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by

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Abstract

This paper formulates and estimates a structural life cycle model of married couples' labour supply and consumption of durables and non-durables. The purpose of this work has been to find a specification of this class of life cycle models that can be estimated in the absence of observations of consumption of non-durables, and the price and the physical stock of durables. We allow for a particular kind of non-separability in the demand for durables, and treat durables and non-durables as a (single) Hicks composite good.

Keywords: Empirical, life cycle model, labour supply, consumption, intertemporal non-separability

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1 Introduction

This paper formulates and estimates an empirical life cycle model for two-person households that choose labour supply and consumption including consumption of durables in an environment of uncertainty about future prices. Ideally, estimation of this model requires complete life cycle data for all these goods and households' expectations about the corresponding prices, including the interest and the income tax rates. Since there exist no such data sets, and economic theory is rather weak on how to measure the demand for durables, empirical work treats at least some of the goods in a rather summary way. We will also argue that measurement error in the observations of the consumption of non-durables may be important. The point of departure of this work has then been to modify the theory so that a complete life cycle model of labour supply and consumption of durables and non-durables can be estimated in the absence of reliable data for consumption of non-durables, and the purchase price and the physical stock of durables. In contrast to the standard, and presumably unrealistic, assumption of intertemporal separability, we allow for a particular kind of non-separability in the demand for durables.

The paper is organized as follows. Section 2 presents the standard life cycle model of consumption of durables and non-durables, and discusses some of the problems related to estimation of preferences over these goods. We discuss the serious measurement problems, and raise the important point that the first order condition for durables does not reflect the existence of fixed costs in the demand for durables. The standard assumption of intertemporal separability is also discussed.

In Section 3 we present the general framework of the complete model to be estimated. We introduce a particular form of habit persistence in the demand for durables. The specification is analogous to the one that is found in Bover [5], Hotz, Kydland and Sedlacek [14], Johnson and Pencavel [16] and Muellbauer [24]. However, in contrast to these works, which analyse labour supply and consumption of non-durables, we relate this specification to the stock of durables. We argue that our specification is consistent with an interpretation that says that the household gains utility from an increase in the stock of durables relative to what "remains" from the last period. In the determination of what "remains" from the last period, we allow for physical as well as psychological depreciation. Psychological depreciation is introduced to take into account that after some time the household may tire of the present stock of durables. This means the physically existing capital stock does not yield as much utility as before, but since it can be resold in the market, it must be treated differently from the stock that is physically depreciated.

If the stock of durables is totally depreciated (in the utility context), our specification of the utility of durables implies that utility depends on the stock of durables. Hence, the standard specification of the utility of durables is a special case of our specification.

It appears that an advantage of our interpretation is that it leads us towards a specification that can be estimated in the absence of reliable observations of the consumption of non-durables, and the purchase price and the physical stock of durables. This advantage is demonstrated, before we end section 3 by commenting on the estimation strategy. Section 4 presents a particular empirical specification which is estimated, and in Section 5 we look at the details of the estimation procedure. Section 6 gives an account of the data, and Section 7 presents the estimation results. Finally, some concluding remarks are made in Section 8.

2 Confronting the Standard Life Cycle Theory with Data

2.1 The standard framework

We now look at some problems related to the estimation of preferences over durables and non-durables. In order to focus on the main problems, assume that lifetime preferences are an inter- and intratemporal separable function of durables and ordinary consumer goods only. Thus

$$U_0 = \sum_{t=0}^{T}(1+\rho)^{-t}\left[U_{ct}(C_t) + U_{kt}(K_t)\right], \tag{1}$$

where ρ is the time preference rate, K denotes stock of durables, C is consumption of non-durables, and subscript 0 and T denote the beginning and the end of the planning horizon. We also assume perfect certainty about future prices and preferences, and that labour supply, H, is exogenous.

In the absence of personal income taxation, the within period wealth constraints are

$$w_t H_t + (1+r_t)F_{t-1} = p_t C_t + q_t\left[K_t - (1-\delta_f)K_{t-1}\right] + F_t, \quad t = 0, 1, \cdots, T, \tag{2}$$

where F is assets measured in nominal terms, r is the nominal interest rate, w, p and q are the nominal prices of leisure, non-durables and durables, and δ_f is the physical depreciation rate for durables. If $\delta_f < 1$ (and ≥ 0), the specification of the wealth constraint implies that durables can be sold in a second hand market.

Despite the fact that households may face different[1] prices, we assume that all (pre-tax) prices are equal for all households. Except for the fact that bequests at the beginning of the planning period can be exogenously included into the value of F_0, we do not take explicit account of the possibility of bequests. Neither do we consider that families can place their wealth into other kinds of assets, such as bonds, shares, pension funds, arts or antiques.

We assume that durables are bought at the end of the period. Since this stock is continuously being depreciated during the subsequent period, $q_t(1-\delta_f)K_{t-1}$ is the market value of the stock of durables that was demanded in the last period and that is left at the end of period t.

In what follows we assume that there are no binding credit market restrictions. Maximization of the preference function (1) subject to the wealth constraint (2),

[1]The households may face different prices, for example, because they live in different regions of the country or because banks offer different terms to different customers.

given values of initial stocks of assets and durables, and the terminal stock of assets, yields the following first-order conditions,

$$\frac{\partial U_{ct}}{\partial C_t} = \lambda_t p_t, \quad t = 0, 1, \cdots, T, \tag{3}$$

$$\frac{\partial U_{kt}}{\partial K_t} = \lambda_t q_t - \frac{1}{1+\rho}\lambda_{t+1}(1-\delta_f)q_{t+1}, \quad t = 0, 1, \cdots, T, \tag{4}$$

and

$$\lambda_t = \frac{1}{1+\rho}(1 + r_{t+1})\lambda_{t+1}, \quad t = 0, 1, \cdots, T-1, \tag{5}$$

where λ_t is the Lagrange multiplier, i.e. the marginal utility of wealth.

2.2 Some data - and measurement problems

Equations (3) to (5) and the wealth constraints (2) constitute a simultaneous equation system that determines C_t, K_t, F_t and λ_t, for $t = 0, 1, \cdots, T$, as functions of all the exogenous variables of the model, including the parameters of the lifetime utility index. In most cases it is, however, impossible to find these reduced form equations. If λ can be observed, however, it appears that the relevant demand functions in the life cycle context are the Frisch demands, cf. MaCurdy [20].

Concerning the estimation of these functions, it is a problem that λ_t is latent and depends on all the exogenous variables of model. Kornstad [18] discusses various solutions to this problem. These solutions typically involve a two stage estimation procedure, where the first stage involves estimation of the parameters related to intraperiod allocations, while the second stage involves estimation of the parameters related to interperiod allocations. However, even if one estimates only within period preferences (stage one), which typically requires less data, it appears that the data requirement is quite large. For instance, in the estimation of the differenced marginal utility of wealth constant demand functions, MaCurdy's fixed effect approach, cf. [20, 22], demands panel data for consumption and (after-tax) prices for all goods (at least one), for at least two periods. Similarly, estimation of the y-conditional demands in the two stage budgeting theory discussed in Blundell [4] and Blundell and Walker [3], demands cross section data for the consumption of all goods, for a variable labelled full income, and for the simultaneous distribution of all current (after-tax) prices. Altonji [2] and MaCurdy [21] propose using the marginal rate of substitution functions, and this approach requires cross section data for all goods (at least two) and their (after-tax) prices. In addition, these approaches may need instrument and taste-modifier variables, and in order to account for eventual cohort effects, estimation of the instrument equations may require panel data. Since the decisions with respect to labour supply and consumption of non-durables and durables are taken simultaneously, ideally, our data should include observations for all these goods. Taking also into consideration the fact that estimation of the parameters determining interperiod allocations typically requires panel data, estimation of complete life cycle models of labour supply and consumption is very data demanding. This extensive data requirement is important to have in mind as we look at some problems that are particular to the estimation of the preferences over durables and non-durables.

A particular problem in the estimation of equation (3), is the measurement of consumption of non-durables. Non-durables include a variety of goods, and the measurement of the consumption of all these goods requires detailed household accounts. To reduce costs, many goods are bought infrequently, but in large quantities each time. This fact, and the fact that the consumption of many goods is season specific, implies that consumption patterns should be observed over longer time periods. Hence, without having access to detailed household accounts for longer time periods, it is hard to obtain reliable observations of the consumption of non-durables.

