Household demand behaviour: evidence from Spanish data.

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To Amparo and Amparo, my wife and my daughter

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Abstract

This thesis analyses different aspects of household demand behaviour using Spanish Family Expenditure data. The first chapter studies the problems of zero records associated with microbudget surveys. We focus on the infrequency of purchase problem and extend the existing theoretical and empirical work to panel data for the estimation of a model for clothing consumption. The estimation procedure proposed deals with sample selection problems with panel data. In the second chapter we analyse child effects on household demand patterns. As widely recognised, the arrival of children in a household affects consumption of different goods in different ways. Consumption of certain sorts of goods (e.g. child clothing and food) are likely to increase while other goods (e.g. adult clothing or alcohol) may be little affected. We make use of the theoretical concept of demographic separability and its relation to the equivalence scale, in the way it stands behind the Rothbarth (1943) method, to calculate costs of children for the Spanish economy. As the effects of children on household behaviour may start even before the child is born in the family, in anticipation to this event, and may last for some time after the child has left the household, these effects should be analysed in an intertemporal setting. The arrival of a child influences labour supply and savings plans long time before children arrive. In chapter three we analyse the effects of the arrival of a new child in a household in the surroundings of child birth by using an intertemporal demand setting (the so called *Frisch* demands). Finally, in chapter four we assess, through microsimulation techniques, the impact of the 1999 income tax reform in Spain, specially focusing on the increase in the children related benefits announced in the reform, and its potential impact to increase the Spanish fertility rate.

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Introduction

This thesis is mainly concerned with the analysis of household demand patterns and the effects of children on the allocation of household expenditure to consumer goods in Spain. We also investigate, using microsimulation techniques, the effects of the 1999 Spanish income tax reform on household welfare and children benefits. In all chapters we use a panel of households drawn from the Spanish Family Expenditure Survey (*Encuesta Continua de Presupuestos Familiares, ECPF*). The organisation of the chapters of this thesis is as follows. In chapter one we investigate one of the major problems associated with microdata when analysing household demand, i.e. infrequency of purchase. In chapter two, using the concept of demographic separability we analyse the effects of children on household demand patterns and calculate equivalent scales for Spain. In chapter three we focus on the effects of the arrival of a child in a household in the surroundings of childbirth. Finally, in chapter four we investigate using microsimulation techniques, the changes in the Spanish income tax system brought by the 1999 reform, specially focusing on children allowances and benefits.

The use of microeconomic survey data sets is wide spread for the analysis of consumer demand. However, one of the major problems associated with microbudget surveys is the existence of zeros in the expenditure records of households. In these surveys zeros might arise for any of the following reasons. First, households may be maximising utility at zero consumption with its current budget, i.e. for its level of income or/and at current prices the household chooses not to consume (corner solution). Second, the household will not participate in the consumption of some commodities at any price and income, for example non-smokers with tobacco (non-participation). Third, although no purchase has been made during the monitoring period of the survey the household is a regular consumer of the goods (infrequency of purchase). And, fourth, misreporting may occur due to any reason. Therefore, consumption and purchases may differ markedly and there is a problem in fitting a model of consumption directly to data on purchases. As a result, much of the variation in reported expenditures may reflect stochastic elements in purchasing behaviour rather than differences in the underlying consumption.

The incidence of zeros in the expenditure of some commodities has been typically modelled as a Tobit model (Tobin, 1958), the underlying assumption being that both the decision to purchase and the amount of acquisition are driven by the same variables. As pointed out by Cragg (1971), in some situations the decision to purchase and the amount of the acquisition may not be so intimately related. Cragg (1971) developed several models for limited dependent variables that are extensions of the multiple Tobit analysis model in the sense that they allow the determination of the size of the variable (when it is not zero) to depend on variables different from those determining the probability of being zero.

An alternative modelling strategy that introduces a distinction between consumption and purchase behaviour and stresses the fact that a zero purchase may reflect either a zero consumption or a transitory abstention (that may occur for various other reasons) is the Infrequency of Purchase Model (IPM). The IPMs are econometric models that aim at providing the best possible estimation of expected demand functions given the available information about the underlying process of purchase renewals. The IPM provides a separate family of alternative models where zero values occur due to "durability" of a commodity in comparison to the duration of the survey period from which the expenditure observations are drawn.

In this context, Kay, Keen and Morris (1984) stress that the direct information on expenditures provided by household budget surveys may be of more value, since a household's chosen level of expenditure presumably reflects its own evaluation of its long-term economic position. Deaton and Irish (1984) consider a model where the standard Tobit specification is supplemented by the operation of a binary censor that randomly replaces a fraction of the observations generated by the Tobit model with zeros. Blundell and Meghir (1987) claim that the IPM is a "bivariate" limited dependent variable model which may be used as an alternative to the Tobit model in the analysis of household consumption as there is a separate process determining the zero-one discrete behaviour from that determining the continuous observations. Furthermore, when the survey also records the number of purchases made during the recording period, conditioning observed expenditures on the actual number of purchases or any function of it may improve the estimation results (see, for instance, Meghir and Robin, 1992 and Robin, 1993). The advantage of this approach is that if demand depends nonlinearly on total outlay, conditioning on purchase frequencies may substantially reduce this bias due to measurement error, as originally noticed by Keen (1986).

In chapter one we develop an IPM for panel data departing from the IPMs for cross-sectional data. As pointed out by Robin (1993), the main drawback of the cross-sectional IPMs is that given the decision to consume the decision to purchase is *ad hoc* and does not result from a properly defined individual decision process. Everyday consumption and purchases fluctuate according to a dynamic statistical process that should be the result of an underlying economic optimisation. Therefore, the identification of consumption functions requires panel data and, as with cross-sections, only the expected consumer expenditures given present observables are identifiable. With panel data there is the possibility to go beyond the one-snapshot nature of information available in cross-sectional data as we can track household expenditure records over time for those who respond more than once. Other advantages of using panel data are the possibility to control for individual heterogeneity and to introduce price variation.

The extension of the IPM to a panel data setting is analysed in the same context of sample selection panel data models. In this sense, the decision of purchase equation is treated as a selection equation. For this equation we specify, following Chamberlain (1980), Verbeeck and Nijman (1992) and Wooldridge (1995), a conditional distribution for the individual effect. And, for the demand equation, we use an extension of Heckman's sample selection technique to the case where two correlated selection rules generate the sample. We use data drawn from the ECPF, which is particularly suited for the IPMs with panel data, as it is possible to construct a panel of households of eight consecutive periods. We estimate a model for clothing consumption to provide an empirical application of these models. It is of great interest to use panel data to analyse the problem of infrequency of purchase given that with cross-sectional data it is not possible to distinguish among the different reasons that may generate a zero record. These data also allows to control for individual unobserved heterogeneity, and this, as the results of this chapter suggest, is crucial when calculating household demand behaviour or any demand estimate, i.e. income or price elasticity.

In chapter two and three we analyse the effects of children on household demand. These effects are important both empirically and politically, and play a fundamental role in government welfare policies. For instance, in income maintenance programs or in the income tax system, families with many or older children receive, in general, larger benefits or allowances than those with fewer or younger children. As pointed out by many authors, in general, every aspect of household economic behaviour is significantly correlated with the presence of children in the household, see Browning and Lechene (1995), among others. In this thesis we stress two aspects related to the effects of children. First, we investigate how the arrival and presence of children in a household affect consumption of different goods in different ways. Second, we focus on the effects of children in the surroundings of childbirth. As parents can schedule the number of children and the timing of births, some of the child effects would be smoothed away from the child bearing period and a wider time span is needed to investigate these effects.

In chapter two, we analyse how the consumption of certain sorts of goods such as child clothing and food are likely to increase in the presence of children while other goods such as adult clothing or alcohol may be little affected. Deaton, Ruiz-Castillo and Thomas (1989) focus on goods of the latter type, introducing the notion of certain goods being "demographically separable" from children. It is clear that the presence of children does not remove a household's budget constraint and responses to a demographic change of this sort include income effects even on these sorts of goods. However, the idea of demographic separability is that for these goods this may be the only effect. The notion of adult goods figures also in the literature on child costs, particularly in the way it stands behind the Rothbarth (1943) method. This method assumes that households spending the same on adult goods can be taken to share a common welfare level whatever their demographic characteristics. The Rothbarth method is a special case of demographic separability under a specific interpretation of it (see Blackorby and Donaldson, 1995), allowing the identification of children costs. In this chapter, we extend the empirical analysis of demographic separability to panel data through the estimation of a demand system (QUAIDS) over eight goods. We identify a set of putative adult goods and test the hypothesis of demographic separability. Using panel data allows addressing a number of issues. First, as investigated in chapter one, for many of the goods considered, a substantial percentage of households record no purchases in individual periods. Thus, there is not a straightforward interpretation of the regression estimation in terms of preferences if we do not take account of zero record purchases. To deal with the problem of infrequency, we use various strategies (selection of different samples, aggregation, etc.). Second, when dealing with microdata it seems crucial to account for unobserved individual heterogeneity. Third, it is also possible to incorporate price variation into the estimation, improving the potential to distinguish between different types of demographic separability with very different welfare implications. The results in this chapter suggest that both the unobserved heterogeneity and the presence of zero records matter in the estimation. If unobserved heterogeneity is correlated with fertility decisions, for instance, the coefficients of the children variables could be downward biased when fixed effects are not taken into account. We find that the equivalence scales obtained using cross-sectional data seem to underestimate the true values. Finally, when controlling for individual heterogeneity we do not reject the restrictions of symmetry and homogeneity in the estimation of the demand system.

As acknowledged by many authors, the effects of children on household behaviour may start even before the child is born in anticipation of this event, and last for some time after the child has left the family. Pashardes (1991) stresses that the costs of children are in fact paid from reducing consumption in periods when children themselves are not in the family. The household may be saving for future children (precautionary and life cycle or anticipated savings) and therefore reduce their consumption in anticipation to this. This is also argued by Browning and Lusardi (1996). Banks, Blundell and Preston (1994) point out that it would seem natural to expect household expenditure to be influenced by anticipated demographic change, and their results suggest that this is the case. It is also recognised that the arrival of a child in a household influences labour supply (specially for women) and saving plans long before children arrive as households may anticipate children's demand when they attain certain age. This in turn would affect the intertemporal household consumption. Therefore, the investigation of these issues requires an explicitly life-cycle perspective as put forward by Browning, Deaton and Irish (1985), among others.

Focusing on the measurement of child costs for example, Pashardes (1991) claims that child costs are spread over the life cycle and stresses the importance of looking at the intertemporal and contemporaneous aspects of them. The static measure would only be close to the real one if households were unable (or unwilling) to transfer these costs over time. Deaton and Muellbauer (1986) stress the existence and importance of wider concepts of children costs, as the net costs to the parents over the life-cycle could be very different from short run costs that are inferred from studying household budgets, the costs of being born for those very young children, or the costs of education that are borne by parents with college-age offspring.

An important issue in an intertemporal approach is the existence of strong links between labour supply, fertility and consumption. Browning and Meghir (1991) stress that one weakness of most of the studies that look at the effects of children is that they take no account of labour supply. Indeed, labour supply decisions of the wife are highly correlated with the presence and ages of any children in the household. Thus, any estimate of child related effects from demand systems that take inadequate account of labour supply is likely to be biased. This is especially important when investigating intertemporal child effects as the labour supply behaviour of the wife surrounding children birth (especially first birth) is a key factor in the determination of lifetime work experience, and would affect the behaviour of demand and consumption, Browning (1992).

In chapter three we investigate the effects of children in the surroundings of childbirth. Our concern is to analyse the effects of the arrival of a new child on household expenditure patterns in some periods around birth date. In general, the arrival of a new child coincides with a reallocation of the life-cycle expenditure, and not simply a reallocation of "within-period" expenditure shares. As noted above, during this short period some potentially important changes are taking place in the household, like changes in the labour supply (of the wife mainly) and changes in needs (i.e., nutritional effects). To look at this issue we place our problem in an intertemporal setting from which we derive a system of *Frisch* demands for household commodities. We use a panel data set drawn from the ECPF. The advantage of using panel data, apart from controlling for individual heterogeneity, is that one can detect exactly when a child is born in a household and, therefore, it is possible to look at periods before and after birth. This allows to check the extent of children effects on household demand behaviour in the surroundings of child birth. This is consistent with Deaton and Muellbauer's (1986) remark about how important it would be to follow households through the life cycle (although with the ECPF we can only track them during eight consecutive quarters). To analyse these effects we incorporate a set of dummy variables capturing the number of periods before and after birth, in a demand system for 12 commodity categories. We classify demand goods to have specific children goods (e.g. children and baby clothing) and specific adult goods (tobacco, alcohol or out), in order to detect children effects (as income effects and other kind of effects) on different commodities.

Finally, in this intertemporal dimension of the effects of children, it is also interesting to analyse the concept of intertemporal demographic separability. In this sense, one would expect that the path of expenditure of a demographically separable good would remain unchanged (only anticipated income effects implied by the arrival of a child affects these goods), whereas for a non-separable good (like food or children clothing) we would expect children effects apart from income effects. We obtain that there are important specific "jumps" in some children related goods expenditure (clothing, entertainment and food) and no changes in the adult's goods. We also find some effects when interacting dummy variables capturing the timing of birth with labour participation dummies, prices and the interest rate. The "jumps" found seem to reflect that children are to some extent anticipated in the Spanish households within the life cycle. This result has also been pointed out by Browning (1992), Browning and Lechene (1996) and Browning and Lusardi (1997), among others.

The effects of children and the measurement of children costs are important politically and play an important role in government policies. An example of this is the 1999 income tax reform that aimed at increasing children related benefits and giving incentives to increase the Spanish fertility rate. In chapter four we analyse the effects of the 1999 Spanish income tax reform, specially focusing on the children related benefits. It is well known that the parameters and structure of the population of a country change across time. For instance, in Spain there has been a remarkable reduction in the birth rate, together with an increase in the participation of women in the labour market (the Spanish fertility rate dropped from 3.4% in 1941 to 1.2% in 1999, and women participation rate has been increasing during all this period, being currently around 35%). Fiscal policy should take into account all these changes and tax reform should move according to new social parameters. Fiscal reform is an instrument of political economy, in the sense that beyond the basic purpose of raising revenue, it is crucial in providing incentives in working hours/spare time allocation, on the purchase of some goods, on boosting housing market, on the number of children households have, etc.

Given the potential effects of a fiscal reform, assessing its impact is of great interest and this is why simulation techniques are a relevant tool of fiscal policy. They allow examining household behavioural responses to policy changes. This issue is important especially in the case of tax reforms designed to change individuals' behaviour. Simulation techniques enable to calculate the impact of fiscal reform, not just on a number of examples or typical (representative) families, but on thousands of households. In addition, when the data source used is representative of the population, it is possible to infer the revenue implications and distributive effects of the tax reform on different groups of the population.

Based on the 1978 act, the current Spanish income tax system has often been reformed. In 1999 one of the most important reform of the income tax system since 1978 was carried out. The aims of this reform, according to the government, are to simplify the administration and cost of the income tax, to fight fraud and tax evasion, to reduce the tax burden and at the same time to increase the progressiveness of the tax.

The aim of chapter four is to evaluate the effects of the 1999 Spanish income tax reform on a sample of households representative of the Spanish population. This sample has been drawn from the Family Expenditure Survey (EPF) for 1990/91. Using simulation techniques, and assuming that the Spanish socio-demographic structure in 1999 is the same than the one in 1990-91, we predict the cost of the reform in terms of aggregate revenues, make inferences about the revenue implications of specific changes and analyse the distributive effects of the reform on different groups of households. Over this constant population of households, we simulate and compare the current income tax system and the changes that the 1999 reform will bring and address two important questions. First, we evaluate if the new children related benefits, introduced in the 1999 reform, make an improvement with respect to the old system. The results of our simulation suggest that these benefits are similar under both systems, and thus, the announced incentives to increase the fertility rate are not so. Second, we show that there are incentives in the new system, for married women who work part time, to leave the labour market as there is a minimum exemption (under the joint scheme) that is higher than half the guaranteed minimum wage.

Chapter 1

Infrequency of purchase: a model for clothing consumption with panel data.

1.1. Introduction.

Microeconomic survey data sets offer important advantages for the analysis of consumer demand. However, one of the major problems associated with microbudget surveys is the existence of zeros in the expenditure records of households. This is so because a household may be observed to spend nothing over the interview period, on a commodity that nevertheless consumes. It is clear that some commodities, e.g. clothes, are "durable" (or "semi-durable") relative to a typical interview period. Then, in short duration surveys, consumption and purchases can differ markedly and there is a problem in fitting a model of consumption directly to data on purchases. As a result, much of the variation in reported expenditures may reflect stochastic elements in purchasing behaviour rather than differences in the underlying consumption.

In these surveys zeros might arise for any of the following reasons: first, because the household is maximising utility at zero consumption with its current budget, i.e., for its level of income or/and at current prices the household chooses not to consume (corner solution); second, because the household would not participate in the consumption of some commodities at any price and income, for example non smokers with tobacco (non-participation); third, because no purchase has been made during the monitoring period of the survey although the household is a regular consumer of the goods (infrequency of purchase); and, fourth, misreporting due to any reason.

The incidence of zeros in the expenditure of some commodities has been typically modelled as a Tobit model (Tobin, 1958). The underlying assumption in the Tobit model is that both the decision to purchase and the amount of acquisition are driven by the same variables. This is a quite restrictive assumption if we take into account the different reasons that may cause zeros in expenditure surveys.

Cragg (1971) developed several models for limited dependent variables that are extensions of the multiple Tobit analysis model. These models differ from the Tobit model in that they allow the determination of the size of the variable (when it is not zero) to depend on parameters or variables different from those determining the probability of being zero. As pointed out by Cragg (1971), in some situations the decision to purchase and the amount of the acquisition may not be so intimately related.

In the 80s an alternative modelling strategy arose in order to describe the short-run fluctuations of demands that are observed in the data and cannot be accounted for by price and income variations. The so-called Infrequency of Purchase Model (IPM), put forward by Deaton and Irish (1984), Kay, Keen, and Morris (1984), Pudney (1985), and Blundell and Meghir (1987), among others, introduces a distinction between consumption and purchase behaviour and stresses the fact that a zero purchase may reflect either a zero consumption (as in the previous corner solution models) or a transitory abstention that may occur for various other reasons. The IPMs are econometric models that aim at providing the best possible estimation of expected demand functions given the available information about the underlying process of purchase renewals.

Kay, Keen and Morris (1984) stress that the direct information on expenditures provided by household budget surveys may be of more value, since a household's chosen level of expenditure presumably reflects its own evaluation of its long-term economic position. Their paper is concerned only with the infrequency of purchase issue, i.e., the relationship between the recorded expenditure and consumption of individual households. Deaton and Irish (1984) consider a model where the standard Tobit specification is supplemented by the operation of a binary censor. Taking the Tobit specification as the starting point they add a second censoring process that randomly replaces a fraction of the observations generated by the Tobit model with zeros. Blundell and Meghir (1987) claim that the IPM is a bivariate limited dependent variable model which may be used as an alternative to the Tobit model in the analysis of household consumption. They call their model "bivariate" as there is a separate process determining the zero-one discrete behaviour from that determining the continuous observations. The IPM provides a separate family of alternative models where zero values occur due to "durability" of a commodity in comparison to the duration of the survey period from which the expenditure observations are drawn.[1] In each case, allowing for these separate processes relaxes one of the strong assumptions underlying the standard Tobit model.

A natural extension of the two-regime IPMs, when the survey does not only record expenditures but also the number of purchases made during the recording period, consists of conditioning observed expenditures on the actual number of purchases or any function of it (see for example Meghir and Robin, 1992 and Robin, 1993). The advantage of this approach is that if demand depends nonlinearly on total outlay, conditioning on purchase frequencies may substantially reduce this bias due to measurement error, as originally noticed by Keen (1986).

As pointed out by Robin (1993), the main drawback of these IPMs is that given the decision to consume the decision to purchase is *ad hoc* and does not

[1] The question remaining once one of these broad specifications has been chosen relates to the feasibility of estimation and the provision of diagnostic tests for some of the underlying distribution assumptions. Both of these points are tackled in some detail in their paper and suggest the potential usefulness of applications of these models and tests to other data sets and preference specifications.

result from a properly defined individual decision process. Everyday consumption and purchases fluctuate according to a dynamic statistical process that should be the result of an underlying economic optimisation. Therefore the identification of consumption functions requires panel data and, with cross-sections, only the expected consumer expenditures given present observables are identifiable.

It is worth mentioning that all the above methods have been applied to cross-sectional data. With panel data, however, there is the possibility to go beyond the one-snapshot nature of information available in cross-sectional data in the sense that we can track household expenditure records over time for those who respond more than once.[2] An important implication with panel data is that if we observe an alternation of positive and zero records over the number of interviews that a household undergoes, then we can infer that the household is a consumer of the good under consideration. We can also infer that zeros are due to, depending on the reference period and on the variability of the household budget between interviews, either infrequency of purchase or a switching regime between corner solutions and positive consumption.[3] For some goods (i.e. clothing) we can rule out the second possibility given that a person may not buy any clothes during a particular week, but nevertheless does not go naked. In this study we are mainly interested in the case of zeros due to infrequency of purchase. Thus we would rule out other possibilities by focusing on this sort of problem. As a result, it might be worth investigating the expenditure record of a group of households which can be tracked over time (panel data) since the probability of erroneous inference decreases with the number of periods we observe for every household.[4] Furthermore, using panel data would improve the estimations, given that the selection of those households who purchased at least once during the survey would not eliminate all the zero values of the number of

[2] The data set we use in this chapter is the Spanish Family Panel Expenditure Survey (*Encuesta Continua de Presupuestos Familiares*, ECPF), from which it is possible to construct a real panel of eight periods for about 2,500 households.

[3] However, in reality, changes in taste can induce participation change.

[4] Table 1.1 shows the dramatic decrease in the proportion of zeros in the expenditure of clothing, as more periods of the survey are taken into account.

times that a household purchases. Other advantages of using panel data are that it is possible to control for individual heterogeneity and to introduce price variation.

Departing from the IPMs for cross-sectional data we have developed a IPM for panel data. The extension of the IPM to a panel data setting connects directly to the literature that deals with problems of sample selection with panel data. We use several panel data estimators in order to estimate the consumption equation for clothing. First, the decision of purchase equation, is treated as a selection equation. For this equation we specify, following Chamberlain (1980), Verbeeck and Nijman (1992) and Wooldridge (1995), a conditional distribution for the individual effect. Second, in the demand equation, we use an extension of Heckman's sample selection technique to the case where two correlated selection rules generate the sample. An application of all these models is provided using the Spanish Panel of Family Expenditure Survey (*Encuesta Continua de Presupuestos Familiares*, ECPF), and our results suggest that both price variation and individual heterogeneity play a role in the estimation of these models.

The layout of the chapter is as follows. In the next section we describe the statistical models and diagnostic tests. In section 1.3 the empirical application of each model is given using individual survey data drawn from the Spanish ECPF. Finally, section 1.4 concludes.

1.2. Statistical models and diagnostic tests.

1.2.1. Statistical models.

We use the Tobit model (Tobin, 1958) to account for censoring in commodity demand. The underlying assumption in this model is that the same stochastic process determines <u>both</u> the value of continuous observations on the dependent variable and the discrete switch at zero. This means that a zero realisation of the dependent variable represents either a corner solution or a negative value for the underlying latent dependent variable. This restricts other quite reasonable determinants of zero observations such as infrequency of purchase and non-participation or misreporting in commodity demand.[5]

The Tobit specification rests on strong distributional assumptions which should be tested if this model is to be used as a modelling framework for individual behaviour (see Chesher and Irish, 1987, Gourieroux, Monfort, Renault and Trognon, 1987, Blundell and Meghir 1987, among others). It is crucial to notice that as soon as it is recognised that zero observations on the dependent variable may be generated by infrequency of purchase then the censoring rule that underlies the Tobit model is invalid as a description of the censoring process and the sample log-likelihood function is misspecified. As a response to these problems, and following the literature, the bivariate models (or two regime IPMs) that we are going to consider provide a framework for dealing with these additional censoring rules.

The two-regime IPMs are obtained by conditioning expenditures on the alternative: purchasing or not. To deal with additional censoring rules, Deaton and Irish (1984) develop a simple frequency of purchase model in which it is assumed that consumers correctly report purchases, but purchases themselves are made at intervals which may be longer than the period of the survey. To simplify the model they consider that the period is a fraction *p* of the purchase period. In this case, a purchase of y_i / p_i (where y_i is expenditure of household *i*) is observed with probability p_i during the survey, while with probability (1- p_i) no purchases are observed. This model is called the p-Tobit model.

Deaton and Irish (1984) stress that with microdata, misreporting and infrequency of purchase are not distinguishable, at least with constant *p*. With non-constant *p*, identification would require some separation of the variables influencing consumption from those influencing p_i . An extension of this model, where the p_i are individual specific, can be found in Blundell and Meghir (1987). They develop a particular form of the IPM where zero values for the dependent

[5] This restriction has been recognised, among others, by Atkinson and Jenkins (1984), Deaton and Irish (1984) and Blundell and Meghir (1987).

variable cannot be attributed to corner solutions. This is a consumer demand model where consumption is always positive but recorded expenditures are often zero.[6] In this type of model, the latent variable is never directly observed. A positive expenditure will represent a purchase of stock whose services will be consumed over future periods, typically longer than the period of observation. The IPM that Blundell and Meghir (1987) present can be viewed as a snapshot of the dynamic process determining stock accumulation and consumption of services.

