

As we mentioned above, specifications of Euler equations estimated on micro data often found significant labour supply effects, especially for female labour supply and especially at the extensive margin rather than the intensive

²⁷ Effectively in Section 7.2 we did consider an important deviation from the standard LC model: we did not allow consumers to borrow. Whether this makes a difference to the results we discussed depends on how binding the exogenously given borrowing restriction is, given the income profile and the needs of the individual family.

one (see, for example, Blundell, Browning, and Meghir (1994) and Attanasio and Weber (1993, 1995)). The non-separability of leisure and consumption in the utility function can induce a positive correlation between life-cycle movements in consumption and earnings and 'explain away' the excess sensitivity of income, a point first made by Heckman (1974) in response to a paper by Thurow (1969). Some papers that used aggregate time series data to estimate models with non-separable preferences between consumption and leisure include Mankiw, Rotemberg, and Summers (1985), and Eichenbaum, Hansen, and Richard (1988). The more recent papers mentioned above make the same point empirically within the context of the Euler equation estimated on individual level datasets.

While dealing with these effects with the Euler equation is relatively straightforward, incorporating the non-separability of consumption and leisure in simulation models that obtain numerical solutions for consumption and saving is considerably complex, especially if one considers the extensive margin with fixed costs of going to work. These costs introduce important non-convexities into the life-cycle optimization problem and thus make numerical solution much harder. Moreover, in the presence of tenure effects and the like, the wage process becomes endogenous and the number of state variables one has to keep track of for solving the problem increases. Although some studies now exist that construct life-cycle models with non-separable leisure and consumption and non-convexities,²⁸ we are not aware of simulations that have directly addressed the issue of the sensitivity of saving to taxation.

A paper that stresses the importance of endogenous labour supply for optimal taxation of capital (and labour) is the recent paper by Conesa, Kitao, and Krueger (CKK) (2007) who consider an overlapping generation model with uninsured idiosyncratic shocks and ability differential. The result that 'taxing capital is not a bad idea after all' and, in particular the high level of the optimal tax rate on capital in this model is in part due to the high elasticity of labour supply and the potential distortion induced in such a context by high labour taxes. It might be interesting to investigate more realistic models of labour supply behaviour (where the elasticity is much lower than that considered by CKK and maybe focused on the intensive margin). It would also be interesting to characterize the interactions between endogenous labour supply and different levels of the elasticity of intertemporal substitution for consumption.

²⁸ Low (2005), Attanasio, Low, and Sanchez-Marcos (2005, 2008), Bottazzi, Low, and Wakefield (2007) are examples of life-cycle models that incorporate explicitly labour supply with important non-convexities.

Intertemporal non-separabilities: durables and habits

So far we have considered models where preferences are intertemporally separable, that is, consumption in any period does not affect the marginal utility of consumption in subsequent periods. This assumption rules out models of habit formation. Moreover, if the only data on durable commodities are on expenditure (rather than the service flow provided by the stock of durables) and/or if durables are subject to adjustment costs, durable commodities also introduce important intertemporal non-separability in preferences.

Models of habit formation and intertemporal non-separability have a long history. In demand analysis, without uncertainty, the early contributions of Philips and Spinnewyn (1984) and Spinnewyn (1981) used a dual approach that rewrote the dynamic non-additive problem in terms of an additive utility function that depends on appropriately defined stocks, rather than current consumption. Browning (1991) used a similar idea within a life-cycle model and presents results that allow one to incorporate both durables and habits. Browning (1991) does consider uncertainty but uses point expectations rather than rational expectations. Studies that used macro time series data to analyse intertemporally non-separable models include Eichenbaum and Hansen (1990), Mankiw (1982), Bernanke (1985), and Heaton (1993, 1995). In the 1990s, habits have become very popular as a way to explain certain puzzles concerning asset pricing (see, for instance, Campbell and Cochrane (1999)).

Surprisingly few papers have used micro data to study models with habits. Meghir and Weber (1996) use US Consumer Expenditure Survey (CEX) data to estimate a demand system nested in a life-cycle model which allows for habits, while Dynan (2000) uses the US Panel Study of Income Dynamics (PSID). The remarkable result that Meghir and Weber find is that while the demand system (based on a few commodities) does exhibit persistence, this seems to be entirely explained by non-separability between durables and non-durables, rather than by habits. Padula (1999) presents Euler equation estimates for non-durable consumption that also show strong non-separability between non-durable consumption and the services of the stock of cars, for which he has observations in the CEX.