However, if we observe the cash flow related to the purchases of durables, we may use the period specific wealth constraints and the consumer price index to calculate the consumption of non-durables. But since we, in most cases, do not observe the purchase of durables in addition to all the other variables we need, this method is rarely useful.

Concerning the demand for durables, notice that if there are no binding constraints in the credit market, the first order condition (4) can be written

$$\frac{\partial U_{ct}}{\partial K_t} = \lambda_t \left[q_t - (1 - \delta_f) \frac{q_{t+1}}{1 + r_{t+1}} \right], \tag{6}$$

where $q_t - [(1 - \delta_f) q_{t+1}/(1 + r_{t+1})]$ is the user price of durables (including capital gains).

Again, measurement problems are serious. According to economic theory, consumption should be measured in physical units or in real terms, and not as an expenditure evaluated in current prices. It is also evident that consumption is a stream which should be measured per time unit, but apart from that economic theory gives very few guidelines. Since durables yield a flow of services for many periods, it is difficult to quantify the consumption of durables for a particular year.

Assuming there is a fixed relationship between the consumption and the stock of durables, the stock can be used as an argument in the utility index, cf. equation (1). The measurement problems, however, are still serious. An important reason is that durables typically have many characteristics that influence utility. For example, the utility of housing depends on characteristics such as location, the number of different kinds of rooms and "quality". The multiplicity of characteristics mean that a division of housing into homogenous subgroups will inevitably result in a huge number of groups. Even if it was possible to define these groups, it is still a problem that no existing data set includes all the information required to determine the distribution of all housing into the various groups. This fact becomes even more accentuated when we consider that estimation typically requires observations of other variables as well.

According to equation (6), the user price of durables is the relevant price for the demand for durables. Another problem related to the estimation of preferences over durables then is how to measure the user price of durables. This price is only rarely realized in the market, which means that for practical estimation purposes it cannot be observed directly. An alternative is to calculate it indirectly using observations of the purchase prices, the (after-tax) interest rate and the physical depreciation rate.

Notice then that the practical problems related to the measurement of durables also make it problematic to quantify the purchase price of durables. Since the user price includes the purchase price from two different periods, and the depreciation rate is rarely known, this means that the indirect method can not be used either.

The difficulty of observing the purchase price of durables suggests an approximation in which we use the (real) market value of durables[2] as an argument of the utility index. A problem with this approach is that, since most second-hand durables are only rarely resold, it is difficult to obtain reliable predictions of the market values for all relevant goods. Although this problem may be serious, it is not obvious that it is more serious that the problems related to the measurement of expenditures on non-durables. It may be easier to ask for information about the most important durables than about a large number of non-durables.

The fact that many data sets do not include the market value of durables, in addition to all the other variables we need for estimation, is a serious problem. Since we typically do not observe $q_t(1-\delta_f)K_{t-1}$ and the other components of the wealth constraint, indirect observation through the wealth constraint is also difficult.

We therefore conclude that it is difficult to obtain reliable observations on the market value of durables. Due to missing theoretical foundations, it is even more difficult to determine and observe their consumption and prices. Reliable observations of the consumption of non-durables are also difficult to obtain, but this is due to practical problems and cost considerations, rather than theoretical problems.

In what follows we assume that the only consumption data we observe are $q_t K_{t-1}$ and the total cash flow related to the purchases of durables and non-durables. The cash flow may be calculated indirectly through the wealth constraints.

[2]In order to get a kind of a real value the market value can eventually be divided with the consumer price index.

2.3 Some additional arguments in favour of an alternative specification for durables

If δ_f equals one, either because there is no second-hand market or because physical depreciation is high, the user price coincides with the purchase price. Since durables and non-durables are treated in the same way in the utility index, this means that, apart from the fact that some durables can be resold, standard economic theory treats durables analogously to non-durables. As will now be argued, it is not obvious that this should be the case.

Standard life cycle theory assumes that consumption of durables can be treated as a continuous variable, and that no transactions costs are incurred in purchasing these goods. According to the first order condition (4), consumption should be adjusted until the marginal utility of durables equals its (net) marginal cost. This means that the demand for durables should continuously be adjusted in accordance with changes in the user price. In the case of housing, these adjustments involve important transactions costs of both the pecuniary and non-pecuniary kinds. If we divide housing into homogeneous subgroups with respect to location, number of rooms, and quality, we can also question whether it is reasonable to assume that it is possible to make marginal changes in its consumption. (This fact is also relevant for labour supply.) Both these facts raise the question of whether the marginal, and quite fine, comparisons that follow from the first order conditions, are good approximations to the comparisons households actually make. Maybe the household adjusts more roughly, in the sense that it can only choose between a limited number of baskets of goods. In the case of the demand for housing we can think of this basket as consisting of the purchase price of the housing, location, number of rooms, and a measure of quality. Households then choose the basket that maximizes utility.

Another argument in favour of a specification for durables other than the one presented in section 2.1 is the following. Economic theory allows $\partial(\partial U_t/\partial X_t)/\partial X^*_{t'}$ $\neq 0$, where X_t and $X^*_t = C_t, K_t$, for $t, t' = 0, 1, 2, \cdots T$. That is, the marginal utilities may depend on the consumption of all goods in all periods. Estimation of specifications that are based on the first order conditions then requires life cycle data for the consumption of all goods (in addition to the other variables that are needed).

Given this fact, most empirical analyses realize that some kind of separability assumption must be invoked. Most empirical analyses assume that preferences can be reasonably approximated by an intertemporal separable function, and it is also frequently assumed that even the within-period utilities are separable, cf. equation (1).

Intertemporal separability means that $\partial(\partial U_t/\partial X_t)/\partial X^*_{t'} = 0$, where X_t and $X^*_t = C_t, K_t, t \neq t'$ for $t, t' = 0, 1, 2, \cdots T$. That is, the marginal utilities are functions of current consumption only, and it is possible to estimate within-period preferences from cross sectional data only, cf. Altonji [2], Blundell [4] and MaCurdy [21].

Intertemporal separability does, however, imply that habits play no role in the demand for the various goods. Duesenberry's relative income hypothesis (1949) focuses on habits in aggregate demand, and Muellbauer [24] claims that "Evidence from the estimation of complete systems of demand equations suggests that habits or persistence effects play an important role in consumer behaviour.". Bover [5] concludes that her estimation of a life cycle model "strongly support the importance of past hours in determining current hours decisions.". We therefore conclude that the assumption of intertemporal separability seems to be rather unrealistic.

3 A Model with Habits or Psychological Depreciation

This section considers modifying the life cycle model outlined in the previous section to account for habits in the demand for durables. The modification relies on a story in which habits inference the demand for durables, but not the demand for non-durables. An advantage of this modification is that it can be estimated for the case in which we observe neither the consumption of non-durables nor the price and the physical stock of durables.

The model is extended to include female and male labour supply, personal income taxation and the possibility of credit market constraints, and constitutes the general framework of the empirical analysis.

3.1 The model formulation

Assume lifetime preferences

$$U_t = \sum_{k=t}^{T} \frac{1}{(1+\rho)^{k-t}} G\left[U_{zk}(Z_k) + \sum_{j=f,m} U_{jk}(L_{jk})\right], \tag{7}$$

where L_f and L_m are female and male leisure, and Z is a composite good defined as

$$Z_k \equiv C_k + \frac{q_k}{p_k}\left[K_k - \beta K_{k-1}\right], \tag{8}$$

where β is a constant. The good Z then includes both non-durables and durables. In the next section we present a theory that leads to this specification and the interpretation of β, but for the moment we merely postulate that Z is the relevant consumption good related to the consumption of durables and non-durables.

In order to account for personal income taxation, we introduce the tax function $I_k(w_{fk}H_{fk}, w_{mk}H_{mk}, r_kF_{k-1})$. Thus, income taxes are levied on wage and interest incomes, and we ignore wealth taxes. If F is negative, the household is in a net debt position, and the specification of the tax function allows deductions of interest expenses. The index k on the tax function indicates that the marginal tax rates vary across periods.

The time invariant monotonic transformation of within-period utility, G, implies that we allow for a particular kind of non-separability in the within-period utility of Z, L_f and L_m, cf. equation (13) and (14). It can be argued that this transformation does not reflect the special dependency between the household's utility of female and male leisure. An alternative would then be to introduce a separate transformation of $[U_{fk}(L_{fk}) + U_{mk}(L_{mk})]$. Given the proposed estimation procedure, cf. equation (36) and (37), we cannot, however, use a similar Box-Cox transformation of $[U_{fk}(L_{fk}) + U_{mk}(L_{mk})]$ as we have used for $[U_{zk}(Z_k) + U_{fk}(L_{fk}) + U_{mk}(L_{mk})]$, cf. equation (31).