Finally, a generalisation of these models could be obtained by conditioning expenditures on the purchase frequency variable instead of the previous particular indicator function.[7] Robin (1993) points out that the identification of consumption functions requires panel data and that, with cross sections, only the expected consumer expenditures, given present observables, are identifiable. In general, however, it is hard, if possible at all, to derive a closed form for these expectations both because this requires information on the joint process of the set of demand and explanatory variables, and because of the non-linearities arising from the qualitative structure of the model. Moreover, even if this time-aggregation were possible, it is well-known that not all the preference parameters would be identifiable. And furthermore, with the type of data available in micro-surveys, in order to identify the nature of the observed zeros we would need prior information.

With panel data it is possible to find out more about the nature of the zero reports. In the particular case of clothing expenditure it seems (see table 1.1) that the frequency of purchase story is the most reasonable. From this table we may also infer an informal test that gives evidence on the fact that during the recording period everybody consumes clothes but not everybody spends on clothing. As we take into account more periods of the sample there is a dramatic drop in the

[6] The example they take is clothing expenditure. Consumption services from this commodity are very rarely zero but surveys with short recording periods have some zero expenditures due to the durability of clothing items and the resulting infrequency of purchase by consumers.

[7] Instead of conditioning on purchase frequencies, one could condition on any measurable function of purchase frequencies, see Robin (1993) and Meghir and Robin (1992), for some applications of this extension.

proportion of zeros (in the expenditure of adult clothing). This is what one would expect if infrequency of purchase is the main reason behind zero reports on clothing expenditure.[8]

In order to use the advantages of panel data, the extension we propose is to develop a commodity demand model for panel data that follows the developments for cross-sectional data of Kay, Keen and Morris (1984), Keen (1986), Pudney (1985 and 1989) and Blundell and Meghir (1987). Following Blundell and Meghir (1987) we also choose a commodity (clothing) for which it is unlikely that any zero expenditures represent a corner solution.

The motivation of developing an IPM for panel data is to compare this model with the IPM with cross-sectional data in order to shed some light on the existence of individual heterogeneity and to assess the possibility of identifying those models with only cross-sectional data. Apart from the advantages already mentioned, when dealing with panel data, it is possible to introduce price variation. In the specification below, the first equation tries to capture the decision of purchase and the second the consumption of clothing. Therefore, we have to introduce individual unobserved effects in both equations.

Formally, defining y_{it} as the observed expenditure of individual i in period t for i=1,...,N and t=1,...,T, we have

$$(1.1) \quad E(y_{it}|z_i) = E(y_{it}|z_i, D_{it} > 0)p_{it} + E(y_{it}|z_i, D_{it} \leq 0)(1 - p_{it})$$

where D_{it} is the latent variable describing the decision to purchase, $p_{it} = \Pr(y_{it}|z_i)$ is the probability of purchase and $z_i = (x_{it}, x_{it-1}, \ldots, x_{iT})$.[9] If y_{it}^* represents consumption, then assuming that $E(y_{it}^*|z_i) = E(y_{it}|z_i)$ and noting that $E(y_{it}|z_i, D_{it} < 0)(1 - p_{it}) = 0$, we have

$$(1.2) \quad E(y_{it}|z_i, D_{it} > 0)p_{it} = E(y_{it}^*|z_i)$$

[8] A detailed description of the data can be found in appendix B.

[9] In the conditioning set we only use the sub-set of all the strictly exogenous regressors of the model. Also note that the first element in each x_{it} is a one. In the case at hand we get that we can not reject that the share of clothing expenditure for some homogeneous groups of households is statistically the same (after accounting for individual purchase policy).

As noticed by Blundell and Meghir (1987), since $p_{it} < 1$ and can be regarded as an individual specific depreciation rate, (2) implies that observed expenditure when positive will, on average, exceed the level of consumed services.[10] It is interesting to discuss the nature of the above assumption. It is possible to some extent to check the truthness of the assumption through the inspection of the real data. For example, following Deaton and Irish (1984), if the assumption is true then those households who only buy four times out of eight quarters should buy twice as much as those who buy the eight periods. Taking the empirical individual probabilities one can assess the extent of this assumption.[11] Moreover, if we aggregate the data over time per individual it is possible to relax the assumption that $E(y_{it}^*|z_i) = E(y_{it}|z_i)$ (as we present below). Relaxing the above assumption does not prevent us from implementing a consistent estimator. Table 1.1 presents evidence about this point, i.e. aggregation over time (individual means) eliminates the zero records.

Assuming that

$$(1.3) \quad E(y_{it}^*|z_i) = x_{it}'\beta + E(\alpha_i|z_i),$$

the censoring rule generating y_{it} in any random sample may therefore be written as

$$(1.4) \quad y_{it} = \begin{cases} \dfrac{x_{it}'\beta + E(\alpha_i|z_i)}{p_{it}} + u_{it} & if \quad D_{it} > 0, \\ 0 & otherwise \end{cases}$$

where we assume that $E(u_{it}|\alpha_i) = 0$.[12]

[10] For some individuals, specially those at the end of their life, the assumption $E(y_{it}^*|z_i) = E(y_{it}|z_i)$ can be restrictive. In our empirical application we drop all those households in which the head of the household is older than 65, which is the retirement age in Spain.

[11] To make this comparison it is necessary to select homogeneous households: same composition, income, labour supply, etc.

[12] We could assume instead that $E(u_{it}|\alpha_i)$ is not zero but is time invariant so that this can be absorbed into the unobserved individual effect, α_i.

Now, to complete the specification, the decision to purchase can be modelled as

$$(1.5) \quad D_{it} = x_{it}'\theta + \eta_i + a_{it}$$

Note that we write x_{it} as the explanatory variables in both (1.4) and (1.5). We use these variables in both equations to simplify notation although some exclusion restrictions, i.e. some elements of x_{it} will be omitted in equation (1.4), in order to identify both sets of parameters.

To estimate the above model we use different approaches. Firstly, we present an estimator based on the aggregation over time of our data set. Secondly, we use the same approach than Wooldridge (1995).[13] Finally, we present a two step procedure where the first step follows the approach of Wooldridge (1995) for the treatment of the individual effects, and the second stage takes differences to eliminate the individual effects of the demand equation.

As table 1.1 shows, aggregating over time solves the problem of zero records. Therefore, an interesting exercise is to specify the model of interest in terms of the unit means, i.e., aggregating the data set over time for each individual.[14] The idea in using the time aggregated model is to avoid the problem of zero records in the dependent variable, although this will have the cost of assuming strong exogeneity of the regressors.

The previous identifying assumption (i.e., $E(y_{it}|z_i) = E(y^*_{it}|z_i)$) can be relaxed given that for this estimator we only need to assume that

$$(1.6) \quad E\left(\sum_{t=1}^{T} y_i | z_i\right) = E\left(\sum_{t=1}^{T} y_i^* | z_i\right)$$

where, as before, y_i^* is consumption and y_i is expenditure. Therefore, on average zero records compensate positive purchases, and we do not need to assume (calculate) any probability of purchase. The aggregation of purchases,

[13] This approach follows the same ideas than Chamberlain (1980), to treat the unobserved individual effect.

[14] Thus, if the panel data set is composed of N individuals and T time periods, aggregating over time yields a data set of N observations.

taking into account the zeros of the sample, can be equated to the average consumption. This assumption is weaker than the previous one in the sense that if the reason behind the zero records is infrequency then the longer the time span the more likely the assumption to hold. A simple inspection of table 1.1 confirms the intuition behind (1.6).

To get consistency when we aggregate the model across time for each household we need to make some assumptions. First, we assume asymptotics on N (observations or individuals). Second, we impose independence between the frequency of purchase and consumption, which implies, to some extent, the absence of selectivity bias. Finally we assume strict exogeneity, i.e., $E(error_{it}|z_i) = 0$, which means that there is no feed-back in the aggregated model.

It should be stressed that this model is robust to any frequency of purchase structure given that we do not assume anything about the underlying probability of purchase. The only required assumption is time stationarity of the frequency of purchase (or time stationarity of the probability of purchase per individual).[15] A final remark on this estimator is that it does allow for heteroscedasticity and therefore it is possible to test for heteroscedasticity.

We turn now to the other estimators. Both are two step estimators and in both cases we use the same kind of assumptions for the unobserved individual effects in the first step. Thus we discuss the first step, i.e. we focus on the characteristics of the frequency of purchase equation (the selectivity equation). We assume that in equation (1.5), (η_i, a_{it}) are jointly normally distributed with $E(a_{it}) = 0$ and a_{it} independent of z_i; η_i is a time-constant unobserved individual effect. To allow η_i to be correlated with z_i we can specify, following Chamberlain (1980),[16] a conditional distribution for η_i given z_i that allows for dependence between the individual effect and the explanatory variables in the

[15] It does not seem to be very strong to assume that the pattern of purchase of a household is quite stable in the long run, i.e., that the distribution of the purchase probability of clothing is constant over time for each household.
[16] Verbeeck and Nijman (1992) and Wooldridge (1995) use also this approach.

decision of purchase equation. For convenience, we assume that the dependence is only via a linear regression function,

(1.7) $\eta_i = \chi_0 + x_{i1}'\chi_1 + x_{i2}'\chi_2 + ... + x_{iT}'\chi_T + c_i$

where c_i is a random term, assumed to be independent of z_i with a zero mean normal distribution. Substituting (1.7) into (1.5) we have the following frequency of purchase equation

(1.8)

$$D_{it} = \delta_{t0} + x_{i1}'\delta_{t1} + x_{i2}'\delta_{t2} + ... + x_{iT}'\delta_{tT} + v_{it} \quad i = 1,...,N. \quad t = 1,...,T.$$

where $\delta_{t0} \equiv \chi_0$, $\delta_{tr} \equiv \chi_r$ for $r \neq t$ and $\delta_{tt} \equiv \chi_t + \theta$, for $r=t$ and $v_{it} \equiv c_i + a_{it}$. Equation (1.8) can be rearranged as follows

(1.9) $D_{it} = z_i'\delta_t + v_{it} \quad i = 1,...,N, \quad t = 1,...,T$,

where $\delta_t' = (\delta_{t0}, \delta_{t1}, ..., \delta_{tT})$.

We assume that the v_{it} are independent of z_i and distributed as a $N(0, \sigma_t^2)$. As pointed out by Wooldridge (1995), although normality is assumed, the temporal dependence in $(v_{it}: t = 1,...,T)$ is entirely unrestricted. In our specification, without loss of generality, we assume that $\sigma_t^2 = 1$. Therefore, the probability of purchase, p_{it}, can be estimated as $\Phi(z_i'\delta_t)$, where $\Phi(\cdot)$ represents the standard normal distribution function.

Turning to the estimation of the equation of interest, the consumption equation for clothing, we use two approaches. As mentioned before both of them parameterise the individual fixed effect in the same way. The first of these two methods also relies on Chamberlain's (1980) idea that individual effects are a linear projection of the explanatory variables. Wooldridge (1995) derives this first approach for a sample selection panel data model. In this chapter we follow procedure 4.2 of his paper, which deals with a selection correction problem in panel data when only the selection indicator (D_{it} in our case) is observed.

Recalling equation (1.4) the equation that describes the behaviour of individuals who purchase may be written as

$$(1.10)\quad \Phi(z_i'\delta_t)y_{it} = x_{it}'\beta + E(\alpha_i|z_i) + u_{it} \qquad \text{for } D_{it} > 0$$ [17]

Further we assume that for t=1,...,T,

$$(1.11)\quad E(\alpha_i|z_i, v_{it}) = L(\alpha_i|z_i, v_{it}),$$ [18]

$$(1.12)\quad E(u_{it}|z_i, v_{it}) = E(u_{it}|v_{it}) = L(u_{it}|v_{it}),$$

where L(·|·) denotes the linear projection operator.[19] Equation (1.11) can be written as

$$(1.13)\quad L(\alpha_i|z_i, v_{it}) = \psi_{t0+} + x_{i1}'\psi_{t1} + \ldots + x_{iT}\psi_{tT} + \phi_t v_{it},$$

where ψ_{t0} is a scalar and ψ_{tr}, r=1,...,T, are Kx1 vectors. The key point of this expression is that under assumptions (1.11), (1.12) and the assumption that $E(v_{it}|z_i) = 0$ the ψ_{tr} are constant across t.[20] Thus, from equation (1.13) we get,

$$(1.14)\quad \begin{aligned} E(\alpha_i|z_i) &= \psi_{t0} + x_{i1}'\psi_{t1} + \ldots + x_{iT}\psi_{tT} + \phi_t E(v_{it}|z_i) = \\ &\psi_0 + x_{i1}'\psi_1 + \ldots + x_{iT}\psi_T \end{aligned}$$

Therefore, given the above assumptions we can identify β. In order to estimate it we only need to find the expectation of $\Phi(z_i'\delta_t)y_{it}$ given $(z_i, D_{it} > 0)$. This gives,

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[17] It is important to note that u_{it} may be potentially heteroscedastic given that the probability of purchase appears dividing in the error term. Thus, the estimation procedures used are robust to heteroscedasticity.

[18] Assumption (1.11) is similar to an assumption used in Chamberlain (1980) except for the term v_{it}. As pointed out by Wooldridge (1995), except for the linearity, the distribution of α_i conditional on (z_i, v_{it}) is otherwise unrestricted for all t; i.e., conditional heteroscedasticity of unknown form is allowed.

[19] The first equality in (1.12) implies that u_{it} is mean independent of z_i conditional on v_{it}. This conditional mean independence always holds if (u_{it}, v_{it}) is independent of z_i. We have already assumed that v_{it} are independent of z_i. Finally, equation (1.12) does not impose any restriction on the temporal dependence of u_{it}, or on how u_{it} relates to v_{ir}, $r \neq t$. The second equality of (1.12) is less restrictive and could be relaxed. For simplicity we assume that $E(u_{it}|v_{it}) = \rho_t v_{it}$, for some scalar ρ_t.

[20] This comes from a simple application of the law of iterated expectations.

(1.15) $E(\Phi(z_i'\delta_t)y_{it}|z_i, D_{it} > 0) = x_{it}'\beta + z_i'\psi + \gamma_t\lambda(z_i'\delta_t)$

All the above leads to the following procedure:

(i) For each t=1,2,...,T estimate equation (1.9) by standard probit. For $D_{it} > 0$ obtain the inverse Mills ratio $\lambda(z_i'\hat{\delta}_t)$ and the probability of purchase $p_{it} = \Phi(z_i'\hat{\delta}_t)$. For those observations in which $D_{it} > 0$ define $\hat{w}_{it} \equiv (x_{it}', z_i', 0, \ldots, \hat{\lambda}_{it}, \ldots, 0)$.

(ii) Obtain $\hat{\theta} \equiv (\hat{\beta}', \hat{\psi}', \hat{\gamma}')'$ as the pooled OLS estimator in the following equation: $y_{it} = w_{it}'\theta + \varepsilon_{it}$ for $D_{it} > 0$.

(iii) Estimate $A\text{var}(\hat{\theta})$ taking into account that we have previously estimated the probabilities of purchase and the selectivity term.[21]

The second approach we use to estimate the demand equation is explained in what follows. Recalling equation (1.10) we can take differences between all possible individual observations in which the household purchase adult clothing. By taking differences we can eliminate the individual effect.[22] Thus, we have

(1.16) $\Delta(\Phi(z_i'\delta_t)y_{it}) = \Delta x_{it}'\beta + \Delta u_{it}$ for $D_{it} > 0$, $D_{is} > 0$ and $t \neq s$.

where $\Delta(.)$ represents the difference operator.[23] To identify the vector of parameters in the equation of interest, β, we must find the expectation of $\Delta(\Phi(z_i'\delta_t)y_{it})$ given $(z_i, D_{it} > 0, D_{is} > 0)$. This yields

(1.17)

$$E[\Delta(\Phi(z_i'\delta_t)y_{it})|z_i, D_{it} > 0, D_{is} > 0] = \Delta x_{it}\beta + E[\Delta u_{it}|z_i, D_{it} > 0, D_{is} > 0]$$

---

[21] See Wooldridge (1995) for a detailed description of how to calculate the asymptotic variance-covariance matrix.

[22] The idea is to exploit as many pair-differences per individual as possible. In the case at hand, as households are observed for a maximum of 8 periods, the maximum pair differences that one can build is 28.

[23] Note that $\Delta(\cdot)$ is the difference operator for all possible pairs that we can built.

The estimation procedure we use is an extension of Heckman's sample selection technique to the case where two correlated selection rules generate the sample (as in our case).[24] The procedure first estimates, by bivariate probit analysis, the factors affecting the probability of purchase in t and s. It then estimates the demand equation by selecting from the sample those pairs in which the individual buys clothing.[25] We use the bivariate probit coefficients to correct for selectivity bias in the estimation. We have then to calculate the expectation of Δu_{it} (the differenced error term in the demand equation) conditional on (z_i, D_{it}, D_{is}). In order to correct for bias with two selection rules (D_{it} and D_{is}), we can follow Ham's (1982) approach.[26] Assuming that the vector of error terms of the two selection terms and the differenced error of the demand equation, i.e. $(v_{it}, v_{is}, \Delta u_{it})$, follows a trivariate normal distribution we can apply Ham's approach[27] to calculate the conditional expectation in the specific problem we have at hand. This conditional expectation can be expressed as follows

$$(1.18) \quad E\left[\Delta u_{it} \middle| z_i, D_{it} > 0, D_{is} > 0\right] = \sigma_{\Delta u v_{it}} \lambda_{its} + \sigma_{\Delta u v_{is}} \lambda_{ist}$$

where $\sigma_{\Delta u v_{it}}$ and $\sigma_{\Delta u v_{is}}$ are the covariance between the differenced error in the demand equation and the errors in the selection equations, respectively. In addition,

$$\lambda_{ts} = \phi(Z_{it})\Phi(Z_{it}^{*}) / \Phi_2(Z_{it}, Z_{is}, \rho_{ts})$$

$$\lambda_{st} = \phi(Z_{is})\Phi(Z_{is}^{*}) / \Phi_2(Z_{it}, Z_{is}, \rho_{ts})$$

$$Z_{it} = z_i \delta_t$$

---

[24] The most efficient estimator would be ML. However, estimating this model through ML would involve the joint estimation of a large number of parameters. Therefore, we use a 2-stage estimator in the line of Heckman's (1979) procedure.

[25] We take all possible differences per individual in all cases where we have 2 positive purchases.

[26] Heckman (1979) proposed a two-stage estimator for the one selection rule case. This approach has been extended to the two selection rules problem by both Ham (1982) and Poirier (1980) in the case of cross-section models. Both of these studies use the developments obtained by Tallis (1961) for a n-dimensional normal distribution. Rochina (1996) extends this approach to a panel data sample selection problem. In this study we follow Rochina (1996) to estimate a demand function for clothing.

[27] This is based on the fact that we have a trivariate normal distribution where one of the variables is truncated, see Tallis (1961) for a more detailed explanation.

$$Z_{is} = z_i\delta_s$$

$$Z^*_{it} = (Z_{is} - \rho_{ts}Z_{it}) / (1-\rho^2_{ts})^{1/2}$$

$$Z^*_{it-1} = (Z_{it} - \rho_{ts}Z_{is}) / (1-\rho^2_{ts})^{1/2}$$

where $\phi(.)$ and $\Phi(.)$ are the univariate standard normal density and distribution functions respectively, $\Phi_2(.)$ is the bivariate standard normal distribution function and ρ_{ts} is the correlation coefficient between the errors in the two selection rules. Using (1.17) and (1.18) we have

$$(1.19)\quad E[\Delta(\Phi(z_i\delta_t)y_{it})|z_i, D_{it} > 0, D_{is} > 0] = \Delta x_{it}'\beta + \sigma_{\Delta uv_{it}}\lambda_{its} + \sigma_{\Delta uv_{is}}\lambda_{ist}$$

$$\equiv \Delta x_{it}\beta + \gamma_{ts}\lambda_{its} + \gamma_{st}\lambda_{ist}$$

This leads to a procedure to estimate β that can be summarised as follows:

(i) For each pair *t-s* estimate the parameters of the selection rule equations by bivariate probit analysis and use these coefficients to form consistent estimates, $\hat{\lambda}_{its}$ and $\hat{\lambda}_{ist}$, of λ_{its} and λ_{ist}. Calculate the probabilities of purchase ($\Phi(z_i'\hat{\delta}_t)$) by estimating a probit for each period. For all pair of individual observations with $D_{it} > 0$ and $D_{is} > 0$ define $\Delta\hat{w}_{it} \equiv (\Delta x_{it}', 0, 0, \ldots, \hat{\lambda}_{its}, \hat{\lambda}_{ist}, 0, \ldots)$.

(ii) Obtain $\hat{\theta} \equiv (\hat{\beta}', \hat{\gamma}')'$ as the pooled OLS estimator in the following equation: $\Delta(\Phi(z_i'\hat{\delta}_t)y_{it}) = \Delta\hat{w}_{it}'\theta + \varepsilon_{its}$ for $D_{it} > 0$ and $D_{is} > 0$ and $t \neq s$.

(iii) Estimate $A\mathrm{var}(\hat{\theta})$ taking into account that we have previously estimated the probabilities of purchase and the selectivity terms.[28]

1.2.2. Diagnostic tests.

In the first procedure to estimate our model we treat the panel data as a cross section. The procedure to estimate a cross-section model follows Blundell and Meghir (1987) approach. The aim of this estimation is to be able to compare the estimates obtained with cross-sectional data to the ones obtained with panel data.

[28] In appendix A we derive the asymptotic variance following the approaches by Ham (1982) and Wooldridge (1995).

As highlighted by Blundell and Meghir (1987) it would be interesting to test for heteroscedasticity and for independence, in the context of this model. In order to do this, we follow their approach.[29]

An interesting test to be carried out is to compare the cross-sectional model of IPM and the time aggregated model. The motivation for this test is that under the assumption of strict exogeneity, the null hypothesis states that both the maximum likelihood estimator in the IPM (the true model), $\hat{\beta}_{CS}$, and the time aggregated model estimator, $\hat{\beta}_{TA}$, are consistent, although the aggregated model estimates are not efficient. However under the alternative hypothesis, and still assuming strict exogeneity, the time aggregated estimator remains consistent but the IPM estimator does not.[30]

As pointed out by Mroz (1987), given that the estimator under the null hypothesis may not be efficient, we can not use Hausman's (1978) formula for the covariance matrix of the differences between the two sets of estimates. Therefore we follow Mroz's (1987) approach to construct the covariance matrix of $\left(\hat{\beta}_{CS}, \hat{\beta}_{TA}\right)$.[31]

Therefore under H_0 we have the chi-squared test based on the Wald criterion

$$(1.20)\quad W = \chi^2_{(K)} = [\hat{\beta}_{CS} - \hat{\beta}_{TA}]'\hat{\Sigma}^{-1}[\hat{\beta}_{CS} - \hat{\beta}_{TA}]$$

where $\Sigma = Var\left[\hat{\beta}_{CS} - \hat{\beta}_{TA}\right]$. Under the null hypothesis, W is asymptotically distributed as a chi-squared with K degrees of freedom. In order to carry out the test we need to calculate the asymptotic variance of $\hat{\beta}_{CS}$ from the infrequency of

29 A test for normality is also implemented for the error term in the frequency of purchase equation for the cross-sectional model.

30 The characteristics of this test are that if we accept the H_0, we accept the IPM as the true model against the aggregated model, but if we reject the null hypothesis we are not sure if we are rejecting the specification of the IPM or the strict exogeneity assumption. In the second case, we should test for strict exogeneity.

31 See Mroz (1987), for a detailed description of the formula to calculate the covariance matrix of $\left(\hat{\beta}_{CS}, \hat{\beta}_{TA}\right)$. All his formulae are based on White (1982a). In our case we specially follow case 3 of the appendix, where he reports the formula when one of the estimators is a multi-stage estimator and the other is a maximum likelihood estimator.

purchase model. In appendix A there is a description of the asymptotic variance for the $\hat{\beta}_{CS}$ estimator.

The second set of tests are based on the panel data estimators. After estimating the model using Wooldridge (1995) approach, it is possible to test for the exogeneity of the individual fixed effects (i.e., $E(\alpha_i|z_i) = 0$).[32]

Another diagnostic that has been carried out is the efficiency gains when estimating the IPM using the information provided in the frequency of purchase equation. Equation (1.4) above holds because of the assumption that $E(y^*_{it}|z_i) = E(y_{it}|z_i)$. It follows that regressing y_{it} on z_i also yields a consistent estimate.[33] Comparing both estimators it is possible to assess the efficiency gains obtained given that the estimator using equation (1.4) should be more efficient because it uses more structure.[34]

Finally, we can compare the IPM with cross-sectional data estimates, $\hat{\beta}_{CS}$, with the estimates obtained from the IPM with panel data, $\hat{\beta}_{PD}$.[35] The motivation of this test is based on the idea that under the hypothesis of no individual effects, both models are consistently estimated but the estimates from the IPM with panel data are inefficient (there is no need of estimating the model with panel data if we do not have fixed effects). However under the alternative hypothesis of correlated individual effects, only the IPM with panel data estimates remain consistent.