While the absence of intertemporal separability is likely to have important consequences for the reaction of savings to changes in intertemporal prices, these have not been explored, to the best of our knowledge, in the literature. The only literature that has extensively analysed the implications of different types of intertemporal non-separabilities is the asset pricing literature. As noted by Hansen and Jagannathan (1991), one of the reasons

for the empirical failure of some popular asset pricing models is the low variability in the price that individuals are prepared to pay in the light of different information about the future, in order to buy a given amount of consumption in the future. Habits (or other forms of non-separabilities) can substantially improve the fit of these models because they effectively increase the variability that can be exploited. An interesting research agenda would be to check what are the implications of this class of models for the responsiveness of saving to the interest rate and, possibly, for the optimal taxation of capital. To answer such a question, however, one has to be specific both about the nature of the non-separability over time (whether current and present consumption are substitutes or complements would obviously make a difference) and about the magnitude of such intertemporal links.

Intertemporal trades restrictions: liquidity constraints

The basic textbook model assumes that the consumer is able to borrow and save at the same interest rate without limit, except the obligation to repay any debt with certainty. This last constraint, if the utility function implies very high disutility of very low consumption levels, effectively imposes a limit to the amount that an individual will want to borrow. If the income process is not bounded away from zero (that is if zero income is a non-zero probability event), then people will not want to borrow. However, even such potentially tight constraint is sometimes perceived as not tight enough. In particular, many researchers think that although income processes might be bounded away from zero (by some type of safety net, for instance), some individuals might find it difficult to borrow in situations where they would want to. If that is the case, the Euler equation will not hold as an equality, but as an inequality: the current marginal utility of consumption will be higher than the discounted future expected marginal utility as, if they could, individuals would bring resources forward and increase current consumption. It is perceived that this problem is particularly relevant for young consumers who face an upward-sloping income profile and yet might find it difficult to move resources forward. This is one reason why the studies on Euler equations based on micro data typically exclude very young individuals²⁹ and why in the simulations in Section 7.2 we explicitly considered the case in which individuals could not borrow at all.

²⁹ When the study is based on time series of cross-sections that are used to construct synthetic cohorts (or pseudo panels) it is thought that at the beginning of the life cycle the composition of households headed by young individuals changes systematically as new households are formed.

The case in which there is a binding and exogenous limit to the amount an individual can borrow is relatively simple to analyse. Such a constraint implies a kink in the intertemporal budget constraint and some households will bunch on that corner. In the period in which the constraint is binding, the individual will consume her income (and run down assets completely). In this respect that period is equivalent to the last period of life: it has been pointed out (see Hayashi (1987)) that a binding liquidity constraint is equivalent to a shortening of the planning horizon and/or to an increase in the discount factor. In such a situation, it is relatively useful to analyse the effect of changes in the interest rate: anything that would lead to an increase in consumption would not have any effect. Consumers at a kink of an intertemporal budget constraint would be less responsive to changes in the interest rate although a sufficiently large increase in the interest rate might induce the consumer to move away from the corner and possibly start to save. However, even in this case, the reaction is likely to be more muted than would be observed in the absence of a constraint.

The presence of liquidity constraints is a symptom of a more general phenomenon which is the incompleteness of insurance markets to allow individuals efficiently to diversify idiosyncratic risk. This type of market incompleteness is central to some of the models, such as that studied by Conesa, Kitao, and Krueger (2006) that imply positive rates of taxation of capital. And yet, the origin of these markets failures is not clear.

Housing and associated market imperfections

Alongside pensions, housing constitutes the largest item in household portfolios, both in the US and in the UK. Moreover, housing is a unique type of asset: it provides a flow of services that consumers enjoy, it is lumpy and can only be transacted and changed by incurring often substantial costs. House prices are often and in many places extremely volatile, and particularly so in the UK (see Banks, Blundell, Oldfield, and Smith (2004)). These fluctuations in the value of houses and the important role they play in household portfolios can generate important wealth effects that have been argued to fuel consumption booms (see, for instance, Muellbauer and Murphy (1990)), although others have argued that an increase in house prices constitutes a disincentive to consumption for households who are net purchasers of housing services (see King (1990); Attanasio and Weber (1994)).

In addition to these considerations, in many countries, including the US and, in the past, the UK, the liabilities associated with housing (such as mortgages) receive special tax treatment relative to other assets and liabilities.

In particular, in the US mortgage interest payments are tax-deductible. In the UK a similar treatment was recently removed. This type of treatment of course adds an attraction to the fact that the housing services enjoyed by home owners are not taxed.³⁰ Finally, houses can often be used as collateral for borrowing. This means that when house values increase, households might find it easier to borrow for a variety of reasons (see Lustig and Van Nieuwerburgh (2005)).