The period specific wealth constraints corresponding to the utility index (7) now become

$$\sum_{j=f,m} w_{jk}H_{jk} + r_k F_{k-1} = \\ I_k\left(w_{fk}H_{fk}, w_{mk}H_{mk}, r_k F_{k-1}\right) + p_k Z_k - \delta_p q_k K_{k-1} + \Delta F_k, \quad k = t, \cdots, T. \tag{9}$$

Since purchase of durables are often financed by loan, the possibility of credit market constraints should be considered. We follow Mariger [23], and assume that the families can borrow only against mortgage in property. That is, net debt raised at the end of the period, $-F_k$, cannot exceed a fraction κ of the market value of the stock of durables at the end of that period, $q_k K_k$,

$$-F_k \leq \kappa q_k K_k, \quad k = t, t+1, \cdots, T. \tag{10}$$

It is assumed that κ is invariant of both time and characteristics of the household.

As opposed to Mariger, we do not observe whether or not a household is constrained since we do not know κ and do not observe $q_k K_k$. (In the empirical analysis we assume κ is known and approximate $q_k K_k$ by $q_{k+1} K_k$.)

Despite the importance of labour market constraints we only account for the non-negativity constraint,

$$H_{jk} \geq 0, \quad j = f, m, \quad k = t, t+1, \cdots, T. \tag{11}$$

Leisure and labour supply are also constrained through the time budget, that is

$$L_{jk} = \overline{L} - H_{jk}, \quad k = t, t+1, \cdots, T. \tag{12}$$

We also allow for uncertainty about future prices, including the marginal tax and interest rates. The household maximizes the expected value of the time-preference-discounted sum of lifetime preferences with respect to $Z_{t'}$, $H_{ft'}$ and $H_{mt'}$, for $t' =$

$t, t+1, \cdots, T$, subject to the constraints stated above and given values of F_{t-1}, K_{t-1} and F_T.

Necessary conditions for an optimum are the satisfaction of all the constraints and

$$\tilde{G}' \frac{\partial \tilde{U}_{zt}}{\partial Z_t} = \lambda_t p_t, \tag{13}$$

$$\tilde{G}' \frac{\partial \tilde{U}_{jt}}{\partial L_{jt}} = \lambda_t \tilde{m}_{jt} + \alpha_{jt}, \quad \mathrm{j = f, m} \tag{14}$$

and

$$\lambda_t = \frac{1}{1+\rho} \mathrm{E}_t \left[(1 + \tilde{R}_{t+1}) \lambda_{t+1} \right] + \psi_t, \tag{15}$$

where "tilde" denotes that the variable is evaluated at the optimum, G' is the partial derivative of G with respect to $[U_{zt}(Z_t) + \sum U_{jt}(L_{jt})]$, and

$$m_{jt} \equiv w_{jt} \left[1 - \frac{\partial I_t}{\partial (w_{jt} H_{jt})} \right] \tag{16}$$

and

$$R_{t+1} \equiv r_{t+1} \left[1 - \frac{\partial I_{t+1}}{\partial (r_{t+1} F_t)} \right] \tag{17}$$

are the after-tax marginal wage and interest rates. The Lagrange multipliers λ_t, ψ_t and α_{jt}, $j = f, m$, which are associated with the wealth constraint, the borrowing constraint and the labour supply constraints, are all household- or person-specific.

3.2 The specification of the composite good

To focus on the essential properties of the composite good, neglect the monotonic transformation function G of the preference function (7), and assume that the within-period preferences over consumption of non-durables and durables can be formulated as

$$V_0 = V_0(K_0, K_1, \cdots, K_T, C_0, C_1, \cdots, C_T) = \\ \sum_{t=0}^{T} \frac{1}{(1+\rho)^t} \left\{ U_{kt} \left[K_t - \beta K_{t-1} \right] + U_{ct}(C_t) \right\}. \tag{18}$$

Concerning our specification of the utility of durables, we notice that Bover [5], Hotz, Kydland and Sedlacek [14], Johnson and Pencavel [16] and Muellbauer [24] use a similar specification of the utility of leisure and non-durables.

Notice also that if $\beta = 0$,

$$V_0 = \sum_{t=0}^{T} \frac{1}{(1+\rho)^t} \{U_{kt}(K_t) + U_{ct}(C_t)\}. \tag{19}$$

That is, if $\beta = 0$, our treatment of durables coincides with the standard specification (1). In order to introduce more flexibility in the demand for durables, we assume that the preference structure underlying the demand behaviour can be defined with respect to a reference bundle, cf. Spinnewyn [27], Phlips [25, 26], Houthakker and Taylor [15], and Stadt, Kapteyn and Geer [28].

The choice of reference bundle varies across analyses. Houthakker and Taylor [15] assume that when households hold physical inventory of the actual good, the demand for the good depends on its stock. The reference bundle is now the stock of the good. For other goods such as tobacco, beer and spirits households do not hold inventories of any significance. Consumption of these stimulus are, however, habit-forming, and we can say metaphorically that households have built up a psychological stock of smoking and drinking habits, cf. Houthakker and Taylor. The reference bundle is now this psychological stock of habits, and according to Phlips [26], this "built-in" mechanism is typical for other kinds of non-durables as well.

While these two examples are related to habit formation, Alessie and Kapteyn [1] are concerned with the fact that household preferences are influenced by the behaviour of other groups of households. The reference bundle is then the consumption of these groups, but the reason for introducing the reference bundle is not habit formation. Phlips [26] classifies this type of taste changes as taste changes that result from better outside information due to external influences on the household. For instance, by talking with its neighbours, or reading advertising, the household may obtain new knowledge about goods that it has not yet purchased. Another example is that the consumption of a particular good may reveal that the good is harmful to the health of the consumer.

The reference bundle can also represent minimal requirements of different goods from a physical point of view, cf. the linear expenditure system.

These examples indicate that the reference bundle may well change over time, and that it may depend on past experience. According to the habit-interpretation, we would expect that β (in equation (18)) satisfies the condition $0 < \beta \leq 1$, and that β measures the extent to which habits influence current decisions[3]. Notice also that a more general means of accounting for habits, would be to introduce $\sum_{j=1}^{J} \beta_j K_{t-j}$, where we may reasonably assume $\beta_{t-m} > \beta_{t-n}$, for $n > m$.

Specification (18) implies that households have rational, in contrast to myopic, habits, cf. Muellbauer [24] and Spinnewyn [27]. This means that households recognise that current consumption decisions influence their future marginal rates of substitution. A disadvantage of assuming rational habits from an econometric point of view is that, if households maximize utility with respect to K, the two-stage budgeting property no longer holds since the intertemporal utility function is no longer separable. In what follows we will assume that the relevant good related to the consumption of durables can be measured by $(K_t - \beta K_{t-1})$, and in this case intertemporal utility is separable (in $(K_t - \beta K_{t-1})$).

In order to present an interpretation of β which is particularly relevant for durables, split β into two components according to

$$\beta \equiv 1 - \delta_f - \delta_p, \tag{20}$$

where we recall that δ_f is the parameter for physical depreciation, and where δ_p is the parameter we label as psychological depreciation.

It is assumed that habits are determined by the stock of durables that was demanded in the last period after deductions for physical as well as psychological

[3]Muellbauer [24], using quarterly US consumption data, claims that β can be negative if K_t is purchases of durable goods, but this argument does not fit our specification since K_t is stock of durables.

depreciation. Physical depreciation equals $\delta_f K_{t-1}$. The reason for introducing psychological depreciation is that, according to our theory, the household gets tired of the current stock of durables and wants a change. An example may be the household that moves into a new flat and after some time starts looking for a new flat. Another example may be the husband who, for some months, is very fascinated with his new car, but after some time loses interest. In a utility context this depreciation should also be deducted. But since the psychologically depreciated good $\delta_p K_{t-1}$ can be sold in the market, we must distinguish between physical and psychological depreciation. At the end of period t the utility relevant stock of durables is then $(1-\delta_f-\delta_p)K_{t-1}$.

According to this story it seems reasonable to assume that $\delta_p \geq 0$. On the other hand, if durables are not worthless with respect to utility, but for some reason or another are of sentimental value, δ_p can well be negative. It is then reasonable to assume that the size of δ_p depends on the actual good, and that it may be household- and age-specific. Despite these facts, in the empirical analysis we approximate and assume that δ_p is constant, that is, independent of all these variables.