Under H_0 we have the chi-squared test based on the Wald criterion

$$(1.21) \quad W = \chi^2_{(J)} = [\hat{\beta}_{PD} - \hat{\beta}_{CS}]' \hat{\Sigma}^{-1} [\hat{\beta}_{PD} - \hat{\beta}_{CS}]$$

[32] There is another way to test for the exogenenity of the fixed effects. Under the maintained assumption that $E(\alpha_i|z_i)$ is a linear function of z_i, a Hausman test based on the comparison of the time aggregated estimator and Wooldridge's (1995) type estimator for the IPM, provides also a test for the exogenenity of the individual effects.
[33] A similar estimator has been proposed by Keen (1986) in a cross sectional context.
[34] This point has been already made by Meghir and Robin (1992).
[35] Both estimators used to estimate equation (1.4) can be taken to carry out this test.

where $\hat{\Sigma} = Var\left[\hat{\beta}_{PD} - \hat{\beta}_{CS}\right]$.[37] Under the null hypothesis, W is asymptotically distributed as a chi-squared with J degrees of freedom. In order to carry out the test we need to calculate the asymptotic variances of the estimators from the infrequency of purchase models. In appendix A there is a description of the asymptotic variance for both estimators ($\hat{\beta}_{PD}$ and $\hat{\beta}_{CS}$).

1.3. Empirical application.

1.3.1. Data and variables.

The data for this chapter are drawn from the Spanish ECPF, that is conducted by the Spanish National Statistical Office since the first quarter of 1985 to the last quarter of 1991 (the last wave available for this chapter). This is a quarterly rotating panel that interviews about 3,200 households with a 12.5 per cent rotating rate to avoid, somehow, attrition problems. This survey collects detailed information on household characteristics, income and expenditures. We construct a balanced panel data set in which it is possible to track the same household across time for a maximum of eight quarters. This panel is composed of 12,400 observations (1,550 households over 8 quarters). We select all households staying in the sample for the maximum period of eight quarters and containing one married couple and possibly other adults. The head of the household is older than 20, but younger than 65.[38]

We can think of the model to be estimated as an equation from a complete demand system.[39] As pointed out by Blundell and Meghir (1987), clothing expenditures by household recorded in a survey of limited duration seem to be

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[37] As before, the formulae used to construct the covariance matrix for $\left(\hat{\beta}_{PD}, \hat{\beta}_{CS}\right)$ follow Mroz's (1987) approach.

[38] A more detailed information about the selection process is available from the author upon request.

[39] The demand system we have in mind is the Almost Ideal Demand System (AIDS) derived by Deaton and Muellbauer (1980), in which the variables to be explained, the expenditure shares, are related linearly to the logarithm of prices and the logarithm of total real expenditure.

one of the most appropriate commodity for illustrating infrequency of purchase models. In our case we focus on the demand for adult clothing. The consumption of services from clothing by households must be positive, but after aggregating across all adult clothing expenditures in a household, some zero expenditures are still likely (see table 1.1). The endogenous variable in all estimated models is the share of adult clothing consumption; it represents 8.44% of total expenditure as an average for all individuals in the sample, and 10.36% if we only take into account the sub-sample of consumers with positive observations.

An empirical issue for the estimation of model (1.4) is the consideration of some exclusion restrictions in order to estimate the parameters of both selectivity and demand equations. As pointed out by Blundell and Meghir (1987), the Engel curve, seen as an income-consumption equation, can be thought of as a reduced form from a set of structural relationships describing all household expenditures, savings and even labour market decisions. Therefore, a variety of economic and demographic variables can be expected to enter the determination of consumption. The probability of purchase, on the other hand, may depend more directly on variables determining the relative time and money costs of purchase and on general economic and demographic factors.[40] It would also be interesting to depart from a structural model for both the consumption policy and the purchase policy, in the same lines than Meghir and Robin (1992). In practice, we follow Blundell and Meghir (1987) approach and introduce a set of demographic variables in the selection equation that differs from the one used in the demand equation. We also introduce quarter dummies in our selection equation, but not in the demand equation.

As mentioned in section 1.2, the x_{it} matrices include all the exogeneous variables of the model (i.e., socio-demographic variables, participation in the

[40] Looking at studies that have modelled expenditures in the FES (e.g., Atkinson and Stern, 1980; Atkinson, Gomulka and Stern, 1988; Deaton and Irish, 1984; Kay, Keen and Morris, 1984; Blundell and Meghir, 1987) and using other data sets (e.g., Meghir and Robin, 1992, García and Labeaga, 1993), it is important to notice that family composition and age variations may be important determinants of consumption. And following the approach by Blundell and Meghir (1987), we also enter education and labour market variables as variables that may influence the level of consumption and the degree of 'stocking-up' through current or future income expectations.

labour market dummies, time and/or quarter dummies). In the empirical exercise we account for the potential endogeneity of total expenditure (either by using lags and/or total income).

As explanatory variables we use the logarithm of total real expenditure (lrtexp) to account for the effect of income. We use quarterly prices for clothing. This variable is defined in terms of the logarithm of the relative price, i.e., the ratio of the price index of clothing to the price index of other goods (lpcloth). It is important to notice that the variability of this variable captures seasonal effects. In order to capture other possible seasonal and time effects we also introduce quarter and year dummies (q2, q3, q4 and d86, d87, d88, d89, d90, d91).

The rest of the variables included in our empirical specification are the following: family composition variables (n1, n2, n3, n4, na1, na2, no) which take into account the number of children, adults and elderly people in the household;[41] education of the head of the household (ed4, ed0); place of residence of the household (drura, dcity); age of the head of the household and wife (ag1, ag2); labour status of the head of the household and wife (dunem, demploy, dpensi, dwwife) and employment category of the head of the household (bcollar, wcollar, unskill, highrank). The descriptive statistics of these variables, for both the whole sample and the sub-sample of consumers, and a glossary of variable definitions are provided in the appendix B.

1.3.2. Results and diagnostics.

The empirical applications that we report in this section (see table 1.2) refer to the three statistical models that have been presented in the previous section. The first column refers to the maximum likelihood estimates of the infrequency of purchase model using the whole sample as a cross-section. In the second column we report the estimates for the time aggregated model. Finally, the third and the fourth columns of the table present the results of the IPM using

[41] The family composition variables used in the selection equations are: D1, D2, D3, D4, DA1, DA2, Do, D2q and D2qq. In the data appendix there is a description of these variables.

panel data: in column 3 we have the estimates using Wooldridge's (1995) estimator and in column 4 we present the estimates obtained with the "all-pairs" estimator.[42] We also report price and income elasticities of clothing consumption for all the models estimated (see table 1.3).[43]

In the estimation of the IPM for cross-sectional data we replicate the approach of Blundell and Meghir (1987) for the demand of clothing. In the consumption equation, we observe that price increases contribute to an increase of the share of expenditure on adult clothing. Rises in income increase the share spent on adult clothing as well. A striking result is that age (both for the head of the household and his wife) does not seem to affect the share spent on adult clothing. This result seems to be counterintuitive. The presence of children in the family, as could be expected, has important effects on the share of adult clothing. The fact that the head of the household is unemployed does not seem to affect the share of clothing consumption, while if the wife is working or the head of the household is a blue collar worker the share spent on adult clothing increases. Looking at the locational variables, households living in rural areas have a bigger share spent on adult clothing, and the opposite seems to happen to households living in big cities. Regarding education, it may be expected that the higher the education level of the head of the household the lower the share spent on clothing. This seems to be confirmed by our results. To test for independence and heteroscedasticity we use the approach derived ins Blundell and Meghir (1987). We use the score test following the methodology developed by Gourieroux, Monfort, Renault and Trognon (1987). Computation of the score test statistic in our empirical illustration follows Chesher's HR^2 formulation (1983). The independence and heteroscedastic tests give quite acceptable results (see bottom of table 1.2). As a summary, the overall properties of this model of consumption

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[42] In both panel data estimators we implement a GMM estimator (using the method developed by Arellano and Bond, 1991) to account for the endogeneity of total expenditure.

[43] In order to save some space, the frequency of purchase estimates for both the cross-section specification and for the panel data estimates (using probit and biprobit specifications) are not reported in this chapter although they are available from the author upon request.

are quite reasonable. The standard errors reported in column 1 of table 1.2 have been calculated using the asymptotic variance developed in the appendix.

We turn now to the estimates of the frequency of purchase equation.[44] The frequency of purchase probability estimates have plausible properties although the model is overparameterised. Income influences positively the probability of purchase, and educational variables, family composition variables and locational variables seem to have effects in the right direction. The age of the head of the household and the age of his wife have opposite effects, the older the wife the less is the probability of purchase. We have estimated this model under the assumption of independence and normality of the disturbance term. We test for normality of the error in the binary censor for the frequency of purchase model. The result we get from this test is that we can not reject the H_0 of normality.[45]

The second step in our empirical application is the estimation of the time aggregated model (column 2 of table 1.2).[46] The aim of estimating this model is to compare it with the IPM estimated using cross-sectional data. To do this we use a variation of the Hausman test (see Mroz, 1987). Assuming strict exogeneity all over, the null hypothesis of the test is that the IPM is the true model (as we use probabilities of purchase in the IPM, the estimates are more efficient), while the time aggregated model is consistent. The result of the test is $\chi^2_{(17)}$ = 114.18, and therefore we reject the null hypothesis. This could imply that the assumption of strict exogeneity is not appropriate or that the IPM specification is not the correct one.[47]

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[44] We have modelled the purchase probability equation using quarter and year dummies, income, labour status of the head of the household and his wife, education level of the husband, place of residence of the family, age and age squared of both the head of the household and his wife, property status of the house and a set of family composition dummies.

[45] The normality test is based on the Bera and Jarque (1982) methodology which can be regarded as components of White's Information Matrix test (White, 1982b).

[46] This estimator is robust to any frequency of purchase model given that, after time aggregation over individuals, practically all zeros disappear from the sample (see table 1.1); therefore there is no need to specify the purchase probability model.

[47] It seems that it is the assumption of strict exogeneity which is leading us to reject H_0, as for some variables, e.g. log real expenditure, it is hard to assume that are exogeneous.

The third step in our analysis is the estimation of the IPM with panel data (column 3 and 4 of table 1.2). We have estimated the IPM with panel data using two estimators: Wooldridge's (1995) estimator and the "all-pairs" estimator. An important issue when using panel data is that we control for individual heterogeneity and we include price variation across time, allowing to estimate elasticities more reliably.

In the estimation of the demand equation with panel data using Wooldridge's (1995) we previously estimate the frequency of purchase equation (the selectivity equation) for each period t using a probit model in order to estimate both the selection correction terms (Mills ratios) and the frequency of purchase probabilities, respectively. To estimate the probit model for the frequency of purchase equation we have used only those variables which could reasonably be considered strictly exogenous (see footnote 42).[48] As a second step we estimate the demand for clothing equation. To account for the potential endogeneity of log real expenditure we use an IV estimator including as instruments both log real total income and/or lags of log real total expenditure. We also include year dummies in the instrument set. Overall the results we get are quite plausible and are in line with the predictions of the economic theory.

With these results we have tested both for the exogeneity of the fixed effects and for the importance of the selection. The result of these tests are $\chi^2_{(153)} = 367.2$ and $\chi^2_{(8)} = 354.4$, respectively, suggesting that it is crucial to control for unobserved individual heterogeneity and for selection.[49] Finally, we have also analysed the efficiency gains that one obtains comparing the estimates of this model to the ones obtained after regressing y_{it} on z_i in the lines presented in the previous section. The prediction is that this last estimator is still consistent although the Wooldridge's (1995) estimator should be more efficient as it uses

[48] We do not report the results of the estimation of the selection equation in order to save some space, although these are available upon request.

[49] We have also tested for the existence of individual effects by comparing the estimates of the time aggregated model and the estimates using Wooldridge's (1995) estimator. The result of this test is $\chi^2_{20)} = 76.62$ and therefore we reject the H_0.

more structure. Indeed, this estimator is more efficient being the efficiency gain around a 10% on average.

The second panel data estimator is the "all-pairs" estimator. In a first step we estimate 28 bivariate probits (one for each possible pair combination).[50] Using the bivariate probit estimates we construct the selection correction terms and the probabilities of purchase in order to estimate the demand equation in a second stage.[51] In the estimation of this equation as we take first differences to get rid of the individual effects, we have dropped all those regressors which do not change very much over time (i.e., educational variables[52], place of residence), and only those variables that change over time remain in our estimation (prices, number of children, labour status of the husband and wife, log real expenditure, quarter dummies). As before, we account for the potential endogeneity of log real total expenditure by using an IV estimator; the instrument set is composed by log real total income and/or lags of log real total expenditure.

A further step in our analysis is to compare the IPM with panel data estimates with the IPM with cross sectional data estimates using the test developed in the previous section. The result we get from this test is $\chi^2_{(24)} = 1{,}317.82$, and therefore we clearly reject the null hypothesis, suggesting that there are fixed effects which have to be taken into account in the estimation of these models, or, in other words, we reject the IPM estimated with cross-sectional data against the IPM estimated with panel data.[53]

Finally, in table 1.3 we report the estimated values of income and price elasticities together with their standard values, for all models estimated. The

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[50] In each biprobit model we use as starting values the estimates of two probits (one for D_{it} and one for D_{is}). The correlation coefficient of the two error terms in the selection equations ρ_{ts} is on average equal to 0.889. We have also tested for the independence between the two probits, i.e., H_0: $\rho_{ts}=0$ using the LM statistic derived by Kiefer (1982). In all cases we reject H_0, suggesting the estimation of the two selection rules by a bivariate probit.

[51] Separate selection rules are estimated for the frequency of purchase equation in both t and s for each individual since, as argued by Poirier (1980), combining two selection rules into one will produce a hybrid model and inconsistent parameter estimates.

[52] The education variables refer to the head of the household past education, therefore there is not much change in these variables.

[53] The result of the test does not vary significantly if we use the "all-pairs" estimator instead of Wooldridge's (1995) estimator.

income elasticities we get seem quite reasonable (and always significant) although it seems that the estimate from the IPM with cross-sectional data is the most precise (the lowest standard error). In the case of the price elasticities all the estimates are negative (as predicted by the economic theory) although we have a different range of estimates. For the case of the time aggregated model the result does not seem to be correct (-2.37).

1.4. Conclusions.

This chapter discusses several classes of bivariate limited dependent models which may be used as alternatives to the Tobit model in the analysis of household consumption behaviour for goods that present some infrequency in their purchase. The IPM provides a separate family of alternative models where zero values occur due to "durability" of a commodity for which the expenditure observations are drawn. Most of the empirical applications of these models have used cross-sectional data although it is crucial to control for individual heterogeneity and price variation in this context. In our application we propose a panel data model which takes into account these questions. We estimate this panel data model using two alternative panel data estimators.

We have estimated these models using a panel of households drawn from the Spanish ECPF for the period 1985 to 1991. Our main concern is to compare the estimation results when estimating infrequency of purchase models using cross-sectional data and panel data and we also carry out some diagnostic tests. We develop an IPM for panel data and a time averaged model which, under some restrictions, is robust to any specification of the infrequency of purchase equation. We also test these models against the cross-section model in our empirical application. We have also tested for the exogeneity of the fixed effects and the results we get seem to be in the direction that it is important to account for unobserved individual effects.

1.5. Appendix A: Asymtotic variances.

1.5.1. The asymptotic variance of the IPM estimator with IV.

We represent the demand equation by the regression function:

(1.A.1) $y(\theta)_i = x_i\beta + u_i$ i=1,...,N.

where we denote the parameter vector of the frequency of purchase equation by θ, and

(1.A.2) $y(\theta)_i = y_i\Phi(z_i\theta)$

where y_i is the share of adult clothing expenditure over total expenditure of the household and $\Phi(z_i\theta)$ is the probability of purchase. To compute the asymptotic standard errors we need the derivatives of $y(\theta)_i$ with respect to θ

(1.A.3) $\frac{\partial y(\theta)}{\partial \theta_k} = y_i\phi(z_i\theta)z_{ik}$

The estimator of θ (the Probit estimate) has an asymptotic covariance matrix V_θ. The error term of the model, when we condition on consistent parameter estimates $\hat{\theta}$, can be approximated to the first order by

(1.A.4) $u_i^* = u_i - (\partial\, y(\theta)/\partial\theta)(\hat{\theta}-\theta) \equiv u_i - Q_i'\,(\hat{\theta}-\theta)$

hence $E(u^*(u^*)') = \Sigma + QV_\theta Q'$.[a1] Then we have[a2]

(A.5)
$$\begin{aligned}(\hat{\beta}-\beta) &= \left(\sum_{i=1}^{N} D_i x_i m_i'\right)^{-1} \sum_{i=1}^{N} D_i m_i u_i^* \\ &\overset{D}{=} \left(\sum_{i=1}^{N} D_i x_i m_i'\right)^{-1} \sum_{i=1}^{N} D_i m_i \left[u_i + Q_i'\,(\hat{\theta}-\theta)\right]\end{aligned}$$

where the (1xM) vector m_i is the vector of instrumental variables for individual i, D_i is an indicator function that take value 1 if the individual has a positive

[a1] In general there should exist a correlation between u_i and Q_i in expression (1.A.4). However, since the right IPM is the one given in equation (1.4) of section 1.2, it follows that the correlation between the error term from the second stage and the error term from the first stage is equal to 0 and therefore the relation is 0.

[a2] The expression $A \overset{D}{=} B$ means that A has the same asymptotic distribution as B.

purchase and zero otherwise. Then the asymptotic covariance matrix of β, ignoring covariance terms (Lee, Maddala and Trost, 1980, p. 500), yields,

(1.A.6)

$$A\operatorname{var}(\beta)=\left(\sum_{i=1}^{N}D_i x_i m_i'\right)^{-1}\sum_{i=1}^{N}D_i m_i\left[\operatorname{var}(u_i)+Q_i'\operatorname{var}(\hat{\theta})Q_i\right]\sum_{i=1}^{N}D_i m_i'\left(\sum_{i=1}^{N}D_i x_i m_i'\right)^{-1}$$

$$=\left(\sum_{i=1}^{N}D_i x_i m_i'\right)^{-1}\left(\sum_{i=1}^{N}D_i\operatorname{var}(u_i)m_i m_i'+\sum_{i=1}^{N}D_i m_i\left(Q_i'\operatorname{var}(\hat{\theta})Q_i\right)\sum_{i=1}^{N}D_i m_i'\right)\left(\sum_{i=1}^{N}D_i x_i m_i'\right)^{-1}$$

$$=\left(\sum_{i=1}^{N}D_i x_i m_i'\right)^{-1}\left(B_1+B_2\operatorname{var}(\hat{\theta})B_2'\right)\left(\sum_{i=1}^{N}D_i x_i m_i'\right)^{-1}$$

where $B_1=\sum_{i=1}^{N}D_i\sigma^2 m_i m_i'$ and $B_2=\sum_{i=1}^{N}D_i m_i Q_i'$. In the case at hand, we take u_i^2 as σ^2, where σ^2 is the variance we have estimated from the IPM with cross-sectional data (that is a Tobit model modified by the fact that we multiply the dependent variable by a an estimated probability). And V_θ is the asymptotic covariance matrix of θ. The asymptotic variance of θ is as follows

$$\text{(1.A.7) } V_\theta=\left[\sum_{i=1}^{N}\frac{[\phi(\theta' z_i)]^2}{\Phi(\theta' z_i)[1-\Phi(\theta' z_i)]}z_i z_i'\right]^{-1}$$

that is the inverse of the information matrix from the probit model, Amemiya (1981).

1.5.2. The asymptotic variance of the IPM with panel data estimator.

To calculate the correct variance-covariance matrix of the parameter estimates we have to take into account that we have estimated in a first step both the selection terms and the probabilities of purchase.[a3] We write the residual of the equation we estimate as follows,

$$\text{(1.A.8) } \Delta e_{it}=\Delta\varepsilon_{it}+\gamma_1(\lambda_1-\hat{\lambda}_1)+\gamma_2(\lambda_2-\hat{\lambda}_2)-\left(\Delta\Phi(\delta)y_{it}-\Delta\Phi(\hat{\delta})y_{it}\right)$$

[a3] We can use, following Ham (1982), a generalisation of Lee, Maddala and Trost (1980). We also follow the approach developed by Wooldridge (1995).

Let $\hat{\theta}$ now denote the GMM estimator from the regression on the selected sample, but where $\Delta\hat{w}_{it} = \Delta w_{it}(\hat{\delta})$ is used in place of $\Delta\hat{w}_{it}$. It can be shown, following Wooldridge (1995) that

$$(1.A.9)\ \sqrt{N}(\hat{\theta} - \theta) \overset{d}{\rightarrow} Normal(0, A^{-1}BA^{-1})$$

where

$$(1.A.10) \qquad A \equiv E\left(\sum_{t=1}^{T} D_{it} D_{is} \Delta w_{it} P_{\Sigma} \Delta w_{it}' \right)$$

where D_{it} and D_{is} are two indicators functions that take value 1 if the individual has a positive expenditure on adult clothing and 0 otherwise. Also,

$$(1.A.11) \qquad P_{\Sigma} = m_{it}'(m_{it} e_{it}^2 m_{it}')^{-1} m_{it}$$

where m_{it} is the Mx1 vector of instrumental variables for individual i in period t, and e_{it} is the residual from the second step GMM regression. And

$$(1.A.12) \qquad B \equiv Var(p_i) = E(p_i p_i')$$

the Gx1 vector p_i is defined as $p_i = q_i - D_1 r_i + D_2 s_i$, where, as in Wooldridge (1995), for each t $\hat{r}_{it} = \hat{r}_{it}(\hat{\delta}_1)$ is the (2+2Q)x1 vector equal to minus the inverse of the average estimated Hessian times the estimated score of the bivariate probit log-likelihood function for observation i, and analogously, $\hat{s}_{it} = \hat{s}_{it}(\hat{\delta}_2)$ is the (1+Q)x1 vector equal to minus the inverse of the average estimated Hessian times the estimated score of the univariate probit log-likelihood function for observation i. From the above expression, $q_i \equiv \sum_{t=1}^{T} D_{it} D_{it-1} \Delta w_{it} P_{\Sigma} e_{it}$ is a Gx1 vector, D_1 is a GxT(2+2Q) matrix and D_2 is a GxT(1+Q) matrix. To estimate $\text{Avar}(\hat{\theta}) \equiv A^{-1}BA^{-1}/N$, first define

$$(1.A.13) \qquad \hat{A} \equiv N^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} D_{it} D_{is} \Delta w_{it} P_{\Sigma} \Delta w_{it}'$$

$$(1.A.14) \qquad \hat{D}_1 \equiv N^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} D_{it} D_{is} \Delta w_{it} P_{\Sigma} \hat{\theta}' \nabla_{\delta} \Delta w(\hat{\delta}_1)$$

$$(1.A.15) \qquad \hat{D}_2 \equiv N^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} D_{it} D_{is} \Delta w_{it} P_{\Sigma} \nabla_{\delta} \Phi(\hat{\delta}_2) y_{it}$$

where $\nabla_\delta \Delta w(\hat{\delta}_1)$ and $\nabla_\delta \Phi(\hat{\delta}_2) y_{it}$ are the GxT(2+2Q) and 1xT(1+Q) gradients of $\Delta w(\delta_1)$ and $\Phi(\delta_2) y_{it}$ evaluated at $\hat{\delta}_1$ and $\hat{\delta}_2$, respectively. Let $\hat{e}_{it} = \Phi(\hat{\delta}) y_{it} - \Delta \hat{w}_{it}(\hat{\delta})$ be the residuals from the second step GMM regression for all i and t such that $D_{it} = 1$ and $D_{is} = 1$. Then for each i=1,...,N define $\hat{q}_i \equiv \sum_{t=1}^{T} D_{it} D_{is} \Delta w_{it} P_\Sigma \hat{e}_{it}$ and $\hat{p}_i = q_i - \hat{D}_1 \hat{r}_i + \hat{D}_2 \hat{s}_i$.

A consistent estimator of B is then $\hat{B} \equiv N^{-1} \sum_{i=1}^{N} \hat{p}_i \hat{p}_i'$. The asymptotic variance of $\hat{\theta}$ is estimated as $\text{Avar}(\hat{\theta}) \equiv \hat{A}^{-1} \hat{B} \hat{A}^{-1} / N$, and the asymptotic standard errors are obtained as the square root of the diagonal elements of this matrix.

1.6. Appendix B: The data.

The data used in this study is a sample of 12,400 observations (1550 households during eight periods), from the Spanish ECPF. Means, standard deviations and a glossary of definitions of the variables are presented in the following tables.

1.6.1. Glossary of variable definitions.

Age:

ag1: age of the head of the household,

ag2: age of the wife.

Household composition:

n1: number of children ≤4 years of age,

n2: number of children >4 and ≤8,

n3: number of children >8 and ≤13,

n4: number of children >13 and ≤17,

na1: number of adults ≥18 and ≤24,

na1: number of adults >24 and ≤64,

no: number of elderly people >64.