For all these reasons, housing should play a very important role in every analysis of life-cycle consumption and saving. And yet, very little is known about the interactions of housing and saving/consumption choices. Some papers take a reduced form approach (Attanasio and Weber (1994); Attanasio et al. (2009); Campbell and Cocco (2007); Bottazzi (2004)) although they explicitly use the life-cycle model as a framework to organize the empirical evidence. More recently, some contributions have started to build realistic life-cycle models that include an important role for housing (see Attanasio et al. (2007); Attanasio, Leicester, and Wakefield (2008); Bottazzi, Low, and Wakefield (2007); Li and Yao (2007); and Sanchez-Marcos and Rios-Rull (2006)). The last of these papers even tries to explain the evolution of the house prices. An early attempt at constructing such a model was contained in Ortalo-Magne and Rady (2006).

The papers we cite here constitute only a small first step in the investigation of what we think is an important research agenda. There are still many unanswered questions about the role of housing in life-cycle models, many of which are relevant for the issues discussed in this chapter. We do not have a good equilibrium model and understanding of house prices. We do not fully understand the role of houses and of the fluctuations in their prices in individual wealth accumulation decisions. We do not fully understand the effect of privileged tax treatment of housing on saving behaviour and how this interacts with other forms of wealth taxation.

Hyperbolic discounting and temptations

One of the basic blocks of the intertemporal consumption model described above and extensively used in the literature is that individuals are assumed to discount the future with a constant discount factor. Such a 'geometric discounting' assumption has recently been argued to be implausible. In the past ten years, David Laibson, and Ted O'Donoghue and Matthew Rabin,

³⁰ Local taxation in the UK is based on property value, but the link to the value of housing services is not very clear for this banded tax and, perhaps more importantly when we are thinking about the taxation of assets, the tax is based on residence rather than ownership.

have been the main promoters of an apparently slight deviation from geometric discounting: hyperbolic or quasi-geometric discounting. This model, that has recently received a considerable amount of attention and originates in the work of Strotz (1956) and Phelps and Pollak (1968), assumes that while the discounting between subsequent dates in the far future is geometric (the ratio of utility at any two future dates $t + k$ and $t + k + 1$ is β) the factor that discounts the immediate future relative to the present is smaller than β so that current utility is weighted more highly than in the geometric case. This model has been deemed to be able to explain several phenomena, such as the tendency to procrastinate over saving decisions and the demand for commitment devices (see Laibson (1994, 1997); Harris and Laibson (2001); and O'Donoghue and Rabin (1999a, 1999b)). Recently, Angeletos et al. (2001) have calibrated such a model using numerical methods similar to those discussed above to construct life-cycle profiles similar to those we presented in Section 7.2, while Laibson, Repetto, and Tobacman (2005) use simulation based estimation methods in an attempt to pin down the discount function. Harris and Laibson (2001) derive an Euler equation relevant for a hyperbolic discounter.³¹ Finally, some interesting field experiments (Karlan and Zinman (2008)) have tested for the presence of a demand for commitment devices in saving markets in the Philippines using a randomized trial.

The hyperbolic discounting model, however, is not without drawbacks. The main problem, already noticed by Strotz half a century ago, is that the preferences induced by hyperbolic discounting are time inconsistent. Effectively, instead of one consumer, we have to deal with many selves (the same individual at different points in time) that interact in determining intertemporal choices. This leads to conceptual difficulties with welfare analysis.³² A second consequence of 'multiple-selves', as noted forcefully by Krusell and Smith (1998) among others, is the presence of multiple equilibria and the consequent difficulty in characterizing intertemporal consumption allocations.

The problems with the hyperbolic discounting model make the recent contributions of Gul and Pesendorfer (2001, 2004) (GP) particularly interesting. These authors build an axiomatic representation of preferences that yield a utility function in which, in addition to the standard terms, a consumer is affected by the temptation of immediate gratification. In particular, utility is assumed to be affected not only by the choice a consumer makes, but also

³¹ The empirical applicability of such an Euler equation is doubtful as it requires the evaluation of the derivative of the value function.

³² Laibson, and O'Donoghue and Rabin, have proposed different measures of welfare in these models.

by the choice set from which the choice is made. In this framework, while consuming a certain consumption stream the consumer is also affected by other unchosen streams as they might tempt her and/or force her to exercise costly self-restraint. This structure is captured by two different functions, the first defined as usual over consumption and the second that describes the 'temptation' the consumer might face. The self-control issue induced by this second function generates a utility loss for the consumer.