The upper limit of β implies that $\delta_f + \delta_p \geq 0$. If $\delta_f + \delta_p = 0$, equation (18) reduces to

$$V_0 = \sum_{t=0}^{T} \frac{1}{(1+\rho)^t} \left\{ U_{kt}\left[K_t - K_{t-1}\right] + U_{ct}(C_t) \right\}. \tag{21}$$

This means that for the special case that $\beta = 1$, equation (18) implies that the household is concerned about the increase in the stock of durables .

It remains to explain the relationship between equation (7) and (18) in their specification of preferences over non-durables and durables. By substituting $(K_k - \beta K_{k-1})$ into the wealth constraint (9), the wealth constraint can be written

$$\sum_{j=f,m} w_{jk}H_{jk} + r_k F_{k-1} - I_k\left(w_{fk}H_{fk}, w_{mk}H_{mk}, r_k F_{k-1}\right) = \tag{22}$$

$$p_k C_k + q_k\left[K_k - \beta K_{k-1}\right] - \delta_p q_k K_{k-1} + \Delta F_k. \tag{23}$$

If $(K_k - \beta K_{k-1})$ is the relevant measure for consumption of non-durables, the specification of the wealth constraint and the associated preference function imply that $(K_k - \beta K_{k-1})$ can be viewed just like any other good. (In this respect the term

$-\delta_p q_k K_{k-1}$ can be interpreted as negative income.) This means that we can use the Hicks aggregation theorem for aggregation of these two goods into a Hicks composite good.

The application of the Hicks composite good theorem, cf. Deaton and Muellbauer [9], requires that the price ratio q/p is constant over time. In the long run this assumption seems reasonable, and there are also arguments that justify this assumption as a reasonable approximation during the sample period, cf. section 7. In what follows we assume that the composite good theorem can be used.

3.3 The measurement of the composite good

For estimation purposes we need observations of Z. Let

$$Y_k \equiv C_k + \frac{q_k}{p_k}\left[K_k - (1-\delta_f)K_{k-1}\right], \tag{24}$$

which is the cash flow from purchasing non-durables and durables measured in units of the price of non-durables. The composite good can now be expressed as

$$Z_k \equiv Y_k + \delta_p D_{k-1}, \tag{25}$$

where

$$D_{k-1} \equiv \frac{q_k K_{k-1}}{p_k}$$

is the (real) market value of the stock of durables that was demanded at the end of the previous period, measured in the current prices. If $\delta_p = 0$, then $Z_k \equiv Y_k$, and specification (7) implies that households have preferences over the cash flow related to purchase of durables and non-durables.

In what follows we assume that we can observe D_{k-1} for at least one period. It remains to give an account of how we can observe Y_t. Since our data do not include reliable observations of this variable, we use the indirect approach. We have

$$Y_k = \frac{1}{p_k}\left[\sum_{j=f,m} w_{jk}H_{jk} + r_k F_{k-1} - I_k\left(w_{fk}H_{fk}, w_{mk}H_{mk}, r_k F_{k-1}\right) - \Delta F_k\right]. \tag{26}$$

Apart from the unknown habit persistence parameter δ_p, we observe all components of the composite good. We are left with the problem of obtaining reliable observations of the market value on durables, but we do not need to observe the consumption of non-durables, and the price and the physical stock of durables. It is also reasonable to assume that δ_p is small compared with Y, and measurement errors in D may then be less serious than in the standard framework presented in section 2. Specification (8)/(7), and the first order condition (13), then circumvent the problems related to obtaining reliable observations of the consumption of non-durables. Since durables are only one of the components of Z, we also believe that it reduces the problems related to the fixed costs in the demand for durables. In section 4 and 5 we show that δ_p can be treated as a parameter to be estimated.

3.4 Estimation strategy

Since the composite good, Z, with the exception of the unknown parameter, δ_p, can be treated as an ordinary good, the estimation approaches used for the standard life cycle model with intertemporal separability are relevant for the model outlined in the previous section. These approaches are surveyed in Kornstad [18], and we will now focus only on the use of the marginal rate of substitution functions, cf. MaCurdy [21] and Altonji [2].

According to economic theory, households adjust demand until the marginal rate of substitution between two arbitrary goods equals the relative price of the goods. For instance, if there are no binding constraints in the labour and the credit markets, we have

$$\frac{\partial U_{jt}/\partial L_{jt}}{\partial U_{zt}/\partial Z_t} = \frac{m_{jt}}{p_t}, \quad j = f, m. \tag{27}$$

That is, in equilibrium the marginal rate of substitution between female/male leisure and the composite good is equal to the real after-tax marginal wage rate.

By choosing a particular class of lifetime preferences, the marginal utilities can be expressed in terms of the unknown parameters of the preferences and the (realized) values of L_j and Z, and we obtain two specifications that can be used for estimation of the within-period utilities.

The possibility of bias in the estimates of labour supply functions from a subsample of workers that are unconstrained in the labour market is well known, cf. Heckman and MaCurdy [12]. According to Heckman [11], the bias can be viewed as an "omitted variables" bias.

Heckman assumes that it is possible to find a simple expression for the reduced form of the relationship to be estimated. This assumption simplifies the calculation of the omitted variable considerably, but the approach can not be easily modified to include structural equations. Except in very special cases it is impossible to find the reduced form equations of the lifetime paths for L_j and Z, so we ignore the possible selection problem.

Also notice that the marginal rate of substitution functions cannot be used to estimate the transformation function G. Using the Frisch demands for Z and the Euler equation (15) in the case of no binding constraints in the credit market, we find that

$$\frac{G' \partial U_{zt} / \partial Z_t}{p_t} = \frac{1}{1+\rho} \mathrm{E}_t \left[(1 + R_{t+1}) \frac{G' \partial U_{zt+1} / \partial Z_{t+1}}{p_{t+1}} \right], \tag{28}$$

where G' is the partial derivative of G. Assuming e_{t+1} is the one-period forecast error, this expression implies

$$\frac{G' \partial U_{zt+1} / \partial Z_{t+1}}{p_{t+1}} = \frac{1+\rho}{1+R_{t+1}} \left[\frac{G' \partial U_{zt} / \partial Z_t}{p_t} \right] (1 + e_{t+1}). \tag{29}$$

If expectations are rational, e_{t+1} is uncorrelated with

$$\frac{1+\rho}{1+R_{it+1}} \left[\frac{G' \partial U_{zt} / \partial Z_t}{p_t} \right], \tag{30}$$

and we have found an equation that can be used as a basis for estimation of the parameters of the G-function and the time preference rate ρ. In this situation, as with the estimation of equations based on the marginal rate of substitution functions, we face a possible selection problem if the relationship is estimated from a subsample of households that are unconstrained in the credit market.

Section 5.1 discusses the estimation procedure in more details.

4 A Particular Empirical Specification

In what follows we assume that the monotonic transformation function G is given by

$$G = \frac{U_{ik}^{\theta} - 1}{\theta}, \tag{31}$$

and that (within-period) preferences are of the Box-Cox type

$$U_{ik} = \frac{(Z_{ik} + z_0)^{\sigma} - 1}{\sigma} + \Gamma_{ik} \frac{L_{fik}^{\gamma} - 1}{\gamma} + \Omega_{ik} \frac{L_{mik}^{\omega} - 1}{\omega}, \tag{32}$$

where subscript i denotes household and θ, σ, γ and ω are unknown coefficients. The coefficients γ and ω determine the intertemporal substitution elasticities $1/(\gamma - 1)$ and $1/(\omega - 1)$, which measure the percentage change in the consumption of leisure in any two periods in response to a percentage change in the relative wage rate for those periods, cf. Heckman and MaCurdy [12]. The interpretation of σ is less straightforward, since $\beta \neq 0$, implying that Z is not an ordinary physical good.

If the within-period utilities are to be strictly concave, σ, γ and ω must all be less than one. Since the cash flow related to the purchases of durables and non-durables, as well as the parameter δ_p, are allowed to be negative, Z can be negative. If z_0 is zero and Z is negative, the (Box-Cox) utility of Z is undefined; in order to avoid this problem, we introduce the parameter z_0. Notice also that since δ_p is unknown, the smallest value of $Y_t + \delta_p D_{t-1}$ can not be observed, and we (must) treat z_0 as a parameter to be estimated.