Education of the head of the household:

ed0: illiterate or no educational background,

ed1: primary education,

ed2: secondary education,

ed3: pre-university studies,

ed4: university studies.

Size of town of residence:

drura: family is living in a town of less than 10,000 inhabitants,

dcity: family is living in a town of more than 500,000 inhabitants.

Educational dummies:

dana: head of the household is illiterate or has no educational background,

duni: head of the household has a university degree.

Labour status:

demploy: head of the household is working (full-time or part-time),

dunem: head of the household is unemployed,

dpensi: head of the household is a pensioner,

dwwife: wife is working.

Occupational dummies:

bcollar: head of the household is a blue collar worker,

wcollar: head of the household is a white collar worker,

unskill: head of the household is a unskilled worker,

highrank: head of the household is in a high rank job.

Property regime of the house of the household:

drent: house where the household lives is rented,

dseh: the household owns the house.

Quarter dummies:

q1: quarter 1,

q2: quarter 2,

q3: quarter 3,

q4: quarter 4.

Year dummies:

d85: year 1985,

d86: year 1986,

d87: year 1987,

q88: year 1988,

d89: year 1989,

d90: year 1990,

d91: year 1991.

Total expenditure:

lrtexp: logarithm of total real expenditure.

Price:

lpcloth: logarithm of real price of clothing (deflated by index price of "other non-durables goods").

Family composition dummies:

D1: =1 if n1>0, =0 otherwise,

D2: =1 if n2>0 and n2=0, =0 otherwise,

D3: =1 if n3>0 and n1=n2=0, =0 otherwise,

D4: =1 if n4>0 and n1=n2=n3=0, =0 otherwise,

DA1: =1 if na1>0, =0 otherwise,

DA2: =1 if na2>0 and na1=0, =0 otherwise,

Do: =1 if no>0, =0 otherwise,

D2q: =1 if D2 or D3 =1, =0 otherwise,

D2qq: =1 if D1 or D2 or D3 =1, =0 otherwise.

1.6.2. Descriptive statistics.

Table 1.A.1.
Descriptive statistics.

	All observations		Positive Observations	
Variable	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**
Share adult clothing	0.086	0.090	0.104	0.089
ag1	46.244	11.131	46.787	10.976
ag2	43.469	11.366	43.959	11.192
n1	0.259	0.529	0.238	0.513
n2	0.261	0.516	0.232	0.488
n3	0.437	0.672	0.416	0.656
n4	0.256	0.501	0.277	0.516
na1	0.374	0.648	0.403	0.666
na2	2.043	0.544	2.054	0.543
no	0.146	0.407	0.151	0.413
lpcloth	0.073	0.015	0.073	0.015
drura	0.319	0.466	0.324	0.468
dcity	0.066	0.248	0.063	0.242
ed0	0.231	0.421	0.238	0.426
ed1	0.035	0.183	0.034	0.182
drent	0.127	0.333	0.123	0.329
dseh	0.085	0.279	0.090	0.286
demploy	0.789	0.408	0.790	0.407
dunem	0.065	0.246	0.061	0.240
dpensi	0.143	0.350	0.145	0.352
dwwife	0.194	0.396	0.197	0.397
bcollar	0.035	0.184	0.038	0.192
wcollar	0.393	0.488	0.389	0.487
unskill	0.118	0.323	0.116	0.320
highrank	0.023	0.151	0.024	0.152
lrtexp	12.829	0.486	12.876	0.473
lrtinc	12.814	0.486	12.830	0.483

1.7. Appendix C: Tables.

Table 1.1.

Proportion of zeros on adult clothing expenditure.

	Quarter							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Number and proportion of zeros in each quarter (whole sample)	1536 (19%)	1531 (17.6%)	1537 (17,5%)	1575 (17,9%)	1272 (18,3%)	940 (18,2%)	690 (18,5%)	420 (17,6%)
Number and proportion of zeros remaining after each quarter (whole sample)	1536 (19%)	496 (5.7%)	209 (2.38%)	106 (1.2%)	58 (0.83%)	23 (0.44%)	12 (0.32%)	6 (0.25%)
Number and proportion of zeros in each quarter (panel)	264 (17%)	240 (15.5%)	234 (15.1%)	260 (16.8%)	263 (17.0%)	250 (16.1%)	283 (18.2%)	262 (17.0%)
Number and proportion of zeros remaining after each quarter (panel)	264 (17%)	65 (4.19%)	21 (1.35%)	8 (0.52%)	5 (0.32%)	2 (0.13%)	1 (0.06%)	0 (0.0%)

Notes:

1. ECPF, 1985.1 to 1991.4.
2. Whole sample: the number of observations is 53,091 and the number of zeros is 9,600. Therefore, the proportion of zeros is 18.1%.
3. Panel sample: the number of observations is 12,400 (1,550*8) and the number of zeros is 2,056. Therefore, the proportion of zeros is 16.58%.

Table 1.2.

Demand estimates for the Infrequency of Purchase Model.

	Method of estimation							
Variable	IPM with cross-sectional data[(1)]		Time aggregated model[(2)]		Wooldridge estimator[(3)]		All pairs panel data estimator[(4)]	
Intercept	-0.5087	(0.0069)	-		-0.0980	(0.0451)	-	
ag1	0.0001	(0.0001)	0.0002	(0.0004)	-0.0006	(0.0022)	-0.0004	(0.0010)
ag2	0.0002	(0.0041)	0.0001	(0.0003)	0.0026	(0.0023)	0.0002	(0.0010)
n1	-0.0125	(0.0017)	-0.0116	(0.0025)	-0.0077	(0.0044)	-0.0061	(0.0018)
n2	-0.0187	(0.0013)	-0.0179	(0.0023)	-0.0103	(0.0044)	-0.0080	(0.0017)
n3	-0.0198	(0.0015)	-0.0181	(0.0017)	-0.0145	(0.0034)	-0.0111	(0.0013)
n4	0.0062	(0.0016)	0.0097	(0.0025)	-0.0022	(0.0033)	-0.0007	(0.0012)
na1	-0.0226	(0.0123)	0.0007	(0.0023)	-0.0019	(0.0033)	-0.0018	(0.0013)
na2	-0.1111	(0.0159)	-0.0085	(0.0029)	-0.0025	(0.0050)	-0.0033	(0.0019)
lpcloth	0.0459	(0.0145)	-0.1371	(0.0701)	0.0272	(0.0127)	0.0436	(0.0091)
drura	0.0088	(0.0018)	0.0063	(0.0026)	0.0052	(0.0019)	-	
dcity	-0.0148	(0.0034)	-0.0170	(0.0041)	-0.0128	(0.0030)	-	
ed0	0.0091	(0.0021)	0.0063	(0.0034)	-0.0039	(0.0055)		
drent	0.0133	(0.0025)	0.0101	(0.0038)	0.0097	(0.0174)	-	
dunem	-0.0033	(0.0035)	-0.0008	(0.0064)	-0.0082	(0.0035)	-0.0044	(0.0025)
dwwife	0.0039	(0.0021)	0.0049	(0.0032)	0.0049	(0.0020)	-0.0022	(0.0016)
bcollar	0.0135	(0.0043)	0.0136	(0.0075)	-0.0073	(0.0090)	-0.0005	(0.0037)
wcollar	-0.0024	(0.0020)	-		-0.0110	(0.0050)	-0.0077	(0.0022)
unskill	0.0032	(0.0028)	-		-0.0015	(0.0056)	-0.0013	(0.0023)
highrank	-0.0084	(0.0055)	-		-0.0332	(0.0035)	-0.0251	(0.0056)
lrtexp	0.0479	(0.0053)	0.0317	(0.0035)	0.0182	(0.0035)	0.0451	(0.0137)
q2	-0.0122	(0.0021)	-		-0.0092	(0.0021)	-0.0077	(0.0008)
q3	-0.0176	(0.0021)	-		-0.0119	(0.0025)	-0.0095	(0.0008)
q4	-0.0087	(0.0024)	-		-0.0029	(0.0025)	-0.0033	(0.0014)
d86	0.0176	(0.0083)	-		-		-	
d87	0.0151	(0.0036)	-		-		-	
d88	0.0101	(0.0034)	-		-		-	
d89	0.0078	(0.0034)	-		-		-	
d90	0.0053	(0.0035)	-		-		-	
sigma	0.0765	(0.0005)	-		-		-	
N	12,400		1,550		10,041		30,273	
Log-likelihood	-1.6797		-		-		-	

Notes:

1. Dependent variable: share of adult clothing times the probability of purchase. Test for independence $\chi_{(1)}$=2.749. Test for heteroscedasticity of the errors $\chi_{(6)}$=12.233.
2. Dependent variable: time averaged share of adult clothing. Estimates obtained using the between-groups estimator.
3. Dependent variable: share of adult clothing times the probability of purchase. Estimates using the Wooldridge (1995) estimator. GMM estimates.
4. Dependent variable: share of adult clothing times the probability of purchase. Estimates using all possible pairs differences (i.e., taking differences when D_{it}>0and D_{is}>0 for $t \neq s$). GMM estimates.
5. Asymptotic standard errors in parenthesis.

Table 1.3.

Price and income elasticities.

	Elasticity	
Model	**Price elasticity**	**Income elasticity**
IPM with cross-section data	-0.55 (0.13)	1.46 (0.018)
Time Aggregated Model	-2.37 (0.70)	1.37 (0.037)
IPM with Wooldridge estimator	-0.73 (0.13)	1.18 (0.035)
IPM with all pairs estimator	-0.57 (0.09)	1.45 (0.136)

Notes:
1. Standard errors in parenthesis.

Chapter 2

Children and demand patterns: evidence from Spanish panel data.

2.1. Introduction.

The arrival of children in a household is widely recognised to affect consumption of different goods in different ways. Consumption of certain sorts of goods such as child clothing and food are likely to increase while other goods such as adult clothing or alcohol may be little affected. Deaton, Ruiz-Castillo and Thomas (1989) focus attention on goods of the latter type, introducing the notion of certain goods being "demographically separable" from children. Of course, the presence of children does not remove a household's budget constraint and responses to demographic changes of this sort are almost certain to have income effects even on these sorts of goods, but the idea of demographic separability is that for these goods this may be the only effect. The notion of adult goods figures also in the literature on child costs, particularly in the way it stands behind the Rothbarth (1943) method. Under a specific interpretation of the Rothbarth method,[54] it is a special case of demographic separability (see Blackorby and

[54] The method suggested by Rothbarth (1943) assumes that households spending the same on adult goods can be taken to share a common welfare level whatever their demographic

Donaldson, 1995). Although the method relies in part upon assumptions which are fundamentally untestable using demand data, it is true that testing for demographic separability would be the same as testing for an implication of the Rothbarth method for preferences. A similar point has been stressed by Pollak and Wales (1979).

Deaton, Ruiz-Castillo and Thomas (1989) apply this idea to a cross-section of Spanish budget data, identifying a set of putative adult goods and testing the hypothesis of demographic separability. In this chapter we extend the empirical analysis to panel data. This allows us to address a number of issues. Firstly, there is the issue of infrequency of purchase. For many of the goods considered, a substantial percentage of households record no purchases in individual periods and there is no straightforward interpretation of the regression estimation in terms of preferences if we do not take account of zero record purchases. Secondly, when dealing with microdata it seems crucial to account for unobserved individual heterogeneity and panel data allows us to do this. Thirdly, it is also possible to incorporate price variation into the estimation, improving the potential to distinguish between different types of demographic separability with very different welfare implications.

In this chapter, we attempt to overcome the problems outlined above. Since we use a (balanced) panel data set of households drawn from the Spanish Panel of Family Expenditure Survey (referred to as ECPF from now on) for the period 1986-94, we can incorporate price variation and control for unobserved heterogeneity. Moreover, the structure of the data allows us to deal with the problems of zero records. To deal with the problem of infrequency, we use a three-point strategy. First, we change the classification of goods in the sense that some of them are joined into broader subgroups. This is so because it is not possible to deal with zeros generated under different interpretations while estimating a demand system with a great number of groups (Lee and Pitt, 1986, and Wales and Woodland, 1986). As an advantage, this leads to a reduction in the number of zeros in several groups. Second, to deal with the sample selection

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characteristics.

problem implied by dropping non-participants in some commodities (e.g. *tobacco*) we will estimate the model using conditional estimation techniques (see Baker, Mackay and Symons, 1991, and Browning and Meghir, 1991). Third, to check and reduce the incidence of infrequency in some of the goods we will aggregate the data using fifth order moving averages.

The results suggest that both the unobserved heterogeneity and the presence of zero records due to infrequency matter in the estimation. Therefore, any calculation, e.g. elasticities or equivalence scales, based on cross-sectional estimates may suffer from biases arising from these problems. We find that the obtained equivalence scales using cross-sectional data seem to underestimate the true values. If unobserved heterogeneity is correlated with fertility decisions, for instance, the coefficients of the children variables could be downward biased when fixed effects are not taken into account. Moreover, it is worth mentioning that when controlling for individual heterogeneity we do not reject the restrictions of symmetry and homogeneity in the estimation of the demand system.

The rest of the chapter contains four sections. In Section 2.2 we present the economic model and the concepts of demographic separability. In section 2.3 we report the demand system, the econometric treatment, and describe the data and the way in which we deal with the zeros and commodity grouping. Section 2.4 is devoted to discussion of the results. Section 2.5 concludes.

2.2. Demographic separability.

To begin with we need to draw a distinction between adult goods and other goods. Suppose therefore that a consumer has preferences captured in a utility function $u(\boldsymbol{q},z)$ where $\boldsymbol{q}=(\boldsymbol{q}_1,\boldsymbol{q}_2)$ are goods, separated into adult goods $\boldsymbol{q}_1$ and other goods $\boldsymbol{q}_2$ and $z=(z_1,z_2)$ denotes a vector of demographic characteristics, separated into child characteristics z_1 and other characteristics z_2. Denote total household size by n. Prices are $\boldsymbol{p}=(\boldsymbol{p}_1,\boldsymbol{p}_2)$ partitioned similarly to goods and total expenditure is x.

The adult goods are said to be demographically separable from child characteristics z_1 if uncompensated demands take the form

$$(2.1) \quad q_1(x,p,z) = f_1(\theta(x,p,z),p,z_2)$$

where $\theta(x,p,z)$ is a scalar function. If there is more than one adult good then this has the empirically testable implication that income effects and demographic effects are proportional within the group of adult goods

$$(2.2) \quad \frac{\partial q_1(x,p,z)}{\partial z_1'} = \frac{\partial q_1(x,p,z)}{\partial x}\psi(x,p,z)'$$

where $\psi(x,p,z) \equiv \dfrac{\partial\theta(x,p,z)/\partial z_1}{\partial\theta(x,p,z)/\partial x}$ is the vector of common ratios. Note that the factors of proportionality depend on the demographic characteristic concerned but not on the adult good in question. Deaton, Ruiz-Castillo and Thomas (1989) choose to divide these ratios by expenditure per head x/n so as to express demographic influences in the notion of the "outlay equivalent ratios"

$$(2.3) \quad \pi(x,p,z) \equiv \frac{n}{x}\psi(x,p,z)$$

"the amount of additional outlay that would have been necessary to produce the same effect on demand, that additional outlay expressed as a fraction of total household expenditure per household member (p.189)."

Blackorby and Donaldson (1994) establish corresponding necessary and sufficient conditions on the expenditure function $c(u,p,z)$. Either

$$(2.4) \quad c(u,p,z) = A(u,p,z_2) + B(u,p_2,z)$$

or

$$(2.5) \quad c(u,p,z) = \min_{\xi}\{C(\xi,p,z_2) + D(\xi,u,p_2,z)\}$$

for appropriate functions $A(.)$, $B(.)$, $C(.)$ and $D(.)$.

In the first case, (2.4),

$$(2.6) \quad q_1(x,\boldsymbol{p},z) = \frac{\partial}{\partial \boldsymbol{p}_1} A(v(x,\boldsymbol{p},z),\boldsymbol{p},z_2)$$

where $v(\cdot)$ is the indirect utility function and demographic separability holds with $\theta(x,\boldsymbol{p},z) = v(x,\boldsymbol{p},z)$. This is the case referred to by Deaton, Ruiz-Castillo and Thomas (1989) as cost separability and deserves special consideration for its welfare measurement implications. It is clear, in such a case, that any adult good can be taken as an indicator of welfare given $\boldsymbol{p}$ but independently of z_1. This would legitimate the method proposed by Rothbarth (1943) for the evaluation of child costs - the costs of children would be indicated accurately by the difference in total spending between households with and without children but spending the same on any adult goods[55]. If we could establish not only that (2.1) held but also that this was a consequence of (2.6) then measurement of child costs would follow as a natural corollary of demand estimation since effects of children on demands for the adult goods would arise only through their effect on welfare.

However in the second case, (2.5),

$$(2.7) \quad q_1(x,\boldsymbol{p},z) = \frac{\partial}{\partial \boldsymbol{p}_1} C(\xi^*(v(x,\boldsymbol{p},z),\boldsymbol{p},z),\boldsymbol{p},z_2)$$

where $\xi^*(.)$ is the value of ξ solving the minimization in (2.5), demographic separability holds with $\theta(x,\boldsymbol{p},z) = \xi^*(v(x,\boldsymbol{p},z),\boldsymbol{p},z)$. The Rothbarth (1943) method is no longer justified since households spending the same on adult goods, given $\boldsymbol{p}$, are only at like ξ^* and not necessarily at like utility. Testing for demographic separability therefore tests only an implication of the Rothbarth requirements and cannot alone legitimate the use of the Rothbarth method.

To an extent the distinction between (2.4) and (2.5) is fundamentally untestable using simply consumer demand data. Consider, for instance,

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[55] Blackorby and Donaldson (1994) point out that (2.4) is not the same as the necessary and sufficient condition for using spending on *all* adult goods $\boldsymbol{p}_1\boldsymbol{q}_1$ as an indicator of welfare. For that to hold one could allow $B(.)$ also to depend on $\boldsymbol{p}_1$ provided that it were homogeneous of degree zero in those prices. If however we wish spending on *any* set of adult goods to serve the purpose then (2.4) clearly is what is required.

preferences corresponding to an expenditure function of the form

$$(2.8)\quad c(u,\boldsymbol{p},z) = A(u-\phi(z_1),\boldsymbol{p},z_2) + B(u-\phi(z_1),\boldsymbol{p}_2,z)$$

where $\phi(z_1)$ is an arbitrary function. It is compatible with demographic separability, as is easily checked, but does not satisfy cost separability (and must therefore fall under (2.5)[56]). Indeed, since this corresponds to simply adding an amount $\phi(z_1)$ to the indirect utility function associated with (2.4), which can have no implications whatsoever for preferences *over goods*, it must therefore imply the same uncompensated demands. This sort of point, well known since Pollak and Wales (1979), shows that demand data cannot alone identify costs of children using the Rothbarth, or indeed any other, method.[57] Other sorts of preferences implying demographic separability may have testable implications. For example, as Deaton, Ruiz-Castillo and Thomas (1989) discuss, demographic separability may be driven by a special case of more conventional weak separability

$$(2.9)\quad u(\boldsymbol{q},z) = \Upsilon(\upsilon(\boldsymbol{q}_1,z_2),\boldsymbol{q}_2,z).$$

With preferences of this form there is two stage budgeting with child variables affecting only the top stage. Thus

$$(2.10)\quad \boldsymbol{q}_1(x,\boldsymbol{p},\mathbf{z}) = \boldsymbol{g}_1(x_1(x,\boldsymbol{p},z),\boldsymbol{p}_1,\mathbf{z}_2)$$

for some function $\boldsymbol{g}_1(.)$ where $x_1(.)$ is total spending on adult goods. This is demographically separable but with $\theta(x,\boldsymbol{p},z)$ equal to the observable x_1. Note however that this has empirically testable implications over and above demographic separability if we have price variation in the data since

$$(2.11)\quad \begin{aligned} \left.\frac{\partial}{\partial z_1}\boldsymbol{q}_1(x,\boldsymbol{p},z)\right|_{x_1,p_1,z_2} &= \mathbf{0} \\ \left.\frac{\partial}{\partial \boldsymbol{p}_2}\boldsymbol{q}_1(x,\boldsymbol{p},z)\right|_{x_1,p_1,z_2} &= \boldsymbol{0} \end{aligned}$$

[56] To see that they are compatible consider setting $D(\xi,u,p_2,z)= B(u-\phi(z_1),p_2,z)-E(\xi,u-\phi(z_1),z_2)$.

[57] Of course, other behaviour, such as fertility decisions, may contain the information needed but this is out of the scope of this chapter.

neither of which are implied by (2.1) alone.[58]

2.3. Empirical application.

2.3.1. The demand system.

We assume that household preferences are intertemporally separable, so that in each period t household h minimises the cost of reaching utility u_{ht} at prices $\boldsymbol{p}_t$. Following Banks, Blundell and Lewbel (1997), we use a within-period indirect utility function that reflects the need for quadratic Engel curves.[59] Formally, this indirect utility function takes the form

$$(2.12)\quad v_{ht}(x_{ht}, \boldsymbol{p}_{ht}, z_{ht}) = \left[b_{ht}/\ln(x_{ht}/a_{ht}) + d_{ht}\right]^{-1}$$

where $a_{ht} = a(\boldsymbol{p}_{ht}, z_{ht})$ is a linear homogeneous price index, and $b_{ht} = b(\boldsymbol{p}_{ht}, z_{ht})$ and $d_{ht} = d(\boldsymbol{p}_{ht}, z_{ht})$ are zero homogeneous in prices.[60] To derive the demand system we take the Almost Ideal parameterisation of Deaton and Muellbauer (1980) for a_{ht} and b_{ht}

$$(2.13)\quad \ln a_{ht} = \alpha_0 + \sum_{j=1}^{J} \alpha_j(\mathbf{z}_{ht}) \ln p_{jt} + \frac{1}{2}\sum_{j=1}^{I}\sum_{i=1}^{I} \gamma_{ij}^{*} \ln p_{it} \ln p_{jt}$$

$$(2.14)\quad \ln b_{ht} = \sum_{j=1}^{I} \beta_j \ln p_{jt}$$

and we define d_{ht} as

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[58] Although it would be interesting to test for these implications, this is not possible in this chapter as we use a different sort of preferences (no the ones implied by equation 2.9 above), and this is not the topic of the present chapter.

[59] As pointed out by Banks, Blundell and Lewbel (1997), this is in line with the growing body of empirical evidence. They also provide some graphical evidence about the need for quadratic Engel curves. Labeaga and López (1996, 1997) also give empirical evidence about the need for quadratic terms in two applications with Spanish data. The need for higher order Engel curves has been previously analyzed by Gorman (1981) and Lewbel (1989,1991), among others.

[60] The demographic characteristics in the a_{ht}, b_{ht} and d_{ht} functions reflect the possibility that demographic variables may shift preferences.

(2.15) $d_{ht} = \sum_{j}^{I} d_j \ln p_{jt}$

By Roy's identity we derive the Quadratic Almost Ideal Demand System (QUAIDS) budget shares, which can be expressed, after adding an error term ε_{iht}, as

(2.16)

$$w_{iht} = \alpha_i(z_{ht}) + \sum_{i=1}^{I} \gamma_{ij} \ln p_{jt} + \beta_i \ln(x_{ht}/a_{ht}) + \frac{d_i}{b_{ht}}(\ln(x_{ht}/a_{ht}))^2 + \varepsilon_{iht}$$

for good i and household h.[61]

The model does not have constant elasticities (see Banks, Blundell and Lewbel, 1997). If we differentiate the share equation (2.19) with respect to ln$x$ and to lnp_j, respectively, we have,

(2.17) $\mu_i \equiv \frac{\partial w_i}{\partial \ln x} = \beta_i + \frac{2d_i}{b(\boldsymbol{p},\boldsymbol{z})}\left[\ln\left(\frac{x}{a(\boldsymbol{p},\boldsymbol{z})}\right)\right]$

(2.18)

$$\mu_{ij} \equiv \frac{\partial w_i}{\partial \ln p_j} = \gamma_{ij} - \mu_i\left(\alpha_i + \sum_{k=1}^{I} \gamma_{kj} \ln p_k\right) - \frac{d_i \beta_i}{b(\boldsymbol{p},\boldsymbol{z})}\left[\ln\left(\frac{x}{a(\boldsymbol{p},\boldsymbol{z})}\right)\right]^2$$

and, hence, the budget elasticities are given by $e_i = \mu_i/w_i + 1$. The uncompensated price elasticities are given by $e_{ij}^u = (\mu_{ij}/w_i) - \delta_{ij}$ where δ_{ij} is the Kronecker delta. The compensated price elasticities, e_{ij}^c, are calculated using the Slutsky equation, $e_{ij}^c = e_{ij}^u + e_i w_j$.

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[61] There are some advantages of using this flexible specification. First, the preference function from which the QUAIDS is derived does not embody additive separability and permits flexible price responses. Second, a quadratic term in the logarithm of real expenditure allows elasticities to depend on the level of expenditure in a way such that the latter may determine whether commodities are luxuries or necessities.