An advantage of the GP preferences is that they are time consistent while still creating a demand for commitment devices. The GP type specification also evidently generates an extra set of preference effects in responses of consumption and saving to changes in the interest rate, on top of the standard income, substitution, and wealth effects discussed in Section 7.2.1, pp. 686–7. A growing number of studies are now starting to apply these preferences to analyse policy issues: Krusell, Kuruscu, and Smith (2001) embed the GP preferences in a neoclassical growth model to analyse taxation and welfare; Esteban, Miyagawa, and Shum (2007) apply these preferences to derive the optimal selling strategy of a firm facing consumers with self-control problems; Buccioli (2007a) looks at the implications for the design of pension systems while Buccioli (2007b) derives Euler equations that can potentially be taken to data.

7.3.3. The empirical relationship between savings and changes in wealth and intertemporal prices

The evidence on the life-cycle model we discussed in Section 7.3.1 is based on a formal and rigorous approach that takes uncertainty very seriously and exploits the first order conditions of the dynamic problem the consumers are assumed to solve. An alternative and complementary approach is to consider the effects of large reforms that, in a life-cycle framework, should have important implications for consumption and saving plans. Such reforms can be used both to assess the overall validity of the life-cycle model and, in some cases, to measure some of the quantities and elasticities that we have been discussing.

We divide our discussion of the available empirical evidence into two parts. First, we discuss evidence that exploits variation in the value of individual wealth and therefore can change the incentives to save and consume. These changes include changes in pension wealth induced by legislative reforms, changes in house values induced by movement in house prices, and changes in the value of financial wealth induced by movements in stock

prices. Second, we discuss evidence on the effects of changes in the return to specific assets, possibly induced by tax incentives designed to stimulate savings.

To anticipate, our discussion points to several broad conclusions. First, when a shock increases wealth in one part of the portfolio, this does (as the life-cycle model would predict) lead to offsetting changes in other parts of the portfolio, although the offset is often found to be somewhat below one-for-one. Second, when the return on a particular asset is increased (perhaps through a tax break), this generally leads to saving in that asset but for at least some groups this saving may be largely due to reshuffling of wealth out of other assets and so not all of the wealth is new personal—let alone new national—saving. These findings are in line with the model presented in Section 7.2 and our best estimates of key parameters as discussed in Section 7.3.1, pp. 708–10. However, the empirical evidence discussed below also points to some heterogeneity in effects across different wealth shocks or policy reforms, and this often seems to be related to the information available to individuals making decisions, and/or the way they form expectations. Thus the provision of information may be an important element of how policy affects consumption and saving.

Changes in wealth

From a theoretical point of view, the relationship between exogenous changes in wealth and savings is fairly clear, as we showed in the simulations reported in Section 7.2. By increasing the generosity of the pension system one reduces the necessity to save for retirement and, in general, savings will be reduced as a consequence. The analysis of the relationship between pension wealth and savings has a long history: Feldstein (1974) tried to use time series variation in the generosity of US social security to analyse such a relationship. King and Dicks-Mireaux (1982) instead studied the cross-sectional variation in financial and pension wealth to estimate the degree of substitutability between the two. Attanasio and Brugiavini (2003) was one of the first papers to use a pension reform (the 1992 reform of the Italian Pay-As-You-Go system) to look at the same issue.

The UK is a particularly interesting case study because of the large number of reforms that, since the 1970s, the public pension system underwent. Attanasio and Rohwedder (2003) use some of these reforms to analyse the effect of the changes they induced in various pension wealth on savings and, indirectly, the degree of substitutability between financial and pension wealth. In particular, they analyse two reforms: the introduction of the State

Earnings-Related Pension Scheme (SERPS) in 1978 and the November 1980 change in the indexation of the Basic State Pension from earnings to prices, which has led to a substantial relative decline over time in its value. Attanasio and Rohwedder (2003) use the fact that these reforms hit different cohorts at different ages, to estimate the degree to which public pensions (in various forms) crowd out private saving at different points in the life cycle. Their evidence suggests that when SERPS was introduced middle-aged households offset around two-thirds of the implied new state pension wealth by adjusting consumption and other forms of saving. The offset was more complete for older households. This evidence suggests that income effects (and not just substitution effects) affect households' decisions on saving for retirement. Attanasio and Rohwedder (2003) interpret this evidence within a simple life-cycle model, which logically would imply that a reduction in the generosity of a pension system would induce an increase in savings. This conclusion, however, should be tempered by the second piece of evidence in the study, which shows that the reduction in generosity, in 1980, of the Basic State Pension, induced by the change in its indexation mechanism, did not lead to a 'crowding in' on financial wealth. One possibility is that the generosity of the introduction of SERPS was more widely understood than the reduction in the generosity implied by changing indexation. This could be related to the amount of publicity surrounding the two reforms or to public perception over how permanent the changes were likely to be—particularly as SERPS was introduced with cross-party support whereas opposition parties have often been in favour of indexing the Basic State Pension in line with earnings.