It is also assumed that the person- and age-specific modifiers of tastes, Γ_{ik} and Ω_{ik}, can be related to a vector of exogenous and observable consumer characteristics, X_{ik} and B_{ik}, and unmeasured characteristics, ε_{ik} and η_{ik}, according to $\Gamma_{ik} = \exp(X_{ik}\phi_x + \varepsilon_{ik})$ and $\Omega_{ik} = \exp(B_{ik}\phi_b + \eta_{ik})$. The error terms are needed since the econometrician cannot observe all components that influence preferences.

The first order conditions for leisure and consumption become

$$U_{it}^{\theta-1}(Z_{it} + z_0)^{\sigma-1} = \lambda_{it} p_t, \tag{33}$$

$$U_{it}^{\theta-1}\Gamma_{it} L_{fit}^{\gamma-1} = \lambda_{it} m_{fit} + \alpha_{fit} \tag{34}$$

and

$$U_{it}^{\theta-1}\Omega_{it}L_{mit}^{\omega-1} = \lambda_{it}m_{mit} + \alpha_{mit}. \tag{35}$$

Assuming no binding constraints, either in the labour markets or in the credit market, the relationship between female leisure and the consumption good Z corresponding to equation (27), can be written

$$\ln L_{fit} = X_{it}a_1 + a_2 \ln \frac{m_{fit}}{p_t} + a_3 \ln(Y_{it} + z_0 + \delta_p D_{it-1}) + \nu_{it}, \tag{36}$$

where $a_1 = -\phi_x/(\gamma-1)$, $a_2 = 1/(\gamma-1)$, $a_3 = (\sigma-1)/(\gamma-1)$ and $\nu_{it} = -\varepsilon_{it}/(\gamma-1)$.

The similar relationship between male leisure and Z can be written

$$\ln L_{mit} = B_{it}b_1 + b_2 \ln \frac{m_{mit}}{p_t} + b_3 \ln(Y_{it} + z_0 + \delta_p D_{it-1}) + \mu_{it}, \tag{37}$$

where $b_1 = -\phi_b/(\omega-1)$, $b_2 = 1/(\omega-1)$, $b_3 = (\sigma-1)/(\omega-1)$ and $\mu_{it} = -\eta_{it}/(\omega-1)$.

It also follows that the Euler equation corresponding to equation (29) can be written

$$\ln\left[(1+R_{it+1})\frac{p_t}{p_{t+1}}\left(\frac{Z_{it+1}+z_0}{Z_{it}+z_0}\right)^{\sigma-1}\right] = \ln(1+\rho) + (1-\theta)\ln\frac{U_{it+1}}{U_{it}} + \xi_{it+1}, \tag{38}$$

where $\xi_{it+1} = \ln(1+e_{it+1})$.

5 Estimating the subutilities

Ideally, equation (36), (37) and (38) should be estimated as a simultaneous equation system. We simplify, and use a two stage estimation procedure where we in the first stage estimate the subutilities, cf. equation (36) and (37), before we in the second stage estimate the monotonic transformation G, and the time preference rate ρ, cf. equation (38).

Comparing equation (36) and (37), we notice that the definitions of the parameters a_2, a_3, b_2 and b_3 yield four equations for the determination of the three coefficients γ, σ and ω. The model specification then implies a particular kind of parameter restriction across the two equations, which should be accounted for in the estimation. Moreover, notice that these equations are non-linear in δ_p, and that there are endogenous right-hand-side variables. Estimation then requires a non-linear simultaneous equations procedure; and we apply a full-information maximum likelihood procedure.

First, however, we must choose the taste modifier variables for female and male leisure. We assume that preferences depend on age, and for the female, also on the size of the household. The taste modifier variable X then includes the number of children with age less than 21 years and the age of the female, while B is the age of the male. Even though the decision to have children depends on the behaviour of the household, we assume that these taste modifiers can be reasonably viewed as exogenous in the econometric specification, cf. also the discussion of the wage rate equations (39).

Estimation also requires a decision about what right-hand-side variables should be treated as endogenous from an econometric point of view, and a specification of the instrument equations for these variables. Notice that the logarithm of the after-tax wage rate can be decomposed into two components according to $\ln m_j = \ln(1 - \partial I / \partial(w_j H_j)) + \ln w_j$.

Since we do not allow for learning-by-doing, the household is price-taker in the labour market; this assumption does not necessarily mean that the econometrician should look at the (pre-tax) wage rates as exogenous, cf. Heckman [10]. If there are unobserved variables that influence the person's preferences for leisure, and that are correlated with the wage rate, the wage rate should be treated as endogenous in the empirical analysis. An example may be the comparison between a person who is very motivated for doing a good job at work, and one who is lazy and does not like to work. In this case we expect that the motivated person obtains a higher wage rate than the lazy one, even if we adjust for differences in education and work experience. It is also reasonable to believe that the motivated person has different preferences for work and leisure than the lazy one, and we have a situation where the unobserved variable influences both preferences and the wage rate. We may label this kind of endogeneity "statistical endogeneity".

Many empirical analyses account for this endogeneity of the wage rate by introducing a separate wage equation. This equation typically includes the number of years of education and a measure of work experience as explanatory variables. Important explanatory variables such as motivation and ability are rarely included, and the specification suffers from the omission of these unobservables.

Another problem related to the specification of the wage rate equation is that estimation ideally requires individual life cycle data. If the wage rate equation is estimated from cross sectional data, the estimates also reflect differences in wage rates across cohorts, and the estimated wage equation will not be well-suited for predicting the wage rate for a particular person.

One may include person-specific fixed effects in order to control for unobserved variables. MaCurdy [20] assumes that wages follow a quadratic function in age with intercept and slope coefficients that depend on age-invariant characteristics of the consumer. This specification is then estimated using panel data for 10 years.

We do not have access to panel data that can be used for estimation of wage equations with person-specific fixed effects. Despite this fact, we find the argument for treating the pre-tax wage rate as endogenous quite convincing. Most empirical analyses also seem to adopt this assumption. Based on Heckman [10], and the findings in [8] by Dagsvik and Strøm, we assume that the logarithm of the wage rate is a linear function of work experience, experience squared and education, that is,

$$\ln w_{jit} = M_{jit} g_{aj} + v_{jit}, \quad j = f, m, \tag{39}$$

where M represents the consumer characteristics that are assumed to be exogenous from an econometric point of view, g_a is the corresponding vector of coefficients, and v is an error term. Education is measured in years, and work experience is measured as age minus the years of education minus the age at the beginning of education.

The discussion above and the fact that the wage rate equation is estimated from cross sectional data imply that one must take the greatest care in the interpretation of the regression coefficients.

Since the marginal tax rate depends on the wage and interest incomes, and these depend on the behaviour of the household, the marginal tax rate is endogenous even for the household. To find the instrument for the logarithm of the after-tax marginal wage rate, it remains to determine the instrument for $\ln(1 - \partial I/\partial(w_j H_j))$. We assume that the relevant explanatory variables are the same as for the wage equations, but in addition we include the number of children with age less than 21 years. This variable is included because both labour supply and the demand for durables and non-durables may be influenced by the size of the household. Wage incomes, financial savings and interest incomes and deductions are then influenced by the size of the household, and when the size of these variables is determined, the marginal tax rate is also determined. The instrument equations for the marginal tax rates are then

$$\ln\left(1 - \frac{\partial I}{\partial(w_j H_j)}\right) = B_{jit} g_{bj} + \epsilon_{jit}, \quad j = f, m, \tag{40}$$

where B is the vector of consumer characteristics, that is, experience, experience squared, education and the number of children with age less than 21 years, g_b is the corresponding vector of coefficients, and ϵ is the error term. Based on the above assumption, the vector B can be treated as exogenous in the estimation.

The cash flow related to purchases of durables and non-durables is endogenous for the household. We use education and education squared for the male as instrument variables for Y and add work experience for the female. Education is assumed to reflect the income potential of the household, but since the education of married females and males is (positively) correlated, we include only the education of the male in order to reduce the number of unknown coefficients. Using education squared, acknowledges that the consumption potential increases less than pre-tax wage incomes, since the tax system is progressive. Work experience is introduced as a substitute for age, since cash flow related to purchases of non-durables and, particularly durables, depends on age relative to the age when one finished education.

The instrument equation for the cash flow related to the purchases of durables and non-durables is then

$$Y_{it} = S_{it}g_s + \varsigma_{it}, \tag{41}$$

where S represents the consumer characteristics that are assumed to be exogenous from an econometric point of view, g_s is the corresponding vector of coefficients, and ς is an error term.

An alternative instrumental variable for Y would be gross or net income lagged one period, but since we find it reasonable to assume that there are omitted variables that are correlated with both lagged income and the error term in equation (36) and (37), we do not prefer this alternative.