2.3.2. Demographic separability.

Given the share equation (2.16), the outlay equivalent ratio π_{ir} for the r-th characteristic can be calculated as

$$(2.19)\quad \pi_{ir} = \frac{\left(\alpha_{ir} - \beta_i \sum_{i=1}^{n} \alpha_{ir} \ln p_i\right) n}{\beta_i + 2\frac{d_i}{b(p)} \ln\left(x/a(p,z)\right) + w_i}$$

for $r = 1,\dots,J$ demographic categories. To estimate the ratios we use the parameters estimated from the demand system and replace w_i, $\ln p_i$, $b(p)$, x and $a(p,z)$ by their values at the sample mean of the data.

In order to test for demographic separability, we closely follow Deaton, Ruiz-Castillo and Thomas (1989). For each element of a group of v supposedly demographically separable goods, we define a discrepancy

$$(2.20)\quad \Delta_{ir} \equiv \pi_{ir} - \sum_j \frac{\pi_{jr}}{v}$$

for $i = 1,\dots.,v$. We calculate estimates of the discrepancies and a χ^2 test for the hypothesis of demographic separability

$$(2.21)\quad \Delta_{ir} = 0 \quad i = 1,\dots,v$$

The procedures to derive the standard errors and the details of the test statistics can be found in Deaton, Ruiz-Castillo and Thomas (1989).

2.3.3. Data description and commodity grouping.

In surveys with short recording periods,[62] consumption and purchases may differ markedly and then there is a problem of fitting a model of consumption directly to data on purchases. Consequently, much of the variation in reported expenditures

[62] The recording period in the ECPF is a week for most of the goods (see Table 2.1).

may reflect stochastic elements in purchasing behaviour rather than differences on the underlying consumption. One of the major problems associated with the use of microdata surveys is the existence of zeros in the expenditure records of households. Reasons behind a zero report are diverse and very well known.[63] Firstly, the household might be maximising utility at zero consumption with its current disposable income and at current prices (*corner solution*); secondly, the household might not consume some commodities at any prices (*non-participation*); thirdly, no purchase might have been made during the monitoring period of the survey although the household is a regular consumer of the good (*infrequency of purchase*); and fourthly, purchase may be missreported for some reason.[64]

In general, the estimation method is different when dealing with different causes for the zeros. This is so because while infrequency generates an error in variables problem, non-participation or corner solutions do not. If infrequency is an issue then household expenditure may be an unreliable estimator of household consumption, with extreme values resulting from either the presence in or absence from current expenditure of infrequently purchased items. As a result, conventional estimators of Engel curve parameters based on expenditure data will generally be biased and inconsistent.[65]

We turn now to analyse to what extent we have a problem of zeros in our data set and the nature of them. In Table 2.1 we report four different descriptive statistics, for the 12 presumably adult commodity categories (those used by Deaton, Ruiz-Castillo and Thomas, 1989). In the first column, we present the number and proportion of zeros for the whole sample. In the second column, we report the number of zeros remaining after aggregating expenditure records over time (eight quarters) for each household. As we want to deal with two issues

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[63] Deaton and Irish (1984), Atkinson and Jenkins (1984) or Blundell and Meghir (1987) are examples of the description and treatment of zero expenditures in different goods.

[64] Missreporting is a serious concern only for comparatively few goods, Atkinson and Jenkins (1984). Preference variation (or non-participation) is likely to be especially important when dealing with relatively fine commodity classifications.

[65] See, for instance, Keen (1986), Meghir and Robin (1992) or Hausman, Newey and Powell (1995).

together - the zeros problem and the control for heterogeneity - we also present in column three the number and proportion of zeros when aggregating the data with a moving average of order five. The fourth column reports the empirical probabilities (number of positive purchases over the period that a household stays in the sample divided by eight). Comparing the first and second columns of Table 2.1, the main conclusion that can be drawn is that there is a massive drop in the number of zeros remaining in the sample for some goods after aggregating over the 8 periods per household (e.g., clothing, alcohol, health, personal care, transport, meals out and alcohol out). This suggests that a major cause behind most of the zero reports is infrequency of purchase, although non-participation might also play a role in some goods like transport and, especially, tobacco. The same conclusion applies when we compare columns 1 and 3.

As mentioned earlier, we have different sorts of causes behind a zero report that may be acting at the same time. On one hand, we have the problem of non-participation affecting certain goods. On the other hand we have an infrequency problem affecting some other goods, particularly clothing, alcohol and personal care.[66] In order to reduce or eliminate the impact of the zero reports we proceed as follows. Firstly, given the difficulties in estimating a whole demand system with different reasons for the zeros, we decide to use a new and broader classification of goods: we create a group (*other3*) which includes *other1*, *other2* and *adult education* (zero reports are now 19.5%); we join *alcohol out* and *meals out* in a group called *out* (the proportion of zeros is now 17.8%). Secondly, we choose not to model *health* as we doubt whether this is a good for which demand is comparable to the rest of goods we are modelling, purchases being driven largely by irregular bouts of illness rather than by a stable set of preferences between health and other goods. Finally, we are left with *tobacco* and *transport.* Comparing columns 1 and 2, *tobacco* is a good for which eight consecutive periods with zero records are interpreted to imply non-participation. The fall in the proportion of zeros overall for *transport* after aggregation, suggests that this

[66] We consider that eight consecutive zeros are interpreted as a non-participant household, which mainly affects goods like tobacco, transport and to some extent, alcohol.

is not a clear group of non-participation. This group includes public transport, a service for which expenses over a lengthy period can be covered through single advance payments and where infrequency may therefore be a plausible cause for zero records (a description of the contents of each group can be found in appendix B). To estimate the demand model we split the sample into two sub-samples, smokers and non-smokers, to control for zeros due to non-participation.[67] Finally, in order to assess to what extent we still have an infrequency of purchase problem we estimate the model after transforming the data to moving averages of order five.[68]

2.3.4. Econometric issues.

We use the conditional approach put forward by Browning and Meghir (1991) to estimate a demand system of eight (presumably) adult goods in which we have as the "conditioning set" the following variables. First, male and female participation dummies.[69] Second, household composition variables (number of children in different ages, number of adults and number of elderly people in the household). Finally, we include other demographic variables, i.e., education of the head of the household, labour status of the head of the household, age and age squared of both the head and his partner, number of earners in the household, tenure status of the house, and quarterly and yearly dummies. Other variables used are prices and total expenditure.

As pointed out by Browning and Meghir (1991), with this kind of setting an econometric issue arises: the need to account for the possible endogeneity of some of the right hand side variables in the (conditional) system. The potentially

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[67] We control for sample selection in both cases and check that the estimates are similar, regardless of the sample we use.

[68] The order we use to transform the data has been decided taking into account two aspects. On one hand, the higher the order the smaller the percentage of zeros remaining. On the other hand, we need to keep sufficient periods to transform (e.g., take first differences) and instrument the potentially endogenous variables of the model.

[69] Although the survey does not provide information on hours, we can identify whether the individual in the household works full or part time. In the context of the Spanish labour market, these dummies are sufficient indicators of the hours people work.

endogenous variables are male and female labour market variables and total expenditure. In order to identify the parameters of the model they assume that conditional on total expenditure and the labour variables, asset income and education do not enter the demand. In a panel data context, however, we also have some other instruments (mainly lagged variables) in order to achieve identification. Identification is achieved treating all demographics as exogenous and instrumenting total expenditure (and total expenditure squared) with total income and/or lags of total expenditure.

The demand system (2.16) we estimate can be written as

$$(2.22) \quad w_{ht} = f\left(\boldsymbol{p}_{ht}, x_{ht}, z_{ht} | \delta\right) + \varepsilon_{ht}$$

where w_{ht} is the vector of commodity shares for household h in period t. Given (2.22), a consistent instrumental variables estimator for the parameters δ can be obtained by minimising $\varepsilon'\left(I \otimes P_Z\right) \cdot \varepsilon$, where ε is the vector of error terms, $P_Z = Z(Z'Z)^{-1}Z'$ and Z is the matrix of instruments. The vector of parameters is obtained through an iterative procedure that minimises

$$(2.23) \quad \frac{\partial f\left(\boldsymbol{p}_{ht}, x_{ht}, z_{ht} | \delta\right)}{\partial \delta}\left[I \otimes P_Z\right] \cdot \left[w_{ht} - f\left(\boldsymbol{p}_{ht}, x_{ht}, z_{ht} | \delta\right)\right]$$

Finally, the asymptotic variance-covariance matrix of this estimator is

(2.24)

$$V(\hat{\delta}) = \left[X' G' (I \otimes P_Z) GX\right]^{-1} X' G' (I \otimes P_Z) \Omega (I \otimes P_Z) GX \left[X' G' (I \otimes P_Z) GX\right]^{-1}$$

where Ω is the error covariance matrix and G is the stacked matrix of derivatives in (2.23). In estimating the variance-covariance matrix we evaluate G at the estimated parameter vector and we use the estimated residual vector in order to calculate Ω.[70]

In the demand system we estimate we impose homogeneity, adding-up

[70] See Hansen (1982) and Browning and Meghir (1991).

and symmetry.[71] Moreover, the price index used to deflate total expenditure depends on estimated parameters and is common across all equations, giving rise to an additional set of within and cross-equation restrictions. Following Browning and Meghir (1991) and considering the size of the data set, we have used a two-steps strategy to estimate the demand system. We first estimate the model without imposing symmetry but imposing the cross-equations restrictions, i.e. that we have the same *a(p,z)* and *b(p)* deflating total expenditure in every equation, and the within-equation restriction of homogeneity. Adding up is imposed by letting out of the estimated system the last equation. Then, we estimate the system equation by equation and compute the price index ***a(p)*** and ***b(p)*** using the estimated parameters and re-estimate the model.[72] We iterate until this process converges.[73] This procedure provides consistent parameter estimates for the model without imposing symmetry. The covariance matrix for this IV estimator is given in (2.24) and takes into account the cross-equation restrictions. The second step is then to estimate again the system imposing symmetry using a minimum distance procedure. The symmetry restricted parameters are obtained by minimising $\chi^2 = \left(\hat{\delta} - K\beta\right)' \hat{V}^{-1}\left(\hat{\delta} - K\beta\right)$ where $\hat{\delta}$ is the unrestricted parameter vector, $\hat{V}$ is the variance-covariance matrix of $\hat{\delta}$ and K is the restrictions matrix. The minimised value of χ^2 follows a Chi-squared distribution with degrees of freedom equal to the number of restrictions. An estimate of the covariance matrix of the restricted estimator is $\left(K' \hat{V}^{-1} K\right)^{-1}$.

As pointed out by Arellano and Bond (1991), an estimator that uses lags as instruments, under the assumption of white noise errors, would loose its

[71] We test both for symmetry and homogeneity.

[72] As pointed out in Browning and Meghir (1991), if the value of *a(p,z)* and *b(p)* were known for each household, then we would have a linear estimation problem. Thus as a first approximation to *a(p,z)* we compute household specific Stone price indices, defined by $\log P_{ht} = \sum_{i=1}^{I} w_{iht} \log p_{it}$ where w_{iht} is the budget share of good i in period t for household h.

[73] We observe important differences in the parameters obtained in the first and last iterations indicating that using the Stone price index approximation with no iteration might not be acceptable. Pashardes (1993) points out that the results using the Stone approximation (without iteration) can result in biased parameter estimates, particularly when the AIDS is applied to microdata.

consistency if the errors were serially correlated. Therefore, we have carried out some tests for the validity of the instruments, i.e., tests of the lack of serial correlation. In this chapter we consider three tests: a direct test on the first order serial correlation coefficient of the residuals, a Sargan test of over-identifying restrictions and a Hausman specification test, Hausman (1978). In appendix A, we present a formal description of the test for first order serial correlation, while the other two tests are presented in Arellano and Bond (1991).

In the above stochastic specification (equation 2.24) the vector of error terms, denoted by ε_{iht}, can be decomposed as $\varepsilon_{iht} = \rho_{ih} + u_{iht}$, where u_{iht} is assumed to have zero expectation and to be independently distributed over time and across households, whereas ρ_{ih} is the unobservable individual effect.[74] Even with these assumptions, a problem that may arise in the specification is the correlation between variables and individual effects.[75] Under infrequency of purchase, total expenditure is correlated with the mixed error. If the purchase policy is time invariant then the fact of having infrequency of purchase can be considered as a fixed effect, and therefore total expenditure will be correlated with the time invariant part of the error term (see Meghir and Robin, 1992). When dealing with data that suffers from infrequency it is crucial to analyse the characteristics of the unobserved individual heterogeneity. Investigating the nature of our data we can detect that due to infrequency of purchase we might have a measurement error problem both in the RHS (the commodity shares) and in the LHS (total expenditure). Therefore total expenditure and the error term are currently correlated via the individual effect, but total expenditure can be correlated with the error term due to other reasons. If the only reason for the correlation were the presence of individual unobserved heterogeneity then within-groups estimation would be sufficient to get consistent estimates. If that is not the case, then we should still instrument total expenditure (apart from removing the

[74] The of independence over time can be easily relaxed, as we do in the empirical work. In any case, for deciding the instrument set, we test for the presence of autocorrelation (see Arellano and Bond, 1991).
[75] The assumption of independence between individual effects and regressors has little or no interest in economic models.

individual effects). To check to what extent the infrequency of purchase is leading to correlation between total expenditure and the error term we propose the following test. Using the information provided in our data set, we calculate empirical purchase probabilities approximating them as the number of times a household has a positive purchase over eight (as eight is the number of quarters a household is tracked in the survey). With these estimates at hand, we follow Meghir and Robin (1992) in order to correct the data to avoid the measurement error problem. The weighting scheme (using the empirical probabilities) eliminates the measurement error problem by accounting for its precise structure. With these new data, we re-estimate the model and check if the results are similar. If they are, then our assumption about the nature of the individual effects is correct (under a time invariant purchase policy, which is not a strong assumption, since the length of the observed period for each household is eight quarters). But even so, total expenditure might still be correlated with the error term in which case we still need to instrument this variable (by using total income and lags of total expenditure). Finally, there are several ways to control for the individual effects: we can model them as proposed by Mundlak (1978) or Chamberlain (1982) or take some transformation to remove them (see, for instance, Anderson and Hsiao, 1980 or Arellano and Bover, 1995).[76]

2.4. Empirical results and discussion.

To start with, we have replicated Deaton, Ruiz-Castillo and Thomas (1989) empirical application using our data set.[77] We first estimate the same demand model (using a good classification as close as possible to the one used by them)[78]

[76] We try several transformations in order to remove the fixed effects, i.e. within-groups estimation and first differences.

[77] The data used in their paper are taken from the Spanish *Encuesta de Presupuestos Familiares* (EPF) collected from April 1980 to March 1981. This is a (cross-sectional) survey data set designed to calculate the weights for the Spanish Retail Price Index. The sample size is 23,972 households from all over Spain and data are collected on 625 separate expenditure items. The data we use (ECPF) is perfectly compatible with the EPF since the development of the ECPF aims to re-examine the weights of the Retail Price Index.

[78] Our classification of commodities is broader than the one they use, as the number of goods covered by the ECPF is around 400.

and check if the overall picture is the same.[79] Then, after estimating our baseline (see Tables 2.9 and 2.10 in appendix D) we check and account for possible problems that should be taken into account when using microdata. First, we deal with zero records reclassifying the goods we are analysing into a broader group classification. We also control for price variation. Although the outlay equivalent ratios calculated in doing so look broadly similar overall, some differences are detected. First, the size of the coefficients is, in general, bigger, and for some goods (*entertainment, out* and *other3*) we obtain that the younger the children the bigger the negative value for the outlay equivalent ratio, as one might expect a priori. Finally, in all estimations demographic separability is rejected.[80] After obtaining some evidence that things might improve if a more detailed analysis is carried out, we departed from their empirical analysis in several ways. First, we estimate a demand system in which we account for price variation and impose the restrictions coming from the demand theory by using the conditional approach put forward by Browning and Meghir (1991). Second, we also control for unobserved individual heterogeneity, infrequency of purchase and non-participation.

We have carried out several types of exercises. First, we estimate the demand system using the whole sample. The second sample we use is composed by those individuals who are smokers.[81] In order to check for selection bias we estimate the demand system controlling for sample selection and without controlling for it. We also do the same exercise using the sample of non-smokers. To assess the importance of the infrequency of purchase, we transform the data into moving averages of order five and re-estimate the demand system. Finally, our last exercise is to estimate the demand system accounting for individual heterogeneity by using the panel nature of the data set. As discussed earlier,

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[79] In order to assess these similarities, one can compare the results reported in Tables 1 and 3 in Deaton, Ruiz-Castillo and Thomas (1989) with the corresponding tables in this chapter (Appendix D).

[80] Although only the results for our baseline are reported in appendix D, all other results are available from the authors upon request.

[81] This further selection aims to eliminate those zeros that are due to non-participation in the demand for tobacco.

instruments for total expenditure are lags of total expenditure and/or current total income.[82]

For all the exercises, we calculate the π-ratios and the discrepancies from the mean and we test for demographic separability. We build a test for first order autocorrelation. The values of this test range from 0.2087 to 1.035. We also compute the budget elasticities as well as the uncompensated price elasticities. The test statistics to test for exogeneity and for the validity of the instrument set are also reported. These figures do not reject the null of absence of first order serial correlation in the residual (they have to be compared with a standard normal).[83] We also formulate a Sargan test for overidentifying assumptions following Arellano and Bond (1991).[84] Table 2.2 reports the outlay equivalent ratios for the eight possible adult goods over which we have estimated the demand system (for the smokers and non-smokers sub-samples). In each cell, the top figure relates to the smokers' sample and the bottom figure relates to the non-smokers' one. A negative ratio means that an additional household member in the age category acts like a decrease in total outlay. Fulfilment of the demographic separability hypothesis requires that all outlay equivalent ratios have the same sign and magnitude. Figures in Table 2.2 correspond to the model estimated on the smokers and non-smokers sub-samples.[85]

The general picture from the results obtained confirms the intuition behind demographic separability. For the three children categories, we obtain predominantly negative effects on demand. For the sub-sample of smokers, only 3 of the 24 outlay equivalent ratios are positive, with a positive ratio in the same cases as found by Deaton, Ruiz-Castillo and Thomas (1989): *tobacco* and

[82] As we have quarterly data, we have also tried to instrument total expenditure using total expenditure lagged four periods, but the results were similar to the reported here.

[83] We also calculate a Hausman test in the line proposed by Arellano and Bond (1991). We reject the null that the parameters estimated when controlling for endogeneity are the same to the case where we do not instrument the endogenous variables, both for the system and for each equation separately.

[84] For the Sargan test, we reject the null hypothesis for each equation. As Browning and Meghir (1991) and Kalwij, Alessi and Fontein (1997) we have experimented with the specification of the model on the basis of the results of this test. Our main conclusion is also that the test decreases (although is still rejected) but does not affect the estimates.

[85] In order to save some space we only report results for the children categories (0-4, 5-8, 9-13 and 14-17).

alcohol. These results may suggest that there is evidence that the presence of children of certain ages is associated with increased expenditure on *alcohol* (consumed at home) and *tobacco*.[86] For the non-smokers' sub-sample the general picture is very similar except for *alcohol* for which we get negative signs. Finally, we obtain unexpected results in some of the ranges of age that correspond to adults. There are several important results in the age category over 60 with four additional negative signs in *clothing, meals out, entertainment* and *transport*, four categories for which the presence of an additional member of that age do not contribute significantly to total outlay in Spain.

In order to check to what extent we still have a problem of infrequency of purchase in our data set, we estimate the demand system using a transformed data set, i.e. taking moving averages of order 5. Since we obtain the same results (in terms of demand system coefficients and π-ratios), we may conclude that the problem of infrequency of purchase has been eliminated, although we will further examine this issue in the panel data framework.

In Table 2.2 we also present Wald tests for the hypothesis that all goods are jointly demographically separable from the child category in that column. They test the equality of the π-ratios for each of the 3 child demographic groups through the calculation of the deviations of the ratios from the mean (i.e. the discrepancies) as explained earlier. We present two different types of Wald tests: one for the whole system of presumably adult goods (tests 1 and 3), and another one for those goods that fit better the definition of adult goods (*adult clothing, alcohol, out* and *tobacco*). Under the null of demographic separability these tests are distributed as a χ^2 with 7 (6) degrees of freedom for the smokers (non-smokers) sub-sample when we use the 8 (7) presumably adult goods. The degrees of freedom are 3 when we only use 4 goods as adult goods.

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[86] Deaton, Ruiz-Castillo and Thomas (1989) point out that these effects are consistent with Barten's (1964) model in the sense that the shadow price of adult goods that are not shared with children falls as the number of children increases. In addition, when having children, parents stay more at home reducing the demand for goods consumed out and increasing the demand for some of these goods at home. For the smokers' sample, these results contradict the prediction that, other things being equal, parents are likely to reduce the consumption of these goods to avoid being a bad example to their children, Pashardes (1991).

As in Deaton, Ruiz-Castillo and Thomas (1989),Wald tests are overall highly significant at any conventional significance level. As they argue, one of the possibilities in interpreting these results is to question the relevance of the conventional significance levels themselves. Given that our sample contains around 28,400 observations for the smokers sub-sample (and 13,000 for the non-smokers one), if the size of the test is set at conventional levels, the probability of rejection is likely to be much higher than usual, even if the null hypothesis is very close to being true. Therefore, it may be better to balance explicitly the probability of type I and type II errors using a Bayesian approach like the Schwarz criterion. In the current context, this statistic leads to non-rejection of the model if the χ^2-value is less than the log of the sample size multiplied by the number of restrictions. The results of these tests indicate that demographic separability for the 8 goods is rejected (even using the Schwarz criterion) for the smoker's sub-sample. If we focus only on the 4 adult goods the values of the tests fall below the critical value (except in one case for which we are in the borderline). For the non-smokers' sub-sample neither type of Wald test rejects demographic separability. In this last case, the results might arise from two effects: the π-ratios for *alcohol* are negative and we do not have the positive effects of *tobacco*. These are two goods for which the demographic separability concept does not seem to work in the smokers' sample due to other reasons, such as habits or addiction.

So far, we have controlled for different aspects that we consider important when using microdata in order to get consistent estimates. Given that we have a panel data set we turn now to the panel data estimates to assess to what extent unobserved individual heterogeneity matters. We then estimate the demand system (equation 2.19) using both the within-groups estimator and a first differences estimator for the whole sample, the sample of smokers and the sample of non-smokers. Results for the smokers' sample are reported in Table 2.3. We also present the Wald test for demographic separability.

What seems clear from our results is that the classification of some goods as potentially adult goods is questionable. This is not only true for goods such as *alcohol* and *tobacco*, for which we have already noted reasons for doubting, but also for *entertainment* and *personal care*. As in the cross-section results, we find different results regarding *alcohol* for smokers and non-smokers. Therefore, one can suspect that the results obtained for these goods when treating the data as cross-sectional data might have been driven by the absence of controls for individual heterogeneity, since some other reasons, such as the presence of zeros, have already been ruled out using the MA(5) estimates. For *tobacco* we still get, as before, positive coefficients.

Finally, the overall picture we get (leaving aside *alcohol* and *tobacco*) is similar to the results in Table 2.3. We do not reject the null of demographic separability in any sample. It is important to stress that these results suggest that the unobserved individual heterogeneity is a crucial matter in the context of demographic separability and therefore will have implications in the measurement of children costs. This result has been already anticipated (from a theoretical point of view) by Browning (1992).[87] Another result that should be highlighted is that when we estimate the demand system controlling for unobserved individual heterogeneity we do not reject the restrictions of symmetry and homogeneity. This result is in line with Banks, Blundell and Lewbel (1997). They also control, somehow, for heterogeneity by selecting a homogeneous sample of households.

As discussed in section 2.3.3, we suggest a test to check to what extent controlling for individual heterogeneity solves the measurement error problem arising from infrequency of purchase. To do so, we follow Meghir and Robin (1992) in selecting all those households that purchase all goods (we are left with 5,419 observations). We construct total expenditure using a weighting scheme, with weights computed as the empirical probabilities, i.e. the number of times a household purchases a good over eight. For this sample, we then estimate the model using the constructed total expenditure, and compare these results to the ones obtained without using the re-weighting scheme. In both cases we use a within-groups estimator and instrument total expenditure with total income, under the hypothesis of a two stage budgeting process. We test the similarity of both

[87] There might be cases where there is some preference heterogeneity (or fixed effect) that is correlated with fertility and preferences over goods (Browning, 1992).

sets of results using the means of a Hausman test. Under the H_0 that both results are the same we have that the test is distributed as a $\chi^2(132)$ (alternatively we have done the test in each equation separately). We get a value 8.65 for the χ^2 test (and for each equation the χ^2 ranges between 7.13 and 14.58), suggesting that our assumption about the effect of infrequency of purchase was correct.[88] Therefore, correcting for unobserved heterogeneity using a within-groups method seems to be sufficient to get consistent estimates.

To double check our results we include *tobacco* expenditure in the non modelled commodity category and re-estimate the whole demand system. In this way, we eliminate the selection problem and this allows us to use the whole sample. The idea is then to avoid modelling a good (*tobacco*) for which we have some problems due to the nature of the zeros in the sample. We leave *alcohol* as a separate category although we are aware that some caution needs to be taken with this good. The results we obtain are similar to the previous ones except for *alcohol* where we get negative signs for the children categories. These results highlight the conclusion that both *entertainment* and *personal care* are goods which contain a mixture of adult and children goods. It is also interesting to stress the relation between the goods *alcohol* and *tobacco* due to their similar nature.