If individuals do not fully adjust their personal wealth to accommodate social security wealth, then this may show up in consumption patterns later in life, pointing to an important failure of the life-cycle model, which assumes rationality of saving decisions and rational expectations. Banks, Blundell, and Tanner (1998) (BBT) started a small literature examining how consumption changes around the time of retirement. The fact that consumption falls in retirement is well documented. But this does not necessarily mean that individuals had not saved enough—some part of the drop in consumption may be planned and related to changes in work status. Moreover, if one does not use panel data but a time series of cross-sections, the changes in average consumption will be gradual and could also be explained by changes in family composition and other factors that move more slowly, as well as by declines in labour force participation. By modelling individuals' life-time consumption plans, BBT find that around two-thirds of the drop in consumption growth at retirement that occurred for those cohorts retiring in the 1970s, 1980s, and

early 1990s can be explained within the context of an optimal consumption plan. The residual third remains a puzzle, with one possible explanation being that at least some individuals had not saved enough. Alternatively, there may be a set of people for whom adverse shocks are important: evidence from panel data (Smith (2006)) suggests that it is those who left the labour market as a result of an employment or health shock who experienced a decline in their food spending and potential indicators of their well-being around the time they left paid employment.

The evidence in BBT for the UK was confirmed for the US by Bernheim Skinner and Weinberg (2001) and by Miniaci, Monfardini, and Weber (2003) for Italy. More recently, however, Aguiar and Hurst (2005) convincingly argue that the drop in food expenditure documented by Bernheim, Skinner, and Weinberg (2001) for the US can be explained by a shift in amount of time spent preparing food and shopping. No similar studies exist for the UK.

The evidence in BBT is important for our discussion because it casts some doubt on the ability of the life-cycle model, at a crucial juncture of the life cycle, to explain savings and consumption. The possibility that the failure of the version of the model is explained by a failure of the rational expectation hypothesis is related to the discussion of the results in Attanasio and Rohwedder (2003) on the failure of individual saving to respond to changes in the value of the Basic State Pension. When individuals respond to the pension system and reforms to it, and indeed when they respond to tax incentives, they will be responding given their own understanding, beliefs, and expectations about the systems and reforms that they are faced with. It may be that those beliefs and expectations do not fully capture the nature of a particular part of the pension system, either because individuals do not fully understand some element of the system or because they believe that some part of the system is not credible or will not endure. If beliefs and expectations do not wholly reflect the current rules of the system, then we cannot expect to observe responses to all elements of the system that would accord with the predictions of an economic theory that is predicated on a full understanding and belief of current rules. An important research agenda, therefore, is one that looks at the information available to individual households when making important saving decisions and at their ability to process it efficiently.

Fortunately, new surveys, such as the Health and Retirement Study (HRS) in the US and the English Longitudinal Study of Ageing (ELSA) in the UK and the Survey of Health Ageing and Retirement in Europe (SHARE) for several European countries, have started to collect data on individuals' expectations

that are relevant for their retirement savings decisions.³³ Evidence from ELSA suggests that individuals have quite accurate expectations about some features of their likely retirement, but are less good at predicting other elements. Expectations of being in paid employment at older ages are, on average, similar to the current proportions of older individuals who are in paid work (Banks, Emmerson, Oldfield, and Tetlow (2005)). In addition individuals' expectations of remaining in the labour market at older ages appear to square up with the marginal financial incentives to remain in work: relative to those in SERPS those aged 50 to 54 who are currently in a defined benefit pension on average report that they are less likely, and those who are currently in a defined contribution pension on average report that they are more likely, still to be in paid work five years prior to the State Pension Age (Banks, Blundell, and Emmerson (2005)). On the other hand, on average men and (in particular) women aged 50 and over underestimate their chances of survival to older ages (Banks, Emmerson, and Oldfield (2004)). There is also evidence that, on average, individuals are, if anything, over-optimistic about the amount of private pension income that they can expect to receive (Banks, Emmerson, Oldfield, and Tetlow (2005)).