The purchase price of non-durables is assumed equal to one in the estimation of the equations based on the marginal rate of substitution functions. It is also assumed that D_{t-1} is endogenous from an econometric point of view, although it is predetermined from the perspective of the household at age t. This decision is based on the assumption that there are omitted variables that are serially correlated and that influence preferences as well as D_{t-1}. The instruments used are female and male education, and an index of the number of inhabitants in the area where the household lives. Education is assumed to reflect income and consumption possibilities, while the number of inhabitants is introduced to try to account for the increase of the average price of housing as population density increases.

The instrument equation for the stock of durables is

$$D_{it-1} = J_{it}g_j + \psi_{it}, \tag{42}$$

where J is the vector of household characteristics that are assumed to be exogenous from an econometric point of view, g_j is the corresponding vector of coefficients, and ψ is an error term.

The complete model to be estimated consists of the structural equations (36) and (37) and the instrument equations (39) to (42). The properties of the error terms are as follows. Let $\mathbf{u}_{it} = (\nu_{it}, \mu_{it}, v_{fit}, v_{mit}, \epsilon_{fit}, \epsilon_{mit}, \varsigma_{it}, \psi_{it})'$ be the vector of error terms for the simultaneous equation system. The subsequent analysis assumes that

$$\mathbf{E}\mathbf{u}_{it} = \mathbf{0}, \quad \forall i, t, \tag{43}$$

and that

$$\mathrm{E}(\mathbf{u}_{it}\mathbf{u}_{it}^{'}) = \sum, \quad \forall i, t. \tag{44}$$

It is also assumed that $\mathbf{u}_{it}$ is serially correlated, but uncorrelated between households. Assuming, in addition, that the components of $\mathbf{u}_{it}$ follow a multivariate normal distribution, we can estimate the system by a full-information maximum likelihood procedure. All equations are identifiable, cf. Stewart and Wallis [29], and from the parameters of these equations it is possible to identify the parameters of preferences.

5.1 Estimating the monotonic transformation

Using the definition of U, the parameter estimates for σ, θ, ω, the taste modifier parameters ϕ_x and ϕ_b, and panel data observations of Y, $q_t K_{t-1}$, L_f, L_m as well as the taste modifier variables, it is possible to estimate $\ln(U_{t+1}/U_t)$ and $((Z_{t+1} + z_0)/(Z_t + z_0))^{\sigma-1}$ for use in the estimation of the Euler equation (38).

Estimating the Euler equation requires that we decide which households are unconstrained in the credit market, cf. (10). We do not have access to that kind of information, and for simplicity[4] we assume that $\kappa = 0.9$. Since we cannot observe $q_t K_t$, but only $q_t K_{t-1}$, we also assume that households are unconstrained in the credit market if their net debt is less than 90 per cent of the market value of their durables measured in the prices of the next period, that is, if

$$- F_t < 0.9 q_{t+1} K_t. \tag{45}$$

The selection problem that may be involved by estimating the Euler equation from a subsample of unconstrained households, will be ignored.

[4]One reason may be that households cannot finance the purchase of durables without having any own capital. By choosing $\kappa = 0.9$, we approximate.

The properties of the error term $\xi_{it+1} = \ln(1 + e_{it+1})$ also require comment. Since ξ_{it+1} is a non-linear function of e_{it+1}, the assumption that $\mathrm{E}_t e_{it+1} = 0$ does not imply that $\mathrm{E}_t \xi_{it+1} = 0$. In what follows we assume that the (conditional) variance of e_{it+1} is constant across the sample, and that it is small. By approximating $\ln(1+e_{it+1})$ with a Taylor expansion, we then find that $\mathrm{E}_t \xi_{it+1}$ is small, and that the (conditional) variance of ξ_{it+1} is constant. The Euler equation can then be estimated by a maximum likelihood procedure that treats the estimates for $\ln(U_{t+1}/U_t)$ as exogenous.

6 Data

The data are obtained from the panel data sections of the Income Distribution Survey 1988, 1989 and 1990, the Standard of Living Survey 1991, and an additional postal survey conducted as part of the Income Distribution Survey 1989. All data sets were collected and prepared by the Central Bureau of Statistics in Norway, and I have linked them on the basis of personal identification numbers.

The Income Distribution Surveys consist mainly of tax return data collected from taxation authorities. They yield quite detailed information about wage incomes, dividends, interest incomes and expenditures, financial wealth and debt, and income and property taxes. Transfer payments received, including child benefit, are also reported, and all these variables are used in the calculation of the cash flow related to the purchases of durables and non-durables. By linking two successive surveys, this survey also yields information about financial savings.

The Income Distribution Surveys also contain information about education, and the number and age of children. Given the tables of formal marginal tax rates, they also provide enough information for calculation of the marginal tax rates on wage and interest incomes. I have calculated the marginal tax rates in accordance with the set of regulations, and the possibility of separate taxation of the wage incomes of spouses is considered.

The ordinary Income Distribution Surveys also include the value of the stock of durables measured in the prices relevant for taxation, but these data underestimate stocks considerably. Instead I have linked the Income Distribution Survey 1989 with the additional postal survey, and the Income Distribution Survey 1990 with the Standard of Living Survey 1991. The postal survey and the Standard of Living Survey 1991 include questions about the market value of housing, cottages, cars and private motor boats in 1989 and 1990 respectively, and the variable $q_t K_{t-1}$ includes all these durables.

The postal survey and Standard of Living Survey 1991 also include information about working time in 1989 and 1990. The spouses are asked about their average working time per week and the number of weeks worked. Multiplying these two variables, yields an estimate for labour supply. Leisure is defined as 8736 hours (= total number of hours in a year) minus labour supply.

The (marginal) wage rate is measured as wage income divided by hours of labour supplied. If the worker gets overtime pay, and has much overtime, this wage rate will exceed his normal wage rate. In contrast, if the worker does not get overtime pay, and works much overtime, the observed wage rate underestimates the standard wage rate.

The data are combined in the following way. First we have linked the Income Distribution Survey 1989 and 1990 with the Standard of Living Survey 1991. (The Income Distribution Survey 1989 is included only to get data for financial savings through 1990.) Then we have linked the Income Distribution Survey 1988 and 1989 and the additional survey to the Income Distribution Survey 1989. (The Income Distribution Survey 1988 is included only to get data for financial savings through 1989.) From this last subsample we have excluded all persons who are included in the subsample from the first linkage. Finally, we combine these two subsamples into one sample.

The selection rules are as follows. Only married couples for which both spouses are between 30 and 55 years in 1990 are included. Those couples for which at least one of the spouses has entrepreneurial income in excess of wage income are excluded. Couples for which one or both spouses receive disablement benefit and who have wage and entrepreneurial incomes less than 53 440 Norwegian kroner, are also excluded. Both spouses must work between 200 and 3500 hours[5] a year, and the household must own their housing (not be tenants), to be included.

For some reason, the measurement method for the wage rate seems to bias the distribution of the wage rate, at least for females, cf. appendix 2. As a consequence, all couples for which the wage rate of the female exceeds 230 kroner or the wage rate of the male exceeds 270 kroner, are omitted from the analysis. The sample then consists of 327 observations. For further information about the sample, see summary statistics in table 1.

The pre-tax nominal interest rate is obtained by averaging over the quarterly observations of the private banks lending rents inclusive fees as they are presented in the statistics from the Norwegian Bank. This simplification may bias the estimation results since the (pre-tax nominal) interest rate do vary across households. The average consumer price index published by the Central Bureau of Statistics, is used to measure p_t/p_{t+1}. The average is based on monthly observations.

Estimating the Euler equation requires panel data for L_f, L_m, Y and D for two successive periods. The data are obtained by linking the Income Distribution Survey 1989 and 1990 with the Standard of Living Survey 1991, and the Income Distribution Survey 1988 and 1989 with the postal survey to the Income Distribution Survey 1989. These two subsamples are then linked, and the final sample consists of 229 households. In contrast to the procedure for the sample used in the estimation of the equations based on the marginal rate of substitution functions, only those households that are observed in both subsamples, are included.

[5]The method for the calculation of the wage rates implies that we observe the wage rate for all persons satisfying this labour supply constraint.

6.1 Some arguments in favour of Hicks aggregation

Complete household expenditure data for Norway are collected by the Central Bureau of Statistics. The data for non-durables are based on accounts of expenditures over two weeks, and expenditures for the whole year are found by multiplying these data by 26. The measurement errors introduced by this procedure can be huge, and we prefer to obtain the data from another data source.