Finally, we calculate equivalence scales for different household composition using the Rothbarth method for measuring children costs. Equivalence scales provide answers to questions like how much a household with children would spend compared to a childless household to reach the same welfare, i.e., to answer the iso-welfare question. This question is important in order to calculate child allowances in the income tax system or to calculate social benefits for families with dependants.[89] As highlighted in Browning (1992), among the methods for identifying how much income does a family with children needs to be as well off as a family without children, when we only observe

[88] The critical values for the $\chi^2_{0.95}(132)$ and the $\chi^2_{0.95}(20)$ are 159.81 and 31.41, respectively.

[89] In 1999 there was a reform in the income tax system in Spain. In this reform the government announced important changes in the children's allowances. In chapter 4 we investigate to what extent these children allowances are properly calculated for different types of households.

household expenditure is to use information on expenditure on goods that can be attributed to parents, so called "adult only" goods.[90] This method identifies the estimate of child costs by prior selection of a group of adult goods, the total expenditure on which correctly indicates adult welfare. The presence of children is assumed to affect total expenditure on adult goods only through income-like effects so that, if the correct compensation for child costs were to be said, expenditure on adult goods would be unaltered by changes in the number of children. The Rothbarth method calculates the sum of money that would restore the level of expenditure on adult goods. In terms of the empirical results, we have to bear in mind that demographic separability between adult goods and child characteristics is a necessary but not sufficient condition to make such comparisons which require the stronger assumption of cost separability.

The idea is then to predict, using our demand estimates, the effect of demographic change on total expenditure on adult goods as this is the indicator of the household utility for the Rothbarth method. With these predictions at hand, we can then calculate the total expenditure that different household types would need to get the same adult good expenditure as in a reference (childless) household. If there are economies of scale in child raising then one might expect the cost of a first child to exceed that of a second and so on. This may however be too simple - the cost of a third child may exceed that of a second, for instance, if it is significant that the number of children should not exceed the number of either parent's hands. Also, one could expect that the timing of children as well as their sex would influence these costs, e.g., costs might be higher if the first child is born in a summer season and the second in a winter season, or the sex of the first and second are different. Moreover, the time elapsed between the birth of children in the family would also matter. Other things that would be worth checking are questions related to household demographics. For example, how old are the parents when they have children and how adult expenditure differs in some of the adult goods as the household is ageing (e.g., *tobacco, alcohol,...*). This is important in the sense that household tastes might change due both to the arrival

[90] This line of research is traced back to Rothbarth's (1943) method.

of children and/or the ageing process.

Table 2.5 reports the estimates of the equivalence scales for the two sets of estimates that we have obtained using both cross-sectional and panel data results. Standard errors for the equivalence scales have been also calculated and the procedure is reported in appendix A. For both sets of estimates, we present two groups of equivalent scales: one for the 8 presumably adult goods and another one for the 4 goods that fit better to the definition of adult goods. Looking at equation (2.19), when we drop some adult goods from the system, the cost increases, as expected. The conclusion that one can draw from these results, in spite of all criticisms they can be subject to, is that the equivalence scales calculated using the cross-section results might be underestimated. This suggests that individual unobserved heterogeneity play an important role in this context. Also it is interesting to highlight that the cost for two children are more than twice the cost of one child and also that babies and toddlers (children of age 0-4) have higher costs than children aged 5-8 years, in all cases. This could probably reflect some fixed costs of babies associated to their arrival.[91] Costs of babies and those of children aged 9-13 are rather similar in all sets of results. Therefore, it seems that the age of the children matters in the calculation of the scales (as expectable).

In table 2.6 we present a breakdown by age, number of earners in the household and place of residence of the equivalence scales.[92] It seems that wife and husband's ages matter in the sense that the costs of children are higher for older parents. Also, when someone in the household works (in addition to the husband) there is a general decrease in the equivalence scales. Finally, the results seem to suggest that for households living in a rural area costs are a bit lower

[91] One way to justify these results is that some goods have to be bought when children are present (baby food, for instance), whereas the consumption of some other goods is anticipated (or postponed) as a result of the arrival of a child in the household (holidays or restaurant expenses are typical examples), Banks, Blundell and Preston (1995). If the increase in needs (specially of babies) is more important than the reallocation of some others expenditures, then, this can be the reason behind the higher costs of babies than children of 5-8 years old.

[92] We have also calculated the scales by education but the results remained unchanged. Furthermore, analyzing with more detail what happens in the household in the surrounding of child birth one can detect that some expenditures have to be done when the child arrives (e.g., health, clothing, food).

than the average costs.

Finally, in tables 2.7 and 2.8 we report the (uncompensated) price and income elasticities. Table 2.7 presents the elasticities calculated using the data as cross-sectional data and table 2.8 presents the elasticities obtained when we take account of the panel nature of the data.

2.5. Conclusions.

The notion of demographic separability, introduced by Deaton, Ruiz-Castillo and Thomas (1989), is useful in structuring ideas about the effects of children on demands for goods. Following their earlier work, we test for demographic separability in the context of a demand system estimated with panel data. We estimate a demand system of eight possible adult goods using the QUAIDS model of Banks, Blundell and Lewbel (1997), a model whose use has been extended in later years given the perceived need for non-linear total budget terms in Engel curves. Before estimating the model, we have discussed several ways to minimise the impact of the zero records over the estimated coefficients. We have taken into account the errors in variables problem derived from infrequency of purchase as well as the control for unobserved heterogeneity. An important implication arising from our results is that controlling for unobserved heterogeneity as well as infrequency appears to be quite relevant and helps to improve the estimated results. Finally, the equivalence scales estimated in our preferred specification seem to be in line with previous results obtained by other authors in neighbouring countries.

In this chapter we have looked at the contemporaneous dimension of both the effects and costs of children. In the next chapter, we introduce the notion of life cycle, in the sense that we look at the effects of the presence (arrival) of children in an intertemporal context. We especially focus on some periods before and after a child is born in a household, in order to give some evidence about the need of wider concepts to analyse both child effects and child costs.

2.6. Appendix A.

2.6.1. The autocorrelation test.

As suggested in Arellano and Bond (1991) one can construct a test statistic to test for first order serial correlation in the same lines as the one presented by them to test for second order serial correlation. Therefore, the test that we have performed is described as follows

$$(2.A.1)\ m_1 = \frac{\hat{u}'_{(-1)}\ \hat{u}_*}{\hat{v}^{1/2}} \sim N(0,1)$$

under $E\left(u_{it}u_{i(t-1)}\right) = 0$, where $\hat{v}$ is given by

$$(2.A.1)\ \begin{aligned}\hat{v} &= \hat{u}'_{(-1)}\ \hat{u}_*\hat{u}'_*\ \hat{u}_{(-1)} - 2\hat{u}'_{(-1)}\ X_*\left(X'Z(Z'Z)^{-1}Z'X\right)^{-1} Z'\hat{u}\hat{u}'_*\ \hat{u}_{(-1)} + \\ &\hat{u}'_{(-1)}\ X_* avar(\hat{\delta})X'_*\ \hat{u}_{(-1)}\end{aligned}$$

where $\hat{u}_{(-1)}$ is the vector of residuals lagged one period, $\hat{u}_*$ is a vector of trimmed $\hat{u}$ to match $\hat{u}_{(-1)}$ and similarly for the matrix X_*, and $\hat{\delta}$ is an estimator obtained in (2.26). Note that m_1 is only defined if T > 3. In Arellano and Bond (1991) one can check the proof of the asymptotic normality of the test.

2.6.2. Standard errors for the equivalence scales.

In this appendix we present the procedure to derive the standard errors for the equivalence scales we present. Given the data, the scales, r_j, are a function of the parameters estimated. Let δ_j denote the 1xK vector of the transformation from the parameters estimated into the scales, so that each element of the vector δ_j is the derivative of the scale with respect to the vector of parameters estimated. Then by the "delta method" we have

$$(2.A.3)\ \mathrm{Var}(r_j) = \delta_j'(\mathrm{Var}(\beta))\delta_j$$

with δ_j evaluated at the parameter estimates and at the sample mean of the data and Var(β) the variance covariance matrix of the parameter estimates. The above formula is the one used to generate the reported standard errors for the equivalence scales.

2.7. Appendix B: Data and commodity grouping.

The data used in this chapter is a balanced panel drawn from the Spanish ECPF conducted by the Spanish Statistical Office since the first quarter of 1985. This is a quarterly rotating panel carried out over 3,200 households with a 12.5 per cent rotating rate to avoid attrition problems. This implies a maximum number of collaborating periods of eight for each household. We have selected those households which collaborate eight periods with a sample size N = 6,100, T = 8, beginning to provide information in the first quarter of 1986 (because there was not substitution in 1985) and finishing in the second quarter of 1994 (the last wave available for this chapter). Since there is some degree of attrition, with a percentage of households only providing information for one or two quarters, we need to check for non-random attrition. In any case, the structure of the sample used and that for all households collaborating for at least four periods seem to be the same. Given that we use lagged variables as instruments for several of the estimation methods and we also conduct estimations using a five order moving average procedure, we prefer to use the sub-sample with the maximum number of collaborating periods (eight quarters).

This data set provides information on about 400 commodities, income and its sources for different members of the household as well as other household members characteristics such as age, number of children, occupation, education, size of the town of residence, etc. Table 2.A.1 presents some descriptive statistics of the sample used. The composition of the adult goods is as follows. *Adult clothing* contains all women and men cloths, underwear and footwear. In *alcohol* we have wines, beers and all other alcoholic drinks (whisky, brandy, gin,...). The commodity *out* contains alcohol and food consumed away from home.

Entertainment expenditures refer to all expenses on cinema, theatre, concerts, sports matches (football, rugby, ...), clubs, discotheques and fares to use any sport facilities as well as renting video tapes and all kind of entertainment items that can be hired. *Personal care* contains expenses in hairdressers, barbers, beauty centres and so on. It also contains expenses on gel, soap, shampoo, perfumes, etc.. The commodity *tobacco* is self descriptive. And, finally, in *other3* we include miscellaneous goods as follows: insurance, membership dues and subscriptions, licenses, taxes, transfers to public institutions or other households, gambling, funeral expenses, stationery excluding school materials, payment for financial services and payments for personal services.

Table 2.A.1.
Descriptive statistics

Variable	Definition	Mean	Standard deviation
wadclothing	share adult clothing and footwear	0.0899	0.0879
walcohol	share alcohol	0.0179	0.0256
wout	share alcohol and food out	0.0938	0.0859
wentertainm.	share entertainment	0.0155	0.0274
wperscare	share personal care goods	0.0161	0.0261
wtobacco	share tobacco	0.0232	0.0252
wtransport	share transport	0.0827	0.0838
wother3	share other3	0.0458	0.0699
wrest	share rest non-durable goods	0.6151	0.1591
n1	number of children age 0-4	0.2304	0.5148
n2	number of children age 5-8	0.2050	0.4579
n3	number of children age 9-13	0.3376	0.6114
n4	number of children age 14-17	0.3133	0.5851
na1	number of adults age 18-24	0.4605	0.7325
na2	number of adults age 25-64	1.8620	0.8401
no	number of elderly people	0.4929	0.7710
n	size of the household	3.9019	1.4450
ln	log(size of the household)	1.2878	0.3996
ded1	= 1 if head household illiterate	0.2389	0.4264
ded2	= 1 if head household 1st. and 2nd. School education	0.5918	0.4915
ded4	= 1 if head household university	0.0674	0.2508
dunem	= 1 if head household is unemployed	0.0539	0.2259
dself	= 1 if head household is self employed	0.1595	0.3661
dunsk	= 1 if head household is a unskilled worker	0.0276	0.1637
dwhic	= 1 if head household is a white collar worker	0.3591	0.4797
dbluc	= 1 if head household is blue collar worker	0.1011	0.3015
dnact	= 1 if head household is non-active	0.2566	0.4368
age1	age of head household	49.5351	13.588
age2	age of the wife	40.7212	19.1948
dearn	= 1 if more than one earner in the household	0.2034	0.4025
downh	= 1 if household owns the house	0.7937	0.4046
dsecoh	= 1 if household owns a second house	0.1037	0.3049
drura	= 1 if household lives in a town of less than 10,000 inhabitants	0.2954	0.4562
dcity	= 1 if household lives in a city of more than 500,000 inhabitants	0.1301	0.3364
lrtexp	log real total expenditure	8.5620	0.5311
lrtinc	log real total income	13.0941	0.5381

Table 2.A.1. (Cont.)

Variable	Definition	Mean	Standard deviation
lpclot	log price adult clothing and footwear	0.0240	0.0259
lpalcoh	log price of alcohol	-0.0082	0.0399
lpout	log price of alcohol and food out	-0.0491	0.0453
lpenter	log price entertainment	-0.0115	0.0190
lppersc	log price personal care goods	-0.0769	0.0654
lptobac	log price tobacco	-0.0446	0.0585
lptrans	log price transport	-0.0399	0.0399
lpothe3	log price other3	-0.0020	0.0138
lprest	log price rest non-durable goods	0.0120	0.0156

2.8. Appendix C: Tables.

Table 2.1.
Proportion of zeros, empirical probabilities and monitoring period.

Commodity[1]	1[2]	2	3	4	5
clothing	6,887 (14%)	18 (0.3%)	142 (0.6%)	0.86	month
education	41,337 (87%)	3,835 (65%)	16,002 (67%)	0.15	month
alcohol in	17,190 (36%)	364 (6.1%)	2,028 (8.5%)	0.65	week
alcohol out	11,087 (23%)	585 (9.8%)	2,412 (10%)	0.77	week
entertainm.	26,834 (57%)	1,490 (25%)	6,701 (28%)	0.45	week
health	21,354 (46%)	526 (8.9%)	3,113 (13%)	0.56	quarter
personal care	18,520 (39%)	1,750 (29%)	8,225 (35%)	0.62	week
meals out	30,500 (64%)	297 (5.0%)	1,736 (7.3%)	0.37	week
tobacco	22,865 (48%)	1,957 (33%)	8,183 (34%)	0.53	week
transport	11,682 (25%)	416 (7.0%)	1,845 (7.8%)	0.76	week
other1	24,937 (53%)	978 (16%)	5,053 (21%)	0.49	week[5]
other2	16,353 (34%)	770 (13%)	3,648 (15%)	0.66	week[5]
other3[3]	10,164 (21%)	315 (5.3%)	1,520 (6.4%)	0.79	week
out[4]	9,547 (20%)	491 (8.3%)	2,010 (8.5%)	0.80	week

Notes:
1. Column 1 is the number (percentage) of zeros in the whole sample. Column 2 is the number of zeros remaining after aggregating over the 8 periods per household. Column 3 is the number (percentage) of zeros when the data is aggregated in MA(5). In column 4 we have the empirical probabilities (these are calculated as the number of periods that the household reports a positive purchase over 8). Column 5 is the monitoring period for each good.
2. From the original sample we have dropped all those who have spent nothing in all goods, all those who have a total expenditure of less than 45,000 pesetas for three months and all who have a total income of less than 25,000 pesetas in three months. This figures correspond to NT = 47,400 out of a total of 48,800.
3. Other3 = Other1 + Other2.
4. Out = Meals out + Alcohol out.
5. The recording period for these groups is a mixture of different monitoring periods due to their composition.

Table 2.2.
Outlay equivalent ratios for possible adult goods. Cross-section estimates.

	Children's age categories							
Commodity	**0-4**		**5-8**		**9-13**		**14-17**	
clothing	-0.4723	(0.0454)	-0.5621	(0.0480)	-0.5514	(0.0369)	0.2628	(0.0378)
	-0.2852	(0.0753)	-0.3962	(0.0729)	-0.4939	(0.0519)	0.2032	(0.0531)
alcohol	0.2072	(0.1004)	-0.0249	(0.1042)	-0.0820	(0.0787)	-0.4026	(0.0827)
	-0.1330	(0.2183)	-0.0282	(0.2130)	0.2232	(0.1533)	0.0604	(0.1525)
out	-0.3728	(0.0361)	-0.2097	(0.0376)	-0.2556	(0.0285)	-0.2115	(0.0293)
	-0.3674	(0.0876)	-0.1818	(0.0842)	-0.3170	(0.0592)	-0.1561	(0.0597)
entertainment	-0.3627	(0.0626)	-0.0447	(0.0651)	-0.1249	(0.0491)	0.7677	(0.0585)
	-0.1636	(0.1345)	-0.0683	(0.1307)	0.1629	(0.0935)	0.4991	(0.1006)
personal care	-0.3018	(0.0708)	-0.3342	(0.0743)	-0.4160	(0.0570)	-0.0893	(0.0577)
	-0.3401	(0.1291)	-0.3782	(0.1247)	-0.1913	(0.0871)	0.0087	(0.0889)
tobacco	0.2889	(0.1002)	0.3322	(0.1057)	-0.0984	(0.0780)	-0.2994	(0.0809)
	-	-	-	-	-	-	-	-
transport	-0.0388	(0.0439)	-0.2439	(0.0462)	-0.1491	(0.0348)	-0.2806	(0.0359)
	-0.2012	(0.0847)	-0.3280	(0.0826)	-0.3438	(0.0581)	-0.3955	(0.0587)
other3	-0.5445	(0.0864)	-0.2486	(0.0888)	-0.0584	(0.0669)	0.0363	(0.0696)
	-0.4943	(0.1344)	-0.5471	(0.1290)	-0.2986	(0.0897)	0.0438	(0.0917)
all goods above	-0.2922	(0.0561)	-0.2759	(0.0190)	-0.2696	(0.0143)	-0.0471	(0.0148)
	-0.2925	(0.0425)	-0.3327	(0.0376)	-0.3307	(0.0264)	-0.0001	(0.0564)
Wald test 1 (7)	116.186		79.008		93.849			
Wald test 2 (7)	72.5988		68.587		53.874			
Wald test 3 (6)	5.971		11.869		51.472			
Wald test 4 (6)	1.158		4.971		20.641			

Notes:
1. Cross-section estimates.
2. For each good we present two results: on the top of the cell we report results obtained from the smokers sample (number of observations is 28,408) and on the bottom of the cell we report results obtained from the non-smokers sample (number of observations is 12,480). In both cases the instrument for total expenditure is total expenditure with one lag. We also control for sample selection.
3. Standard errors are in parenthesis.
4. Schwarz criterion for Wald test 1 and 2 is 71.78, and for Wald test 3 and 4 is 56.59.

Table 2.3.
Outlay equivalent ratios for possible adult goods. Panel data estimates.

	Children's age categories							
Commodity	**0-4**		**5-8**		**9-13**		**14-17**	
clothing	-0.2328	(0.0694)	-0.1632	(0.0782)	-0.2359	(0.0704)	0.0962	(0.0773)
alcohol	0.1257	(0.3684)	0.0440	(0.3882)	0.3788	(0.4656)	0.8504	(0.7391)
out	-0.1515	(0.0444)	-0.1368	(0.0506)	-0.1322	(0.0451)	-0.1089	(0.0437)
entertainment	0.0692	(0.1183)	0.1847	(0.1401)	0.1414	(0.1273)	0.4728	(0.1815)
personal care	0.1885	(0.2471)	0.1688	(0.2671)	0.1026	(0.2384)	0.5490	(0.3672)
tobacco	0.6585	(0.2528)	0.7521	(0.2796)	1.0688	(0.3494)	1.0462	(0.3639)
transport	-0.1265	(0.0799)	-0.0278	(0.0915)	0.0207	(0.0837)	-0.0498	(0.0804)
other3	-0.6833	(0.3133)	-0.8755	(0.3975)	-0.8969	(0.3762)	-0.5394	(0.2428)
all goods above	-0.2576	(0.0484)	-0.1910	(0.0549)	-0.1915	(0.0491)	0.0355	(0.0524)
Wald test (7)	20.3549		20.5820		27.5487			

Notes:
(1) Panel data results. Estimation using within-groups estimation method.
(2) We present results obtained from the smokers sample (number of observations is 28,408).
(3) Absolute values of asymptotic t-statistics are in parenthesis.
(4) Schwarz criterion for Wald test is 71.78.

Table 2.4.
Outlay equivalent ratios for possible adult goods (excluding tobacco). Panel data estimates.

	Children's age categories							
Commodity	**0-4**		**5-8**		**9-13**		**14-17**	
clothing	-0.1935	(0.0464)	-0.1758	(0.0527)	-0.2082	(0.0469)	0.0105	(0.0444)
alcohol	-0.2047	(0.1091)	-0.1421	(0.1237)	-0.0298	(0.1102)	0.0797	(0.1043)
out	-0.1153	(0.0575)	-0.0662	(0.0653)	-0.071	(0.0582)	0.0632	(0.0550)
entertainment	0.0896	(0.1333)	0.1918	(0.1514)	0.1621	(0.1349)	0.7757	(0.1305)
personal care	0.15	(0.1107)	0.1112	(0.1258)	0.0612	(0.1120)	0.1999	(0.1062)
transport	-0.0906	(0.0570)	-0.0216	(0.0647)	-0.0203	(0.0576)	-0.0888	(0.0545)
other3	-0.5915	(0.2396)	-0.832	(0.2729)	-1.0033	(0.2449)	-0.6757	(0.2286)
all goods above	-0.2576	(0.0484)	-0.1910	(0.0549)	-0.1915	(0.0491)	0.0355	(0.0524)
Wald test (6)	15.3256		16.7902		25.9739			

Notes:
1. Panel data results. Estimation using within-groups estimation method.
2. We present results obtained from the whole sample (number of observations is 41,040).
3. Absolute values of asymptotic t-statistics are in parenthesis.
4. Schwarz criterion for Wald test is 63.73.

Table 2.5.
Rothbarth's equivalence scales.

Demographic characteristics	C-S Results 8 adult goods	C-S Results 4 adult goods	Panel data results 8 adult goods	Panel data results 4 adult goods
Couple without children	1.00	1.00	1.00	1.00
Couple with one child	1.10	1.12	1.16	1.23
0-4	0.10	0.12	0.16	0.26
	(0.007)	(0.010)	(0.027)	(0.089)
5-8	0.10	0.11	0.15	0.17
	(0.007)	(0.010)	(0.030)	(0.055)
9-13	0.11	0.14	0.18	0.25
	(0.005)	(0.008)	(0.029)	(0.082)
Couple with two children	1.23	1.27	1.39	1.60
two of 0-4	0.23	0.26	0.38	0.71
	(0.017)	(0.026)	(0.018)	(0.326)
one of 0-4 and one of 5-8	0.23	0.25	0.37	0.55
	(0.013)	(0.019)	(0.020)	(0.229)
one of 0-4 and one of 9-13	0.23	0.27	0.41	0.68
	(0.012)	(0.019)	(0.020)	(0.307)
two of 5-8	0.22	0.23	0.36	0.42
	(0.017)	(0.025)	(0.022)	(0.161)
one of 5-8 and one of 9-13	0.22	0.29	0.40	0.53
	(0.011)	(0.017)	(0.022)	(0.216)
two of 9-13	0.23	0.32	0.44	0.66
	(0.013)	(0.021)	(0.022)	(0.290)

Notes:
1. "8 adult goods" = adult clothing, alcohol, out, entertainment, personal care, tobacco, transport and other3.
2. "4 adult goods" = adult clothing, alcohol, out and tobacco.
3. Standard errors in parenthesis.

Table 2.6.
Rothbarth's equivalence scales by demographic breakdown.

	C-S Results		Panel data results	
Demographic characteristics	**8 adult goods**	**4 adult goods**	**8 adult goods**	**4 adult goods**
age1=30 and age2=29				
Couple with one child	1.10 (0.007)	1.12 (0.008)	1.14 (0.027)	1.16 (0.058)
Couple with two children	1.23 (0.014)	1.22 (0.018)	1.31 (0.030)	1.38 (0.049)
age1=56 and age2=55				
Couple with one child	1.10 (0.007)	1.13 (0.011)	1.13 (0.017)	1.25 (0.088)
Couple with two children	1.23 (0.015)	1.31 (0.027)	1.32 (0.044)	1.66 (0.317)
Number of earners>1				
Couple with one child	1.09 (0.006)	1.11 (0.009)	1.16 (0.039)	1.20 (0.058)
Couple with two children	1.21 (0.014)	1.26 (0.021)	1.39 (0.069)	1.50 (0.182)
Living in a rural area				
Couple with one child	1.09 (0.006)	1.11 (0.009)	1.16 (0.026)	1.24 (0.063)
Couple with two children	1.21 (0.014)	1.25 (0.020)	1.41 (0.075)	1.53 (0.203)

Notes:
1. See notes to table 2.5.
2. age1 and age2 are age of the husband and wife, respectively.
3. Standard errors in parenthesis.

Table 2.7.
Estimated demand elasticities. Cross-section estimates.