Good data on expectations of outcomes from pensions is not only interesting in itself, but may also be informative for assessing why individuals respond to the pension system in the way that they do. For example, by using data on retirement expectations and wealth holdings of households in Italy during a recent period of state pension reforms, Bottazzi, Jappelli, and Padula (2006) are able to assess how these reforms affected expectations and then to infer how fully individuals' changes in saving behaviour reflected their new beliefs. They conclude that individuals did not immediately fully internalize the implications of a series of pension reforms in their expectations of retirement outcomes, and that even their expectations about changes in social security wealth were not fully accommodated through changes in private wealth accumulation. Such evidence that inaccurate expectations may be influencing savings decisions is very important since it implies that if different policies are not equally well understood by the affected population then evidence on how saving responds to a particular reform may not be transferable to other episodes even when the same population of savers is involved.

³³ Wave 11 (2001) of the British Household Panel Survey (BHPS) containing a question on individuals self-reported chance of living to age 75 (for those aged under 65) and questions on expected private pension income. The Bank of Italy Survey of Household Income and Wealth, has pioneered questions on replacement rates, expected retirement age, and more generally about income expectations, for some time now.

As we mentioned above, in many countries the largest item in many household portfolios is housing. It is not surprising, therefore, that the relationship between house values and consumption has received a fair amount of attention, especially in a country where house prices have moved considerably, such as the UK. Muellbauer and Murphy (1990), for instance, explain the late 1980s consumption boom as being caused by the increase in house prices over the same period coupled with the development of financial markets that enabled people to borrow against the increased value of their homes. Attanasio and Weber (1994) on the other hand, by looking at micro data, point out that most of the increase in consumption was observed among young consumers, who did not experience large capital gains as ownership rates are lower for that group. Instead, they present simulations of a very simple life-cycle model in which consumers experience an upward revision of future income growth and generate a cross-sectional response (across cohorts) very similar to that observed in the data.³⁴

Dynan and Maki (2001) analyse the effect of capital gains in the stock market on consumption in the US. They find sizeable effects on saving and consumption of changes in financial wealth. In particular, they 'estimate that an additional dollar of wealth leads households with moderate securities holdings to increase consumption between 5 cents and 15 cents, with the most likely gain in the lower part of this range'.

Changes in interest rates

There is also a small empirical literature that looks at the effects of changes in interest rates on individual products on savings. Most of these studies look at the changes in the rate of return induced by tax incentives on specific instruments. An early attempt to stimulate household saving by increasing the return on specific assets providing a privileged tax treatment was, in the early 1980s, tried in the US by widening the availability of Individual Retirement Accounts. Subsequently, the focus shifted to the 401k plans that many employers offer in the US. The 401k plans are much more complex than the original IRAs as they often combine the tax exemption with employer's matching contributions and occasionally with financial education (through workshops, newsletters, and so on).

The issue of whether the tax treatment of these assets has increased personal and/or national saving has been hotly debated. One side of the debate

³⁴ Attanasio et al. (2009) extends the Attanasio and Weber study to more recent years and confirms its basic findings. These contrast with those reported in Campbell and Cocco (2007).

has strongly argued that it has, while another side has argued that most of the large number of contributions to IRAs first and 401ks later have been originated from reshuffling savings that would have occurred regardless. The absence of experimental data has made a definitive answer on this problem difficult to obtain, although many of the papers in this literature³⁵ have used ingenious methods to assess the counterfactual of what would have been the level of savings of IRA or 401k contributors in the absence of these incentives.

The more recent contributions on the topic have shifted the focus to what is the most common asset, that is 401k accounts. Benjamin (2003), for instance, uses an IV approach to estimate the effect of participation into a 401k programme on net financial assets using 401k eligibility as an instrument and finds a reasonably large effect of 401ks onto private and even national saving. Subsequently, Chernozhukov and Hansen (2004), have used an Instrumental Quantile Regression Analysis to analyse the same data studied by Benjamin and allow for effect heterogeneity. They found that while the effect of the programme on net financial assets seems to be increasing with household wealth, for richer consumers substitution from other sources of wealth seem to be important and it is only for poorer consumers that most of the 401k wealth seems to be 'new' wealth.