This paper suggests aggregating C_k and $(K_k - \beta K_{k-1})$ using the Hicks composite good theorem. In light of price reductions for housing over the last years, the use of this theorem may be questioned. There are, however, some arguments that favour this assumption. The first is that the consumer price index, which we assume can be used to measure the price of non-durables[6], includes expenditures related to housing as well. According to [7], the budget share of expenditures related to lighting and heating is about 5 per cent. The second point to notice is that durables include many variants, such as cars, private motorboats, furniture and kitchen and leisure equipment, and price changes for these goods have been less dramatic than for housing. The third point is that it seems reasonable to assume that the price path for durables is more or less similar to the price path for non-durables in the long run. So even if it can be questioned whether this approach is appropriate for the years included in this analysis, the approach may well be more defendable in other periods.

6.2 Measurement error

The possibility of measurement errors in some of the endogenous variables in the model makes the consequences of measurement errors of interest. The estimates of the equations based on the marginal rate of substitution functions are consistent only if the measurement error is of the classical errors in the variables type. This

[6]Unfortunately this index also includes prices of durables, and the observed price of non-durables may then be biased.

means that the observed endogenous variable A in the regression function is related to the true variable A_0 according to $A = A_0 + \varpi$, where ϖ is a randomly distributed error term that is distributed independently of all instrument variables. Given the results presented in appendix 2, the measurement problems related to durables, and the fact that the cash flow related to the purchases of durables and non-durables is observed indirectly through the wealth constraint, this is a very strong assumption.

The same issues of measurement errors arise in the discussion of the consequences of measurement errors in the estimation of the Euler equation (38). If there are measurement errors in equation (36) and (37), the error terms of these equations include measurement errors. This means that the estimate for U is biased, and when we use this estimate in the Euler equation, the measurement errors will be non-linear. In this case, we do not have a classical errors in the variables scheme, and the estimates will no longer be consistent.

7 Empirical Results

This section reports the estimates of the parameters of the subutility and monotonic transformation functions. Since we are not particularly interested in the results from the estimation of the instrument equations, these results are presented in appendix 1. That section also presents the estimates of the parameters of equation (36) and (37).

As it will become evident from this section, the estimation results are, with some exceptions, not very satisfying. One reason may be that we cannot model person-specific fixed effects in the wage equations as well as the other instrument equations, since we do not have access to panel data of sufficient length. Another reason may be the non-linearity in the two equations based on the marginal rate of substitution functions. We may also reasonably assume that treating Y_t and D_{t-1} as endogenous variables in the estimation enlarges the problems related to non-linearity. The fact that the samples include only 327 and 229 observations is also relevant. No matter the reason, the estimation results should be viewed tentatively, and as part of ongoing research.

Since many of the estimates are quite imprecise in the sense that they are not statistically significant, it may be appropriate to clarify the implications of this result. The fact that a parameter is not statistically significant according to the standard T-test does not necessarily mean that we believe it is zero. If we have prior grounds for believing that it is different from zero (For instance, we may believe that females' preferences for leisure increase with an increase in the number of children.), we may continue to believe that even if the T-test does not support our original view. According to Wonnacott and Wonnacott [30], this conclusion is particularly relevant if the test is based on a small sample. The estimation results presented in this section, are based on a small sample.

Table 2 reports the estimates of the parameters of the subutilities. A priori we believe that the parameters of the taste modifiers are different from zero. The estimates of the intercepts of the taste modifiers are quite large, but none of them are statistically significant. We also notice that the estimate of the coefficient on the age variable is approximately the same for females as for males. The sign of these coefficients indicates that an increase in age decreases the preferences for leisure. This means that the marginal rate of substitution between female/male leisure and the composite good decreases, and female/male labour supply increases. These results should, however, be viewed in light of the fact that none of these estimates are determined precisely.

The sign of the estimate of the coefficient on children indicates that females' preferences for leisure increase with an increase in the number of children. The marginal rate of substitution between female leisure and the composite good then increases, and female labour supply decreases. The estimate is within about one standard error of the estimate of Heckman and MaCurdy [12], but it is imprecise.

The estimates for γ and ω are not significantly different from zero. We do not have knowledge of similar studies using Norwegian data, and cannot use this sort of information for claiming that these parameters are different from zero. Both estimates are, however, consistent with the results in [31] by Aaberge, Dagsvik and Strøm, although they use a static and somewhat different model specification. The estimate for γ is also consistent with the results in Heckman and MaCurdy [13]. The implications of the finding that γ and ω are not significantly different from zero, are then ambiguous, in particular when we consider that the sample is small.

Both estimates are consistent with the assumption of a strict concave utility function. Since the absolute value of γ exceeds that of ω, the estimates also imply that male labour supply is more responsive to wage changes than female labour supply, cf. the first order conditions (34) and (35). This result seems to be in contrast with most empirical findings, which indicate that female labour supply is most responsive to wage changes.

If we look at the estimates of the parameters related to the preferences over the composite good, we notice that the standard errors of both z_0 and δ_p exceed the absolute value of the parameter estimates. This means that we cannot reject the null hypothesis that the psychological depreciation factor δ_p equals zero, and suggests that the relevant measure on the consumption of durables is $[K_t - (1 - \delta_f)K_{t-1}]$. The reason for introducing z_0 implies that z_0 should be greater than zero.

In contrast to all the other estimates, the estimate for σ is very precise. It is consistent with the assumption that preferences are strictly concave. Since there are no other studies that use our specification of the composite good Z, this result must be compared with the result of studies[7] that use the standard consumption measure, cf. section 2.1. MaCurdy [21] includes imputed service flow for durables in the consumption measure, and finds that the parameter corresponding to σ is 0.34, with standard error equal to 0.21.

It remains to present the estimates from the estimation of the Euler equation (38), cf. table 3. Notice that the standard errors in this table do not account for

[7]The estimate for σ is very similar to the result in the (static) model of Aaberge, Dagsvik and Strøm [31].

the dependence of the variable $\ln(U_{t+1}/U_t)$ on estimated quantities.

In this case, the estimates for ρ and θ are both statistically significant. The estimate for θ implies that $\theta - 1$ is negative (= - 0.112), and this result is consistent with risk averted households.

8 Summary

This paper formulates and estimates a life cycle model of labour supply and consumption of durables and non-durables for married couples in an environment of uncertainty and personal income taxes. While standard economic theory assumes that preferences are exogenously determined, we respond to the fact that many empirical studies have presented evidence in favour of utility being a relative concept, by specifying preferences subject to a reference standard. According to Boyer [6], the authors of these studies generally argue that although the assumption of given preferences can be reasonable in the short run, in a life cycle perspective it should be challenged. The lack of a well-established economic theory of habit formation, however, raises the question of how habit formation should be modelled. We introduce habit formation only in the demand for durables, and propose to use last year's demand for durables after deductions for physical and what we label psychological depreciation as the reference standard.

Since we do not have access to data for the consumption of non-durables, we aggregate non-durables and the good $(K_t - \beta K_{t-1})$ into a Hicks composite good. We then find a specification of the life cycle model of labour supply and consumption of durables and non-durables that can be estimated in the absence of data on the consumption of non-durables, and the price and the physical stock of durables. We argue that if the psychological depreciation parameter δ_p is small, this specification reduces the bias in the estimate of σ if there are measurement errors in observations of market value of the stock of durables.

In order to allow for more flexibility in lifetime utility, we decompose the period-specific subutilities into one component that determines within-period allocations, and a monotonic transformation that influences the allocations between periods. The monotonic transformation also introduces a particular kind of non-separability in the within-period utilities.

In an empirical application of this specification, we assume that preferences are of the Box-Cox type, and suggest estimating the parameters of the subutilities by using the marginal rate of substitution functions between female/male leisure and the composite good. It is also possible to estimate the psychological depreciation parameter from these functions.

The monotonic transformation of the within-period utilities cannot be identified from these functions, but can be estimated by applying the Euler equation.

The data are obtained by linking the Income Distribution Surveys 1988, 1989 and 1990, the additional postal survey of the Income Distribution Survey 1989, and the Standard of Living Survey 1991. All data are linked on the basis of personal identification numbers. The estimates of θ and ω indicate that males' demand for leisure is more responsive to wage changes than females', but the estimation results should be viewed as tentative. None of these estimates are significantly different from zero. In contrast, the estimate of σ, which influences the preferences for consumption of durables and non-durables, is precise. All estimates are consistent with the assumption of strictly concave preferences.