	Price elasticities								Income elasticity
clothing	-0.129	-0.653	-0.349	-0.113	-0.288	-0.594	0.337	0.471	1.098
alcohol	-2.916	-1.202	0.876	0.725	0.419	-0.445	-0.659	-0.513	0.401
out	-0.328	0.196	-0.156	-0.445	-0.297	0.373	-0.672	-0.726	1.302
entertain	-0.441	0.570	-1.826	-3.656	0.191	0.605	-0.149	3.357	1.216
perscare	-1.269	0.360	-1.433	0.222	-0.689	0.425	0.202	1.311	1.001
tobacco	-2.366	-0.435	1.558	0.680	0.421	-0.996	-0.252	0.407	0.351
transpor	0.355	-0.160	-0.716	-0.029	0.054	-0.078	0.048	0.638	1.170
other3	0.921	-0.240	-1.524	1.752	0.588	0.178	1.190	-4.197	1.216

Notes:
1. Elasticities calculated using cross-section estimates.

Table 2.8.
Estimated demand elasticities. Panel data estimates.

	Price elasticities								Income elasticity
clothing	-0.480	-0.759	0.010	-0.627	-0.181	-0.105	0.093	0.340	1.530
alcohol	-3.506	-0.423	-1.252	1.273	0.277	-0.934	0.012	0.253	0.857
out	-0.113	-0.321	-3.741	-0.790	-0.454	-0.099	-0.976	-1.256	1.039
entertain	-13.490	5.745	-14.094	-17.324	3.505	1.288	-1.341	35.982	0.615
perscare	-1.302	0.297	-1.960	0.849	-0.860	0.355	0.165	2.289	1.047
tobacco	-0.686	-0.739	-0.264	0.306	0.341	-0.521	0.099	0.000	0.444
transpor	-0.016	0.009	-0.982	-0.069	0.046	0.019	1.093	1.607	1.212
other3	0.619	0.277	-2.378	4.197	1.212	0.114	3.308	-7.180	0.344

Notes:
1. Elasticities calculated using panel data estimates.

2.9. Appendix D: Results for comparison with Deaton, Ruiz-Castillo and Thomas (1989).

Table 2.9.
Outlay equivalent ratios of possible adult goods as in Deaton, Ruiz-Castillo and Thomas (1989).

	Age group						
Commodity	**60+**	**24-60**	**18-23**	**14-17**	**9-13**	**5-8**	**0-4**
clothing	0.073 (0.031)	0.063 (0.027)	0.183 (0.031)	0.326 (0.036)	-0.719 (0.033)	-0.722 (0.046)	-0.622 (0.043)
educat	0.075 (0.101)	0.338 (0.097)	2.038 (0.191)	0.706 (0.128)	0.705 (0.118)	-0.480 (0.145)	-1.183 (0.150)
alcohol	0.753 (0.132)	0.833 (0.130)	0.287 (0.113)	-0.270 (0.119)	-0.100 (0.112)	-0.129 (0.157)	0.090 (0.148)
alcohout	0.540 (0.042)	0.952 (0.046)	1.091 (0.051)	0.179 (0.042)	-0.402 (0.038)	-0.281 (0.053)	-0.380 (0.050)
enterta.	0.061 (0.055)	0.278 (0.052)	1.227 (0.081)	1.151 (0.080)	-0.111 (0.057)	-0.040 (0.080)	-0.490 (0.075)
health	-0.136 (0.147)	-0.161 (0.121)	-0.348 (0.133)	-0.404 (0.168)	0.215 (0.162)	-0.013 (0.221)	1.345 (0.253)
mealout	-0.414 (0.034)	-0.240 (0.028)	-0.391 (0.031)	-0.480 (0.039)	-0.365 (0.037)	-0.172 (0.051)	-0.393 (0.048)
perscare	0.154 (0.058)	0.178 (0.051)	0.138 (0.056)	-0.028 (0.063)	-0.404 (0.059)	-0.439 (0.082)	-0.350 (0.076)
tobacco	1.221 (0.145)	2.458 (0.215)	2.377 (0.214)	-0.389 (0.112)	-0.258 (0.104)	0.516 (0.154)	0.563 (0.145)
transpor	-0.015 (0.029)	0.224 (0.027)	0.180 (0.030)	-0.322 (0.033)	-0.250 (0.031)	-0.252 (0.043)	-0.069 (0.040)
other1	-0.185 (0.113)	-0.340 (0.090)	-0.393 (0.102)	-0.535 (0.130)	-0.574 (0.124)	-0.606 (0.171)	-0.608 (0.162)
other2	-0.030 (0.109)	0.110 (0.097)	-0.162 (0.100)	0.047 (0.124)	-0.084 (0.114)	-0.128 (0.160)	-0.118 (0.149)
other3	-0.120	-0.160	-0.088	-0.264	-0.322	-0.474	-0.545
	(0.079)	(0.066)	(0.076)	(0.090)	(0.089)	(0.119)	(0.115)
allgoods (IV)	0.026 (0.019)	0.162 (0.017)	0.199 (0.020)	-0.079 (0.022)	-0.373 (0.021)	-0.358 (0.028)	-0.296 (0.027)
allgoods (no-IV)	0.061 (0.020)	0.222 (0.016)	0.262 (0.020)	-0.060 (0.023)	-0.384 (0.022)	-0.367 (0.030)	-0.305 (0.029)

Notes:
1. Standard erros are in parenthesis.
1. Results to be compared to equation (16) in Deaton, Ruiz-cvastillo and Thosmas (1989).

Table 2.10.
Outlay equivalent ratios: deviations from means as in Deaton, Ruiz-Castillo and Thomas (1989).

	Age group		
Commodity	**9-13**	**5-8**	**0-4**
clothing	-0.524	-0.494	-0.437
	(0.029)	(0.040)	(0.056)
educat	0.901	-0.251	-0.998
	(0.112)	(0.139)	(0.143)
alcohol	0.096	0.099	0.274
	(0.107)	(0.149)	(0.141)
alcohout	-0.206	-0.052	-0.194
	(0.043)	(0.059)	(0.057)
entertain	0.085	0.191	-0.305
	(0.058)	(0.081)	(0.077)
health	0.411	0.215	1.529
	(0.150)	(0.205)	(0.234)
mealout	-0.170	0.057	-0.208
	(0.043)	(0.060)	(0.058)
perscare	-0.209	-0.210	-0.166
	(0.060)	(0.083)	(0.079)
tobacco	-0.062	0.745	0.747
	(0.098)	(0.145)	(0.137)
transpor	-0.055	-0.023	0.115
	(0.039)	(0.055)	(0.053)
other1	-0.379	-0.377	-0.424
	(0.116)	(0.160)	(0.152)
other2	0.112	0.101	0.067
	(0.107)	(0.150)	(0.140)
Wald test (11)	529.286	314.721	117.401

Notes:
1. Standard erros are in parenthesis.
1. Results to be compared to equation (16) in Deaton, Ruiz-cvastillo and Thosmas (1989)

Chapter 3

The effects of children on demand in the surroundings of child birth

3.1. Introduction.

The effects of children on household demand are important both empirically and politically. They play a fundamental role in government welfare policies. For example, in income maintenance programs, families with many or older children receive, in general, larger benefits than those with fewer or younger children (Deaton and Muellbauer, 1986). In general, every aspect of household economic behaviour is significantly correlated with the presence of children in the household.[93] As acknowledged by many authors, the effects of children on household behaviour may start even before the child is born, in anticipation of this event, and last for some time after the child has left the family.[94] Among other

[93] As pointed out by Browning and Lechene (1995), children affect almost all facets of household economic behaviour. They claim that these effects can be classified in direct and indirect effects, being these last effects correlated heterogeneity (fixed effects) or state dependence.

[94] Pashardes (1991) stresses that the costs of children are in fact paid from reducing consumption in periods when children themselves are not in the family. The extent to which parents are willing and able to meet child costs through intertemporal transfers would affect static comparisons of consumption costs between families with and without children. The household may be saving for future children (precautionary and life-cycle or anticipated savings,

demographic factors, the structure and composition of the household is quite important for saving behaviour (Browning and Lusardi, 1996).[95] Parents may provide for their children by using savings or reducing current consumption, and therefore the use of contemporaneous analysis to draw conclusions about the effect of a household feature with a life-cycle dimension would be misleading (Pashardes, 1991).

The arrival of a child in a household influences labour supply and savings plans long before children arrive as households may account for the demand of children when they attain certain age. This issue requires an explicitly life-cycle perspective (Browning, Deaton and Irish, 1985). The limitation of the static analysis of children effects is that one would only be taking into account one snapshot of an intertemporal process. For example, when measuring child costs, it is expectable that these costs are spread over the life-cycle and then the importance of looking at the intertemporal (and contemporaneous) aspects of them, as the static measure would only be close to the real one if households were unable (or unwilling) to transfer these costs over time (see Pashardes, 1991).[96] Deaton and Muellbauer (1986) recognise the existence and importance of wider concepts of children costs, as the net costs to the parents over the life-cycle could be very different from short run costs that are inferred from studying household budgets, the costs of being born for those with very young children, or the costs of education that are borne by parents with college-age offspring.

An important issue in an intertemporal approach to analyse children effects is the existence of important links between labour supply, fertility and consumption. Browning and Meghir (1991) stress that one weakness of most of the studies that look at the effects of children is that they take no account of the effects of differences in labour supply on demands. Indeed, labour supply

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as mentioned by Browning and Lusardi, 1996) and then they reduce their consumption in anticipation to this. Banks, Blundell and Preston (1994) point out that it would seem natural to expect household expenditure to be influenced by anticipated demographic change, and their results suggest that this is indeed the case.

[95] Looking at saving behaviour across household types, savings are found to be higher for married couples and lower for household with children, while single heads with children have the lowest saving rate in the population (see Avery and Kennickell, 1991, and Smith, 1994).

[96] Pendakur (1998) also speaks about the concept of lifetime child costs.

decisions of the wife are highly correlated with the presence and ages of any children in the household. Thus, any estimate of child related effects from demand systems that take inadequate account of labour supply is likely to be biased.[97] This is specially crucial when investigating intertemporal children effects as the labour supply behaviour of the wife in the surrounding of child birth (specially first birth) is quite important in the determination of life-time work experience.[98]

Our concern in this chapter is to analyse the effects of the arrival of a new child in a household in the periods around birth date (six and three months before and three, six and nine months after) on household expenditure patterns over time.[99] In general, the arrival of a new child coincides with a reallocation of the life-cycle expenditure, and not simply a reallocation of "within-period" expenditure shares. It is important to note that around this period some potentially important changes are taking place in the household, like changes in the labour supply (of the wife mainly) and changes in needs (i.e. nutritional effects), see Browning (1992).

To look at this issue we place our problem in an intertemporal setting from which we derive a system of *Frisch* demands for household commodities. We use a panel data set drawn from the Spanish ECPF. The advantage of using panel data, apart from controlling for individual heterogeneity, is that it is possible to detect exactly when a new child arrives in a household. This permits to look at periods before and after this event and check the extent of children effects in the surroundings of child birth.[100] To analyse these effects we incorporate a set of dummy variables in the demand function capturing how many periods a household is still ahead of the birth of a baby (if any baby is born during the period the

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[97] Browning and Meghir (1991) present some evidence that suggests that the assumption that preferences over goods are separable from labour supply is a poor assumption. Arellano and Carrasco (1996) also present some evidence of the relationship between female labour force participation and children variables allowing for individual effects.
[98] As stressed by Browning (1992), even if we condition on other variables, first birth employment is still a significant determinant of life-time work experience, affecting household demand and consumption behaviour.
[99] We focus on this period as in the data set we have we can only track households during 8 consecutive quarters.
[100] This is in line, somehow, with Deaton and Muellbauer (1986) remark about how important would be to follow households through the life-cycle (although we can only track them over eight quarters).

household stays in the sample) and how many periods have passed since that event (we also account for the birth date itself). We model a demand system for 12 commodity categories where the classification of goods has been driven by the idea of having specific children goods (i.e., *children* and *baby clothing*)[101] and specific adult goods (*tobacco*, *alcohol* or *out*) to be able to detect children effects (as income effects and other kind of children effects) on different commodities (see Deaton, Ruiz-Castillo and Thomas, 1989 and Browning and Lechene, 1995).

In this intertemporal dimension of the effects of children, it is also interesting to analyse the concept of intertemporal demographic separability. We would expect that the path of expenditure of a demographically separable good would remain unchanged (only income effects implied by the arrival of a child affects these goods), whereas for a non-separable good (like children clothing) we would expect other children effects apart from income effects.

To anticipate the main results, we obtain that there are important "jumps" in some children related expenditures (*clothing, entertainment* and *food*) and no changes in the adult goods. We also find some effects when interacting dummy variables capturing the timing of birth with participation dummies, prices and the interest rate. The "jumps" we find seem to reflect that children are to some extent anticipated by the Spanish households within the life-cycle. This result has also been pointed out by Browning (1992), Browning and Lechene (1996) or Browning and Lusardi (1997), among others.

The rest of the chapter is organised as follows. In Section 3.2 we present a life-cycle demand model from which we derive a system of *Frisch* demands and analyse the concept of *Frisch* demographic separability and its relation to demographic separability. In section 3.3 we report the empirical model, some econometric issues and the econometric treatment. Section 3.4 is devoted to the discussion of the results and section 3.5 concludes.

[101] Browning (1992) makes a distinction between children and adult goods.

3.2. An intertemporal model for household demand.

The theoretical approach we use to model the intertemporal consumption problem is the conventional model of life-cycle consumption under uncertainty proposed by Hall (1978).[102] In our specific model we follow closely the intertemporal demand model under uncertainty developed in Browning, Deaton and Irish (1985), although we only consider the demand for commodities as the decision variables.[103] The advantage of this approach is that it allows the derivation of constant marginal utility demand functions, or *Frisch* demands. These kind of demand functions separate between anticipated and unanticipated effects of both prices and demographic structure of the household. The important development of this kind of modelling is the realisation that the constant unobservable marginal utility (over the lifetime of the consumer), can be treated as a fixed effect in the econometric analysis.[104] We assume that households preferences over goods can be characterised as satisfying intertemporal additive separability and households maximise utility with continuos replanning (under uncertainty).[105] Households choose their most preferred allocation of expenditures subject to the constraint that the discounted value of the lifetime expenditures equals the present value of lifetime wealth. Conditional on labour supply and other socio-demographic variables, commodity demands at t are chosen to solve the following Bellman equation[106]

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[102] As stressed by Deaton (1992), one of the distinguishing features of recent research on consumption has been the way in which uncertainty has been introduced into the analysis.

[103] We will incorporate labour supply variables as conditioning the demand decision. Therefore, this is an intertemporal model that follows the conditional approach put forward by Browning and Meghir (1991) and Meghir and Weber (1996).

[104] This important development is due to MaCurdy; see Heckman (1978a), Heckman and MaCurdy (1980) and MaCurdy (1981).

[105] The additive separability assumption over time allows to separate the optimisation problem into two stages, i.e. two stage budgeting. Total consumption is first allocated between time periods, and then, subject to this upper stage allocation, each period consumption is distributed among commodity groups, Gorman (1959). We also assume that the additive form of the utility function characterises both intertemporal separability and the additivity over states that is implied by the conditional preference axiom of choice under uncertainty, see Browning, Deaton and Irish (1985).

[106] We implicitly assume that the household has made its fertility and human capital plans. Thus, we will not discuss whether children are the result of a choice.

(3.1) $V_t(A_t) = \underset{A_{t+1}, q_t}{Max}\{u_t(q_t; z_t) + E_t V_{t+1}(A_{t+1})\}$

where $u_t(\cdot)$ is the intratemporal utility function, q_t is a vector of goods in period t, z_t is a vector of labour participation dummies, socio-economic and demographic variables, and A_t is non-human wealth at the end of period t.[107] The evolution of assets is given by the standard difference equation

(3.2) $A_{t+1} = (1+i_t)(A_t - p_t q_t) + y_t$

(3.3) $A_T = 0$

where i_t is the real interest rate, p_t is a vector of prices of goods in period t, y_t is household income in period t and T is the length of life for the household. The expectations operator E_t is taken with respect to future prices, interest rates, and income flows which are assumed uncertain.

The first order conditions for the maximisation of (3.1) subject to (3.2) and (3.3) are

(3.4) $\lambda_t = E_t[(1+i_t)\lambda_{t+1}]$

(3.5) $\dfrac{\partial u_t(q_t; z_t)}{\partial q_{jt}} - p_{jt} E_t[(1+i_t)\lambda_{t+1}] = 0$

where $\lambda_t = \partial V_t / \partial A_t$ is the marginal (lifetime) utility of period t's money (or the reciprocal of the undiscounted price of utility). Equation (3.4) is the standard Euler equation. Therefore using the first order conditions one can derive the *Frisch* demand function for good i under uncertainty as

(3.6) $\dfrac{\partial u_t(q_t; z_t)}{\partial q_{it}} = p_{it}\lambda_t$

[107] The period sub-utility functions are indexed on age t trying to reflect both intertemporal discounting of utility and the modifying role played by the presence and/or the arrival of children and their changing demands over the family life-cycle, as in Browning, Deaton and Irish (1985).

The intertemporal additivity assumption allows decentralisation over time (age), and each period of the life of a household can be seen as the site for an independent utility factory and lifetime utility is the sum of all the household plant outputs, Browning, Deaton and Irish (1985). The link between periods is the discounted price of lifetime utility, i.e. the reciprocal of the marginal utility of lifetime wealth.[108] Under uncertainty we have that commodity demands are chosen to maximise a value function like equation (3.1) that still has a two period intertemporal additive structure between period t and the expected future (from $t+1$ to T). Consequently, *Frisch* demands under uncertainty can be written as

$$(3.7) \quad q_{it} = f_{it}(\lambda_t, p_t, z_t)$$

for period t demand of good i, conditional on λ_t, which is the (lifetime) marginal utility of wealth as perceived at t. The only difference between certainty and uncertainty is the process controlling the evolution of λ_t that is derived from the dynamic optimisation.[109]

As pointed out by Browning, Deaton and Irish (1985), the interpretation of the life-cycle *Frisch* demands is as follows. Under uncertainty, households are constantly receiving new information. If the new information makes the expression (3.4) to hold exactly (not in expected terms) households continue to consume in the predetermined life-cycle path as they do not perceive any new information. Thus *Frisch* demands separate between the effects of movements along the path from movements of the path itself caused by new information.

Finally, in order to estimate *Frisch* demands one has to bear in mind that these are functions of some within period observable variables (prices, socio-demographic characteristics). All the variables from outside the period are

[108] Define the age t profit function under certainty by $\pi_t(\lambda, \hat{p}_t, z_t) = \max_{u, q_t}\left\{\frac{1}{\lambda}u(q_t; z_t) - \hat{p}_t q_t; v_t(q_t; z_t) = u\right\}$. Profits accrue from selling utility and we have as costs the cost of inputs. Then we have the *Frisch* demands as, $-\frac{\partial \pi_t}{\partial \hat{p}_{it}} = q_{it} = f_{it}(\lambda, \hat{p}_t, z_t)$. A caret over a variable means that the variable is discounted to its present value.

[109] The incorporation of uncertainty to *Frisch* demand functions makes the marginal utility of wealth to follow a stochastic rather than a deterministic process.

represented by λ_t.[110] Under perfect certainty $\lambda_t = \lambda$ would be fixed and, given panel data, could be treated as a fixed effect in the econometric analysis, whereas under uncertainty there are several approaches to deal with the stochastic nature of λ_t. In this chapter, we use an approximation for the Euler equation that eliminates the unobservable term.

3.2.1. Demographic separability and the life cycle costs of children.

An interesting issue in the context of intertemporal demand functions (with *Frisch* demands) is the concept of demographic separability and its relation to a lifetime consistent measure of children costs. The costs of children are usually defined as the extra expenditure that a household with children needs to enjoy the same level of welfare that it would have had without them. As put forward by Banks, Blundell and Preston (1996) when one places the welfare measurement in an intertemporal context it is possible to detect consumption changes that occur following a change in the demographic structure of the household and this would come closer to reflecting the consumption costs of children. An intertemporal analysis of this can help to approach a life cycle consistent measure of children costs. However, one should keep in mind that children costs cannot be fully identified as expenditure behaviour cannot identify costs of children without making assumption about these preferences.[111] A key point in measuring the costs of children would be to realise that if intertemporal substitution responses are allowed for in a household, then measuring costs of children using within period spending might be quite restrictive.

One way to make assumptions in order to identify children costs could be via the concept of demographic separability. Deaton, Ruiz-Castillo and Thomas (1989) analyse a concept of demographic separability that formalises the idea that there are groups of goods (adult goods) that have little or no relationship to specific household demographic characteristics (number and age of children).

[110] Many of these variables (such as future income and future prices) are unobservable. λ_t is the marginal (lifetime) utility of wealth in terms of period t's money or as perceived in t.
[111] See Pollak and Wales (1979), for example.

Although the concept of demographic separability may be interesting in itself, one of its most appealing feature is its relation to the measurement of child costs. Within period demographic separability is a suggestion for structuring demand functions across households of different composition, i.e. structuring the preferences for households with children. An attractive idea for identifying child costs is the idea introduced by Rothbarth (1943) that considers expenditure on a group of adult goods as an indicator of adult welfare. Under a specific interpretation of the Rothbarth method, it is a special case of demographic separability (see Deaton, Ruiz-Castillo and Thomas, 1989 and chapter two) that legitimates the method proposed by Rothbarth for the evaluation of children costs.

Then, the aim in investigating theoretically the implications of *Frisch* demographic separability is to relate this concept to the possibility of measuring (lifetime) children costs when dealing with an intertemporal setting. Suppose preferences are intertemporally additive and let the Marshallian, Hicksian and Frisch demands be denoted $\mathbf{f}_t(x_t, \mathbf{p}_t, z_t)$, $\mathbf{g}_t(u_t, \mathbf{p}_t, z_t)$ and $\mathbf{h}_t(\lambda_t, \mathbf{p}_t, z_t)$, respectively. Within period demographic separability of the adult goods $\mathbf{q}_{1t}$ requires

$$(3.8) \quad \mathbf{f}_{1t}(x_t, \mathbf{p}_t, z_t) = \phi_t(\vartheta_t(x_t, \mathbf{p}_t, z_t), \mathbf{p}_t)$$

for some scalar function $\vartheta_t(x_t, \mathbf{p}_t, z_t)$.

One example of this is what we call Frisch demographic separability where

$$(3.9) \quad \mathbf{h}_{1t}(\lambda_t, \mathbf{p}_t, z_t) = \psi_t(\lambda_t, \mathbf{p}_t)$$

so that demographic separability holds with $\vartheta_t(x_t, \mathbf{p}_t, z_t) = \lambda_t(x_t, \mathbf{p}_t, z_t)$. This holds only if the profit function takes the form

$$(3.10) \quad \pi_t(\lambda_t, \mathbf{p}_t, z_t) = \alpha_t(\lambda_t, \mathbf{p}_t) + \beta_t(\lambda_t, \mathbf{p}_{2t}, z_t)$$

where $\mathbf{p}_{2t}$ denotes prices of the non-adult goods. The profit function and its relation to Frisch demand are discussed in Browning, Deaton and Irish (1985).

Another example of this is Rothbarth demographic separability where

(3.11) $\mathbf{g}_{1t}(u_t, \mathbf{p}_t, z_t) = \varsigma_t(u_t, \mathbf{p}_t)$

so that demographic separability holds with $\vartheta_t(x_t, \mathbf{p}_t, z_t) = v_t(x_t, \mathbf{p}_t, z_t)$. This is well known to hold only if the cost function takes the form[112]

(3.12) $c_t(u_t, \mathbf{p}_t, z_t) = a_t(u_t, \mathbf{p}_t) + b_t(u_t, \mathbf{p}_{2t}, z_t)$.

An interesting question is then whether these are compatible. We can use the fact that

(3.13) $c_t(u_t, \mathbf{p}_t, z_t) = \max_{\lambda}[u_t / \lambda \; - \pi_t(\lambda, \mathbf{p}_t, z_t)]$

to see that this is so if and only if

(3.14) $\beta_t(\lambda_t, \mathbf{p}_{2t}, z_t) = b_t(u_t, \mathbf{p}_{2t}, z_t) = \gamma_t(\mathbf{p}_{2t}, z_t)$

in which case within period child costs are independent of base. The point about the relation between Frisch and Rothbarth demographic separability is that they are the same only if λ_t does not vary with z_t given u_t, and this is exactly independence of base.

3.3. The empirical specification, econometric issues and the data.

3.3.1. The empirical specification.

In the selection of the functional form of the household profit function we follow Deaton, Browning and Irish (1985) and introduce the unobserved price of utility additively in the demand function in order to treat it conveniently as a fixed effect

[112] See Blackorby and Donaldson (1995).