If one were to use the life-cycle model and the simulations we performed in Section 7.2, one would conclude that the pure incentive effects of these tax incentives would be, in all likelihood, relatively small. According to the literature we surveyed on the empirical relevance of the life-cycle model, this would not be a completely nonsensical exercise. The Scholz et al. (2006) we cited above, does justify the use of an appropriately detailed version of the model. Moreover, this result would be consistent with the evidence in Attanasio and DeLeire (2002), Gale and Scholz (1994), and Engen, Gale, and Scholz (1996).

The versions of the life-cycle model we considered, however, do not consider explicitly the issue of information and expectation. There is some evidence (see, for instance, Bernheim and Garrett (1995)) that 401k plans might have had an effect on saving by changing the information used by consumers in their investment choices and their financial literacy. This view would also be consistent with the evidence presented in a remarkable new study (see Duflo et al. (2006)) which reports evidence from a randomized trial of saving

³⁵ A survey article by Bernheim (2002) or the symposium in the *Journal of Economic Perspectives* (1996), with Engen, Gale, and Scholz arguing that the tax incentives had led to little new national saving, Poterba, Venti, and Wise favouring the opposite viewpoint, and Hubbard and Skinner adjudicating, provide good introductions to this literature. Some of the key research papers include Venti and Wise (1990); Poterba, Venti, and Wise (1995); Gale and Scholz (1994); Engen, Gale, and Scholz (1996); and Attanasio and DeLeire (2002).

incentives focused on low and middle income families. The authors of that paper conclude that the evidence shows that both incentives and information are important. The focus on the saving behaviour of low and middle income families is particularly relevant for the UK.

As for the case of pensions, the UK provides a very interesting case study, given the variety of new products that have been introduced by the government in an attempt to stimulate the savings, especially of low and middle income families. We have several examples of tax relief on the returns accruing to accessible savings, starting with the introduction of Personal Equity Plans (PEPs) and Tax Exempt Special Savings Accounts (TESSAs), and more recently with the more flexible Individual Savings Accounts (ISAs) (see Adam, Browne, and Heady in Chapter 1 for some discussion of these products, or Attanasio, Banks, and Wakefield (2005) for a fuller discussion).

However, data limitations make it hard to conduct thorough econometric analysis of the UK experience of these accounts, but descriptive evidence is available, again in Attanasio, Banks, and Wakefield (2005). Aggregate evidence on the balances held in TESSAs indicates that these balances tended to jump immediately when new contributions to accounts could be made in a new year, and also that average contributions were often close to the maximum amounts that could be deposited in accounts. This, it is argued, is at least consistent with a pattern of individuals largely reshuffling existing wealth into TESSAs, rather than making substantial new savings during the relatively limited number of years that the accounts operated.

The authors also present microeconomic data on the experience of ISAs which indicate that while the take-up of ISAs was quite high, there is no strong evidence that this had much affect on overall ownership of non-pension financial assets or on levels of saving among those with such assets. However, there was some evidence of an increase in ownership of financial assets among low education groups and the young. This could suggest that ISAs were successful in being more attractive to low-income savers than TESSAs or PEPs had been (chapter 5 of HM Treasury (2000)). On the other hand, this evidence was far from overwhelming and at least one earlier study using micro data had argued that ISAs were little better than TESSAs and PEPs at reaching some low-income groups (Paxton (2003)).

Attanasio, Banks, and Wakefield argue that the UK evidence that they present is consistent with US evidence concerning tax deferred 'Individual Retirement Accounts' (IRAs) that is drawn from Attanasio and DeLeire (2002). Attanasio and DeLeire use short horizon panel data on consumption and argue that while around 40% of contributions to IRAs in the 1980s may

have been additional personal saving, once account is taken of the cost of tax relief then less than one dollar in ten of contributions could be considered to be new national saving. Thus, for the cases that they consider, Attanasio, Banks, and Wakefield conclude that ‘only relatively small fractions of the funds going into tax-advantaged savings vehicles can be considered to be “new” saving. As such, the best interpretation of the evidence is that such policies are expensive ways of encouraging savings.’

From a conceptual point of view, it should be stressed that the type of tax incentives considered in this literature do not fit neatly within the type of exercise we have been considering in Section 7.2 because in that model we considered only one asset paying *the* interest rate. In this context, instead, we have many assets that form household portfolios and the incentive provided changes the return on *some* but not all assets. A useful simulation, therefore, would also have to consider the portfolio problem and the influence that the incentive has on the portfolio allocation. Within this context one should also consider the role played by pensions that, on the one hand, have important tax advantages, while, on the other, they often involve penalties for early withdrawals. The latter make the numerical simulations like those presented in Section 7.2 considerably harder.