The estimate of the psychological depreciation parameter is not statistically significant. This analysis then suggests that $[K_t - (1-\delta_f)K_{t-1}]$ is the relevant measure of the consumption of durables in context of utility.

Finally, we estimate the Euler equation, but as we have argued, for this estimation to give consistent estimates, there is no room for measurement errors. It is then reasonable to assume that the estimates for θ and the time preference rate are biased.

Appendix 1

A Some further estimation results

The aim of this appendix is to give some further information about the estimates of the parameters of the subutilities by presenting the estimates for the parameters of the two marginal rate of substitution functions (36) and (37), and the instrument equations (39) to (42). (All the equations are estimated as a simultaneous equations system by FIML.)

Table 4 shows the estimates of the parameters of the marginal rate of substitution functions. With the exception of the intercepts, none of the variables have a t-statistic in excess of two.

We do not present the multiple correlation coefficients for the following reason. In the reduced form case, the multiple correlation coefficient, R^2, measures the proportion of the original variance in the dependent variable that is explained by the regression as a whole. The marginal rate of substitution function, however, includes endogenous right-hand-side variables, and the meaning of R^2 becomes unclear. Further, the total sum of squares cannot be partitioned into explained and unexplained sums of squares for simultaneous equation estimates, since the residuals are not orthogonal to all of the explanatory variables. The residual sum of squares can then exceed the total sum of squares, and R^2 will be negative if it is calculated via the residual sum of squares.

Table 5 presents the results for the wage rate equations. All estimates are consistent with the results of Dagsvik and Strøm [8]. The parameters of the female wage rate equation are estimated less precisely than the parameters of the male equation.

Regarding the parameters of the instrument equation for $\ln(1 - \partial I/\partial(wH))$, cf. table 6, we notice that while the parameter related to the number of children with age less than 21 years is statistically significant for the female, it is determined rather imprecisely for the male. The estimates for the parameters related to experience,

experience squared and education for the females are within the estimates for the males plus or minus one standard error.

The lack of variables in our data that can reasonably be assumed exogenous from an econometric point of view, and the fact that the few we have access to vary little across the sample, make it hard to find instruments that can reproduce the large variation in cash flow related to the purchases of durables in the sample. From table 7 we also notice that the parameters related to male education and education squared, and to the age of the female relative to the age she completed her education, are all imprecisely determined.

Table 8 shows that the parameters of the instrument equation for the stock of durables are more precisely determined. The parameters related to female and male education are both statistically significant.

Appendix 2

A Measurement errors in the wage rate

The wage rate is measured by dividing wage incomes with labour supply, where labour supply is measured by multiplying average labour supply per week by the number of weeks worked, cf. section 7. For some reason this procedure seems to bias the distribution of the wage rate, at least for females, cf. table 9. This table shows the number of married females and males with wage rate in excess of 200 Norwegian kr and less than 800 kr, their average wage rate and average labour supply, for persons who are classified as employees, cf. section 7. The upper limit of the wage rate is chosen such that very extreme observations are omitted, and the data are obtained by linking the Income Distribution Survey 1990 with the Standard of Living Survey 1991. In order to increase the number of observations, it is now not conditioned that the families also are included in the Income Distribution Survey 1989, as is the case with the sample used in the empirical analysis, and the total sample consists of about 950 observations.

We notice that the average female wage rate is about 22 per cent higher than the average wage rate for males, and that the variance is much higher for females than for males. We also notice that average female labour supply is only about 400 hours, or about one fourth of average male labour supply. Even though the income effect of wage changes may reduce labour supply, these results seem unreasonable.

Taking also into consideration that the females in average are younger than the males and that they have shorter education, the wage rate for at least the females must be biased. As a consequence of these and some other results, all females with wage rate less than kr 40 and greater than kr 230 is omitted from the empirical analysis. For the males the corresponding limits are 50 and 270 kr.

Table 1: Summary statistics for the 327 married couples used for estimation of the equations based on the marginal rate of substitution functions.

	Average	Standard devation	Minimum value	Maximum value
Female leisure per year	7270	553	5616	8528
Male leisure per year	6717	353	5304	8466
Female gross wage rate, NOK per hour (among those who work)	94.7	30.2	43.1	219.8
Male gross wage rate, NOK per hour (among those who work)	117.7	33.8	67.3	266.7
Female marginal tax rate on wage incomes	0.407	0.090	0.231	0.62
Male marginal tax rate on wage incomes	0.523	0.095	0.266	0.62
Marginal tax rate on interest incomes/expenditures	0.394	0.064	0.260	0.456
Cash flow related to purchase of durables and non-durables	320361	227438	-41572	1498183
Stock of durables	1602300	879527	56000	5400000
Female education in years	10.9	2.2	8.0	17.5
Male education in years	11.7	2.8	8.0	19.0
Female age	41.5	6.3	30.0	55.0
Male age	43.9	6.2	30.0	55.0
Female experience in years	24.6	7.0	9.5	40.0
Male experience in years	26.2	7.1	8.5	41.0
Number of children 0-20 years	1.39	1.03	0.0	4.0
Index for inhabitants	3.42	1.30	1.0	5.0

Table 2: FIML estimates† for the subutility.

ϕ_x				ϕ_b		
Constant	Age	Children‡	γ	Constant	Age	ω
32.237	-0.0051	0.0565	-2.228	20.179	-0.0048	-0.8791
(26.496)	(0.0053)	(0.0408)	(2.999)	(11.950)	(0.0033)	(1.3955)

z_0	δ_p	σ
30241.9	0.0333	0.9558
(31029.4)	(0.0662)	(0.0359)

† Standard errors in parentheses.
‡ The number of children with age less than 21 years.

Table 3: ML estimation† of the monotonic transformation.

ρ	θ
0.0663	(0.8881)
(0.0026)	(0.0682)

† The asymptotic standard errors in parenthesis are not adjusted for the use of the instruments.

Table 4: FIML estimates[†] for the coefficients of the marginal rate of substitution functions.

a_1						
Constant	Age	Children[‡]	a_2	a_3	z_0	δ_p
9.987	-0.0016	0.0175	-0.3098	0.0137	30241.9	0.0333
(1.083)	(0.0021)	(0.0103)	(0.2878)	(0.0142)	(31029.4)	(0.0662)

b_1		
Constant	Age	b_2
10.738	-0.0025	-0.5322
(1.627)	(0.0026)	(0.3952)

† Standard errors in parentheses.
‡ The number of children with age less than 21 years.

Table 5: FIML estimates[†] for the coefficients of the wage rate equation for females and males.

	Constant	Experience	Experience squared	Education
Female	3.920	0.0179	-0.00040	0.0373
	(0.237)	(0.0122)	(0.00023)	(0.0112)
Male	4.166	0.0188	-0.00037	0.0298
	(0.188)	(0.0105)	(0.00019)	(0.0067)

† Standard errors in parentheses.

Table 6: FIML estimates† for the coefficients of the instrument equation for $\ln(1 - \partial I/\partial(wH))$ for females and males.

	Constant	Experience	Exp. squared	Education	Children‡
Female	0.0032	-0.0238	0.00044	-0.0245	0.0207
	(0.1286)	(0.0082)	(0.00017)	(0.0046)	(0.0106)
Male	-0.1222	-0.0216	0.00033	-0.0263	-0.00072
	(0.1634)	(0.0101)	(0.00019)	(0.0059)	(0.0039)

† Standard errors in parentheses.
‡ The number of children with age less than 21 years.

Table 7: FIML estimates† for the coefficients of the instrument equation for cash flow related to purchase of durables and non-durables.

Constant	Male education	Education squared	Female experience
-124399	63799.2	-1967.59	-693.798
(275512)	(40069.2)	(1479.99)	(2285.59)

† Standard errors in parentheses.

Table 8: FIML estimates† for the coefficients of the instrument equation for the stock of durables.

	Education		
Constant	Female	Male	Inhabitants
135258	66332.4	49135.4	48865.6
(306063)	(24659.0)	(22763.2)	(43467.2)

† Standard errors in parentheses.

Table 9: The distribution of female and male wage rate for employed persons with wage rate in excess of 200 NOK and less than 800 NOK.

	Female			Male		
Variable	Number	Mean	Variance	Number	Mean	Variance
Wage rate	51	343.8	19197.0	88	281.7	10738.4
Hours†	51	403.7	60186.3	88	1642.3	676742.7
Age	51	40.0	46.6	88	43.6	48.2
Education	50	10.6	4.2	87	13.4	7.5

† Labour supply measured in hours.

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