7.4. CONCLUSIONS

In this chapter we have discussed the implications that the life-cycle model has for the effects of the taxation of saving. We started from the fact that even if the life-cycle model is probably one of the best studied and understood models in economics, quantifying the effects that changes to the interest rate might have on the level and pattern of saving is not completely obvious. There are several reasons for this ambiguity.

First, as is well known, within the life-cycle model several competing effects are triggered by a change in the interest rate: substitution effects, income effects, and wealth effects. Moreover, and more importantly for our discussion, how these effects interact with each other depends crucially on the details of the model. The nature of the income process, the evolution of individual needs (such as family size) over the life cycle, the intertemporal trades individuals can access, and pension arrangements all affect in a quantitatively important fashion the responsiveness of the saving to changes in the interest rate and/or the welfare consequences of such changes. To illustrate this point

we simulated a reasonably realistic life-cycle model and discussed how this responsiveness changes as features of the model change.

Second, there are reasons to believe that the simplest version of the life-cycle model does not necessarily describe the way individuals act and that realistic deviations from the basic version could have important implications. For this reason, we discussed several deviations from the basic model: we considered the case in which labour supply is non-separable from consumption, the case of intertemporal non-separabilities such as durables or habits, the case of various forms of market imperfections, and the role of housing, amongst other factors. The message that emerges from this discussion is that, unfortunately, there are many issues that are likely to be very important and yet we do not know their quantitative relevance for the issues discussed in this chapter. In our opinion, these constitute important items on the research agenda for the future.

Third, although part of the literature has constructed versions of the life-cycle model that seem to fit some aspects of behaviour, especially for prime aged individuals, there are other aspects that are not captured by the same model or by some of the assumptions typically used in the literature. In particular, it is worth stressing that post-retirement behaviour is particularly difficult to capture and that we do not know much about the early part of the life cycle. Moreover, the assumption of rational expectations sometimes seems a particularly strong one, making a research agenda that looks at the information that people use in making intertemporal decisions (as well as at patterns of evolution of cognitive capabilities) particularly interesting and important.

We have also briefly looked at models that depart substantially from the basic rationality assumption typically used in the life-cycle model. We have mentioned two strands that have been quite visible in the literature: the hyperbolic discounting literature and the temptation literature.

In the last part of Section 7.3, we have considered empirical evidence that, while sometimes using the life-cycle model as a conceptual framework, relies on large policy or other large changes in the economic environment in which individuals operate to identify some of the elasticities that are relevant for the relationship between savings and intertemporal prices. What is remarkable is that this literature (whether testing the degree of separability between pension and financial wealth or testing whether tax incentives can increase savings) has, by and large, been divorced from the formal analysis of the life-cycle model.

What can we conclude from our discussion? We offer some tentative conclusions and propose some themes for future research.

1. The life-cycle model is an extremely useful framework that can be used to conceptualize the analysis of saving and consumption behaviour. However, if one wants to take the model to the data for serious quantitative prediction, it is necessary to work with relatively complex and sophisticated versions of the model that take into account a number of factors that have been proven to be empirically important.
2. Numerical simulations are a very useful instrument to answer the questions posed by the use of complex versions of the basic model. While our ability to deal with more complex models has improved considerably, much work remains to be done to incorporate in workable versions of the model many realistic and important details bound to have first order importance.
3. Given the basic structure of the model it is unlikely that changes in interest rates due to preferential taxation or other movements to interest rates will cause big changes in the level of saving. However, that does *not* necessarily imply that the welfare consequences of taxing asset returns would be small. Furthermore, evidence does indicate that people respond to changes in relative interest rates (possibly induced by tax policy) by adjusting portfolio composition.
4. The quantitative implications of more complicated versions of the life-cycle model that involve endogenous labour supply, durables, housing, and so on need to be explored as we still do not have a good idea of what role these phenomena (which are bound to be of first order importance) play.
5. Models with temptation and with information problems are also worth exploring and developing so that they can be brought to data.

This set of conclusions indicates that there remain several research agendas to pursue to complete our understanding of the life-cycle model and the behavioural and welfare consequences of policies that affect the return on saving.

To make more precise recommendations about *how much* we should tax the return to saving will require embedding the insights of the life-cycle model into a framework that introduces other types of taxation and so can contrast the welfare costs of taxing saving against those from taxing other sources of income, or consumption expenditures. Chapter 6, by Banks and Diamond, considers what is known about such frameworks and so often uses the life-cycle model as an input to address the issue of whether our benchmark for taxing saving should be the tax on other incomes, or the zero taxation proposed in the expenditure tax set-up.

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