(with or without random elements).[113] The household profit function is as follows,[114]

$$(3.17)\quad \pi_{ht}(p_t, \lambda_{ht}, z_{ht}) = \gamma\lambda_{ht} + g_t(p_t, z_{ht}) + \sum_{i=1}^{n} \mu_i p_{it} \ln(p_{it} / \lambda_{ht})$$

where i denotes goods (form 1 to n). Provided that $g_t(\cdot)$ is chosen to be linear homogeneous, the profit function is linear homogeneous. This function has the characteristics we require in the sense that it represents a flexible set of preferences that contain the unobservable price of utility as an additive effect.[115]

Taking a second order flexible function for $g_t(p_t, z_{ht})$, for parameters δ_i and $\theta_{ij}=\theta_{ji}$,

$$(3.18)\quad g_t(p_t, z_{ht}) = -\sum_{i=1}^{n} \delta_i(z_{ht}) p_{it} - \sum_{i=1}^{n}\sum_{j=1}^{n} \theta_{ij} p_{it}^{1/2} p_{jt}^{1/2}$$

we derive the following intertemporal function for the *i-th* commodity demand,

$$(3.19)\quad q_{iht} = \alpha_i(z_{ht}) + \beta_i \ln p_{it} + \sum_{\substack{j=1 \\ j\neq i}}^{n} \theta_{ij} \left(\frac{p_{jt}}{p_{it}} \right)^{1/2} - \beta_i \ln(1/\lambda_t) + \eta_{ih} + \varepsilon_{iht}$$

where the α's and the β's are parameters to be estimated that are related to the δ's, μ's and γ's, and where η_{ih} is an idiosyncratic term. Assuming that

$$(3.20)\quad \alpha_i(z_{ht}) = \alpha_{i0} + \sum_k \alpha_{ik} z_{kht}$$ [116]

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[113] Provided that this effect appears additively in the demand function there are several econometric techniques that allow dealing with it (first differences, within groups, orthogonal deviations, etc.).

[114] As mentioned by Browning, Deaton and Irish (1985), there are a number of choices for the dependent variable (e.g., logarithms). However, given that the presence of zeros in some of the goods we analyse may cause some problems and the fact that we are introducing some lags in the estimation of our demand functions, we choose quantities for the dependent variable.

[115] We also have that $\partial^2\pi_{ht}/\partial p_{it}\partial\lambda_t$ is homogeneous of degree -1 for all i and for positive constants μ_i, and $\partial\ \pi_{ht}/\partial\lambda_t$ is zero degree homogeneous.

[116] For simplicity we do not include interaction terms in this expression. In the empirical work we account for interactions in the analysis of some of the demand goods.

we have that the expression for the commodity demand can be written as follows,

(3.21)

$$q_{iht} = \alpha_{i0} + \sum_k \alpha_{ik} z_{kht} + \beta_i \ln p_{it} + \sum_{\substack{j=1 \\ j \neq i}}^{n} \theta_{ij} \left(\frac{p_{jt}}{p_{it}} \right)^{1/2} - \beta_i \ln(1/\lambda_t) + \eta_{ih} + \varepsilon_{iht}$$

Finally, it is interesting to stress that we have modified the model developed by Browning, Deaton and Irish (1985) to account for children, other socio-demographic characteristics and labour supply variables together with some interactions of these variables by making the α's functions of these variables and allowing also for an idiosyncratic error term.[117] This modification is similar to the conditional approach derived in Browning and Meghir (1991) and also applied in an intertemporal setting in Meghir and Weber (1996). One can notice that these equations are linear in the parameters and in the $\ln(1/\lambda_t)$ and can be used for estimation provided that we devise an approximation for the Euler equation.

3.3.2. Some econometric issues.

To estimate the unrestricted demand equations (3.21), we have to account both for the fact that there is a fixed effect capturing individual uncertainty and other unobserved elements in the equation that come from the so called "sufficient statistic", $1/\lambda_t$, Browning, Deaton and Irish (1985).[118] Formally, we are going to use the same approximation as Browning, Deaton and Irish (1985) for the Euler equation, (see also Blundell, Browning and Meghir, 1994). We write the Euler equation as $(1+i_t)\lambda_{t+1} = \lambda_t + \varepsilon_{t+1}$ with $E_t(\varepsilon_{t+1}) = 0$, and then we take logs and approximate $\ln(\lambda_{t+1}) \cong \ln(\lambda_t) - \ln(1+i_t) + \eta_{t+1}$ with $E_t(\eta_{t+1}) = 0$. Using this

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[117] Accordingly, we could also model the β parameters (in the above specification) modified by the socio-demographic variables. This kind of modification of the β's would be accounting for the different effect of some variables, e.g., the interest rate, for families in which a child arrives during the sampling period.

[118] The unobservable lifetime utility of wealth is a "sufficient statistic" in the sense that it summarises all the outside period elements that the individual does not know. It is a perception in period t (given the information at t), of the future values of prices, income, etc.

approximation for the Euler equation and taking first differences in equation (3.21), it is possible to estimate *Frisch* demands as everything that remains is observed.[119]

The arrival of a new child in the household can induce some *dynamic* behaviour on household demand. Intuitively and looking at the classification of goods we use in this chapter there is a group of goods which may be affected by these "new-born children" effects. For example, some expenditures can be done some time in advance as an anticipation of the event (clothing, push chair, cradle, baby bath,...) to spread the expenditures over time. Some of these expenditures are due to an increase in needs (the mother would increase her consumption of food, i.e., nutritional effects). Other expenditures have to be done inevitably once the baby is born (medical expenses, baby food, some clothing), whereas some other expenditures might be reduced due to the financial and time limitations that children impose on the rest of the household (going out, entertainment).

One of the main aims of this chapter is to check and estimate how the arrival of a new child affects household demand patterns in the surrounding of child birth. To capture these effects we construct a set of six time dummies (d_6, d_3, d0, d3, d6, d9) that account for the periods (quarters) in the surrounding of birth and birth itself. This set of dummies can be considered as a semiparametric approach for capturing the effects of a new-born child in a family. We incorporate this set of dummies in the intercept term, $\alpha(z_{ht})$, and the way these dummy variables work is as follows. If a child is born in a household in period t the dummy variable d0 takes value 1 in period t and in subsequent periods. Accordingly, d_3 and d_6 start being equal to 1 in t-1 and in t-2, respectively. In the same way d3, d6 and d9 start taking value 1 in periods t+1, t+2 and t+3, respectively.[120] Moreover, we also account in some goods for differences in the wife's labour supply behaviour as a consequence of the arrival of a child in the

[119] To remove the unobserved individual effects we could use orthogonal deviations. However, we must note that using an alternative to first differences implies to approximate the Euler equation in a different way than the one proposed above.

[120] Note that we use quarterly data and then d_6 tries to reflect that we account children effects 6 months before the baby is born.

household (as we include interactions of labour supply variables and time to birth dummies).

The fact that we are implicitly assuming that households have made their fertility plans (in an upper stage) does not prevent us to account for the effects of children in the demand function. However, we should discuss to what extent we can still have a problem of endogeneity in these variables. We have deliberately chosen the children variables in a way that allows to consider them as predetermined. First, we have a group of variables that account for the number, sex and age of children older than one year. Second, to account for children aged less or equal to one year we introduce the set of dummy variables mentioned above. By doing this we avoid, somehow, the endogeneity of the fertility decision given that the first of these dummies takes value one six months before birth.[121] Fertility decisions may be endogenous when they are introduced in the model together with labour supply decisions (as in Arellano and Carrasco, 1996) or when they are modelled with consumption decisions (as in Browning and Meghir, 1991). In our case knowing that a child is born in period *t* makes the set of dummy variables predetermined (to the econometrician), although the fertility decision in itself may still be endogenous.

Browning (1992) highlights that it looks like fertility is "causing" income over the life-cycle, or that some common set of variables are jointly driving income and fertility. He then suggests that it would be worth while to investigate further income, consumption and fertility decisions in a joint framework. We take this view in the sense that, on the one hand, we do not take labour supply as exogenous, and on the other hand, the way we account for children and child birth allows us to consider these variables as predetermined. In our empirical estimation we also account for labour supply variables as we condition demand on

[121] As mentioned in Browning (1992), some approaches, specially in the female labour supply literature, account for the endogeneity of one or two of the children variables, like planned completed fertility or number of new born babies. Contrary to this approach, we consider that the problem of endogeneity is so only 9 months before birth. In this line Arellano and Carrasco (1996) treat children variables (2 dummies that account for the presence of children between 1-2 years old and between 3-5 years old) as predetermined variables by conditioning on lagged children and wife participation.

labour supply (both for the head of the household and his wife). Due to the potential endogeneity of these variables, we estimate the demand functions instrumenting these variables using education for the head of the household, and job status variables for both workers in the family.[122]

Other estimation problems may arise from having zero expenditure records for some goods. The reasons behind these records are diverse and so has to be the estimation technique. After analysing the importance of this problem in our sample[123] we estimate the *entertainment* equation, where the main reasons for the zero records seems to be non-participation and infrequency of purchase, by using a reduced form p-tobit model in each period. We then predict the entertainment expenditure for each household in each period and use a Generalised Method of Moments (GMM) two-step procedure to estimate the structural demand equation, accounting for unobserved heterogeneity.[124] For *tobacco*, where the main reasons for the zeros are non-participation and corner solutions, we estimate a reduced form independent double-hurdle model for each period. Combining, again, the reduced form predictions for tobacco expenditure, we obtain the structural form parameters of the demand equation using a two-step GMM estimator (see appendix A for details). The rest of the equations have been estimated using a standard linear GMM procedure (see Arellano and Bond, 1991) under the identifying assumptions previously mentioned.

Finally, an interesting aspect when estimating intertemporal demand functions is the importance of dynamics. The durability of some goods (like adult, baby and children clothing) and habits in consumption of some other goods like tobacco and alcohol suggest the possibility of including some dynamics. For some other goods (like *health* or *house energy*) it seems that dynamics do not play any role in the demand function. Potential cross relationships among goods capturing

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[122] Education information is only available for the head of the household. Moreover we only use participation dummies for labour supply as this is the only information we have in our data set.
[123] In table 3.A.1. in the appendix we report the proportion of zeros in each of the demand categories we model.
[124] See Bover and Arellano (1997) for details.

substitution and complementary effects among goods across time could also be analysed.[125]

3.3.3. The data.

We use eleven years (1985-1995) of the Spanish ECPF. This is a rotating panel based on a comprehensive survey run by the Spanish National Institute of Statistics (INE), which involves interviewing 3,200 households every quarter (12.5% of the households being replaced every quarter by a new randomly drawn group).

To estimate our model we select out all those households who are, for whatever reason, not observed for eight quarters in order to get a (balanced) panel of households (with or without children).[126] Moreover, to follow the arrival of children and to construct the set of dummies to birth we need to have the maximum number of periods. We further select out all those households whose head is very young (less than 18) or retired (more that 65), those households in which both partners are pensioners, and those who reported a zero expenditure on food, total expenditure and total income below a threshold (25,000 and 45,000 pesetas, respectively). After all these selections, our sample is composed by 45,632 observations (5,704 households during 8 quarters). In the data appendix there is a more detailed description of these data.

The distinctive and extraordinary aspect of these data is that one can follow the same household for eight consecutive periods (2 years), and this enables to detect how many births have occurred during the sampling period. Therefore, we can analyse the effects of new born children on household demand

[125] Following Meghir and Weber (1996), we have checked using OLS estimates of a simple VAR of order 4 for all the goods we model (together with a joint significance test) to what extent we have some dynamics in our demand equations Our results show that the correlation between levels of consumption is important. Also, it turns out that some of the cross relationships are quite significant. Due to its interest, this issue is going to be analysed in another piece of research and therefore is out of the scope of this chapter.

[126] We are aware of the possibility of attrition bias when estimating the balanced rather than the unbalanced panel. In any case, it is not likely for consumption to be correlated with the decision to leave the survey, given fertility decisions or other conditioning sets.

and/or labour supply of the wife in the surrounding of child birth. In our sample we account for 396 children born during the sampling period.[127] This means that a new born child arrives in 6.9% of households participating in the sample (this figure raises to 9.54% if we account for children born within the 3 months before the interview). The distribution of the new born children, by number and sex, is presented in table 3.1. To check the representativeness of this child birth rate we have calculated the sample fertility rate for this period dividing 9.54% by 8 (number of quarters), obtaining a figure similar to the figure reported by the OCDE for Spain (1.2%).[128]

We further investigate whether there is a pattern of births by quarters. By a simple inspection of the data, new born babies look as if they were planned to be born in the first and fourth quarters of the year (i.e. between September and March), since 64% of them are born during these months. This gives some evidence to the view that children are, in general, planned. This specific pattern could be associated with the Spanish weather in the sense that women may prefer to carry their babies and to give birth in the coolest months of the year.

To capture the effects of new-born children around child birth date we consider the following (non-durable) commodity grouping: *food* (consumed at home), *alcohol*, *tobacco*, *adult clothing*, *children clothing*, *baby clothing*, *house services* (electricity, gas, water and other non-durable goods like cleaning products), *health*, *transport* (defined as the sum of motor fuel and public transport), *entertainment*, *out* (defined as meals out and expenditures in bars, pubs, etc.) and *other* (rest of non-durables).[129] To account for male and female

[127] The real figure increases to 543 births if we also account for those children born in the 3 previous quarters that a household collaborates. We can detect these extra children born because in the data we have both number and age of children.

[128] As the sample used by the ECPF is representative of the Spanish population, one could just take the fertility rate on each quarter and calculate an average for the 8 quarters to get the national figure. Regardless of the method we use, we get a figure around 1.2, on average.

[129] Some other children related goods we tried to analyse are expenditures on nappies and expenditures on nurseries. It was impossible to get the first category (nappies) isolated from the other goods in the same category (i.e., expenses in chemist goods), and therefore the impossibility of checking the effects of the arrival of a child on this expenditure. The prediction one can make in a good like nappies would be similar to the effects on food at home: this is a good for which the expenses are difficult to be postponed or anticipated. For the other category (nurseries) it does not exist a category in the ECPF as itself. Finally, it is important to remark

labour supply we introduce participation dummies. We account for the effect of demographic and socio-economic characteristics by introducing indicator variables for the presence of children by sex and age, the presence of other adults in the household, age and education of the head. We also include time dummies and use quarterly prices. For the interest rate we use the deflated interest rate charged on credit for consumption (for credits between 1 and 3 years). This interest rate is monthly published by the Bank of Spain.[130]

As regards to the demographic variables it is worth giving some more details about the children related variables. To incorporate household composition variables we account both for age and sex of children older than 1 year and younger than 18. Specifically we introduce 12 children indicator variables: *nm1* (*nm2, nm3, nm4_8, nm9_13, nm14_17*) if there is a male child of age 1 (2, 3, between 4 and 8, between 9 and 13, between 14 and 17) in the household, and the same structure if there is a female child (*nf1, nf2, nf3, nf4_8, nf9_13, nf14_17*). For families having a child younger than one year old we introduce a set of dummy variables that are meant to capture the effects of children in the surroundings of child birth. These account for child birth (*d0*), the number of periods before birth (*d_6, d_3*) and the number of periods after birth (*d3, d6, d9*).[131] *d0* takes value one when a child is born in the family, *d_6* takes valued one quarter before birth and *d_3* takes value one two quarters before birth. And *d3*, *d6* and *d9* take value one, when one, two and three quarters after birth have passed, respectively. Some final remarks on the construction of these demographic variables are worth to be made. It is important to be able to distinguish between just born babies and babies older than one year to avoid the endogenous fertility issue. It is also interesting to take into account whether the

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that the majority of nurseries in rural areas in Spain are state owned (and are free or highly subsidised) or are public supported (and run privately). For the nurseries in the cities, prices are not so high, and households can get some deduction of these expenses in the income tax system.

[130] We build real quarterly prices using monthly prices published by the Spanish National Institute of Statistics (INE). As we do not calculate household prices (i.e., we do not use an individual Stone price index), quarter dummies parameters are not independently identified, therefore we only include year dummies for identification reasons. The deflator for both prices and the interest rate is the Retail Price Index also published by the INE.

[131] We can also account for children born in quarters previous to household participation in the sample. This allows us to create, for some of the families, the dummy variables d3, d6 and d9.

child is a first child in the household or there are other siblings in the same household. In the case of households with several children it would be interesting to account for the sex of the children and also, if a new child arrives, the time elapsed between the last baby and the new one, the season in which they are born, etc., as most of the goods that the household buys for their children can be used by a second or other children. We should bear all these questions in mind as the effects of children in some goods like clothing, pushing-chair, etc., may depend quite importantly in all these kind of aspects.

Finally, we have also investigate female participation rates in the labour market in relation to births. Table 3.2 presents female participation rates and tables 3.3 to 3.5 present transition matrices that look at the changes from full-time, part-time and unemployment to full-time, part-time and unemployment, for women who get a child during the sampling period. We look at transitions from six months before birth to the period in which the woman gives birth (i.e., from t-2 to t), to transitions from t to t+2 (where t refers to the period in which the child arrives, and to transitions from t-2 to t+2.[132] In order to understand these tables we should note that the maternity leave allowance in Spain is sixteen weeks and normally women stay at work, if possible, until they give birth and enjoy the maternity leave right after giving birth. The results we get in these tables seem to be in line with these, i.e., women start leaving the labour market after giving birth (the participation rate of women who get a child drops). Looking at the transitions, we can say that the highest transition before birth is from employment to unemployment, whereas we get that both the transitions from employment to unemployment and from unemployment to employment are important right after giving birth. Therefore, we can distinguish between two changes: first, women joining the labour market once they have given birth, and second, women still dropping (maybe they have decided to drop for good or for a long period to raise their children) after giving birth.

[132] It is important to notice that during the 80s and the beginning of the 90s the Spanish labour market was not flexible enough to allow for a significant proportion of part-time jobs.

3.4. Empirical results.

3.4.1. An informal look at the data.

Before proceeding with the estimation results, we consider that two graphical analyses could be of interest. First, given that our focus is on the life-cycle patterns of consumption, it is interesting to present some of the principal features of the data that might be important for consumption. We look at the life-cycle behaviour of some demographics (the number of young and old children), income and consumption (total expenditure) and female participation in the labour market. In figure 3.1, we plot the behaviour of these variables. We construct cohort data to get these figures.[133] In all figures, each line represents the evolution over time of the relevant variable for one date of birth cohort defined over a five year band. In figure 3.1(a) we present the life-cycle path of consumption (total real expenditure). We get the familiar pattern that consumption rises initially and then falls after the late 40s.[134] This result is also obtained for the British Family Expenditure Survey (FES). Figure 3.1(b) shows the evolution of real income. Comparing this graph to figure 3.1(a) it is possible to notice the correlation between them and the shape. As in Blundell, Browning and Meghir (1994) if we assume that income is exogenous, then it seems like consumption tracks income over the life-cycle. In figures 3.1(c)-3.1(f) we plot the paths of some potentially important determinants of consumption and income (children and labour supply of the wife). For the path of children over the life-cycle we construct three figures. First, "old children" (children between 5 and 17 years old), second, "young children" (children between 0 and 4 years old) and third "children" (all children in the household). The shape we get in all these figures is very similar to the one obtained with the FES data. Moreover, as expected, the wife's participation in the

[133] To create cohort data we use the same methodology used in Browning, Deaton and Irish (1985), Deaton (1985) and Blundell, Browning and Meghir (1994). The average number of observations per cell is reported in table 3.A.4 of appendix B.

[134] See Browning, Deaton and Irish (1985), Attanasio and Weber (1989) and Blundell, Browning and Meghir (1994).

labour market drops during the child bearing period (at the beginning of the 30s). The number of children starts to drop after women leave the labour market. It seems that women leave the labour market when they get children but they do not come back to the labour market after the child bearing period, therefore there is a decreasing participation over the life-cycle that is more important in the period when children are young. Another interesting feature of the data is that although female participation falls in the period when children are young household income does not. As noticed in Blundell, Browning and Meghir (1994) one explanation would be that the timing of births in a family is decided taking into account the husband's career profile.[135]

Using our estimation results, in figure 3.2 we present some graphical evidence of how the arrival of a new child affects the intertemporal consumption of the household. In these figures we plot the estimates of the six dummies to birth for the 12 goods we model (together with confidence intervals). We take as reference child birth (set the value equal to zero) and draw a line for each good category that represents the mean sample of each expenditure in each figure (in order to have a reference in each commodity category). Bearing in mind the predictions of the life-cycle theory of consumption and remembering that we are estimating an intertemporal household demand system, we can stress the following results. For most of the non-durables goods we analyse, we get that the effects of the six dummies to birth are not significant (we do not get any significant jump). For some other goods, i.e. *food at home*, *baby clothing* and *entertainment* we do get significant jumps. For the category in which we have expenditure on nappies (and other hygiene products) we also get a significant jump at d0. These results suggest that in households where a new child arrives

[135] Although it seems that these graphs look quite intuitive about the life-cycle features of our data, it is very difficult to infer anything about life-cycle consumption since we do not account for the possible endogeneity of some factors that affect consumption and it is impossible to distinguish between anticipated and unanticipated components in the series, Blundell, Browning and Meghir (1994). Therefore we present below an econometric analysis that would take account of these problems by conditioning on demographics and labour market variables and using an instrumental variables approach.

there are some expenditures (children related expenditures) that can not be smoothed away from the periods around child birth.

Furthermore, it is interesting to think about these goods as intertemporally non-demographically separable, using an intertemporal interpretation of the concept of demographic separability. This finding is also in line with a deeper definition of demographic separability. The effects of the arrival of a new child are none for demographic separable goods, whereas we get significant effects on the expenditures of non-demographic separable goods, in an intertemporal context. The most clear cut example is the evolution of baby and children clothing expenditure and also, to some extent, food at home. We get a significant jump at birth date. For food at home we could expect this kind of behaviour as households can not postpone to feed a baby, and the same kind of argument applies to clothing although this is a more spreadable over time commodity. Weaker evidence is found in other goods like house energy for which one could expect an increase in some of its components (i.e., electricity) when a child arrives. In the same line than food at home and children clothing, there are other goods (as nappies and nurseries expenditures) for which we could expect a jump when the child arrives. Unfortunately with the classification of commodities available in the ECPF it is not possible to isolate any of these two categories.

3.4.2. Estimation results.

We estimate an unrestricted demand system of 12 equations derived from an intertemporal demand function.[136] Ten of these equations are estimated using a typical linear GMM method (see Arellano and Bond, 1991) and the other two using the two step-procedure previously explained (see appendix A, for more details). In table 3.6 we report some of the estimation results we obtain. We can

[136] Two of the 12 categories have been analysed further. We separate the category house energy and services into two sub-categories: *house energy* on one hand and *house services* on the other hand. As the results did not change substantially we have left the former category. We also separate health into two sub-categories: *nappies* (in which there are other hygiene products) and the rest of *health* categories. As it seems that the results obtained in health are driven by the nappies category we report both set of results.

separate the group of commodities we model into three sub-groups. First, we have those goods for which the coefficients of the dummy variables are jointly non-significant for the six dummies (specifically, *tobacco, house commodities* and *house energy, transport, out* and *other non-durable goods*). Although there are some variables which are individually significant or at least at the borderline of significance, we can not reject the null of joint significance for all these groups. These results suggest that the arrival of a child in a household does not affect the life-cycle demand pattern for these goods. Intuitively, one could expect that new born children would affect the demand of some of these goods, for example *house energy* or *out*,[137] as the arrival of a new child implies some extra *needs* and/or time and money restrictions for the household. As we do not get any significant effect, it seems that the household perfectly anticipates the arrival of the child and all the effects are already incorporated in the life-cycle setting.

We have a second group of goods for which we can not reject the null hypothesis that the six dummies to birth are jointly equal to zero, although we get some coefficients significantly different from zero (*alcohol, tobacco, adult clothing, rest of health* and *nappies*). For *alcohol* and *tobacco* it seems that households drop their consumption when a new child arrives. The reasons for this may be diverse, parents may decide to give up smoking when they have a baby, the mother should not drink or smoke if she is breast feeding her child or taking care of her, etc.

Finally, we have those goods for which some of the dummy variables are significant: *food, children* and *baby clothing*, and *health* (under the broader definition). A good that seems to be affected by the arrival of a child in the family is *food.* We get positive (and significant) coefficients for the dummy variables *d0* and *d3.* For *baby clothing* we get positive and significant parameters for the dummy variables (*d_6, d_3*). For *children clothing*, although we do not get any significant coefficient for the dummies individually, we reject the null hypothesis that the six dummies related to child birth are jointly equal to zero. Interestingly,

[137] The composition of *out* (see appendix A for a detailed description of the goods) includes both eating out for work reasons and for leisure, so maybe the effects of a new child are a bit mixed up.

for *baby clothing* the parameters of the dummy variables are significant some time before the child is born. We also get a positive (and significant) coefficient for the dummy variable *d0* in *health*, highlighting the fact that households can not spread over time the health costs incurred when a new child arrives. When we isolate the *nappies* category from the rest of *health* we obtain that this category is driving the results we get for the full *health* category. Somehow, this is not surprising and confirms the "needs story" about children costs. Finally, for *entertainment* we get 3 negative and significant coefficients for the dummy variables. These results are in line with the fact that the arrival of a new baby in the household should affect the demand of these kind of goods.[138]

It is important to highlight the relation between needs and jumps around the child birth date for the expenditure of some commodities. Another issue that is worthy to be raised is the question regarding to the smoothing of expenditures over the life-cycle. If households smooth their expenditures over time it is as if babies were, somehow, anticipated and therefore they adapt their consuming behaviour to accommodate these changes. Anticipation will help us to accept the life-cycle theory. Then children are anticipated and you save (or borrow) to afford them. Even if they are anticipated (meaning that you plan to have a child although may be you do not know when, it can be in 1 or 2 years time) there are some expenditures that should be made once the baby is around, like food or nappies. Therefore, the general conclusion that we can draw from these results is that for some commodities is more difficult to smooth consumption over the life-cycle than for others. This is probably so because the time effects of needs are more important than the anticipation of some expenditures, i.e., some expenditures have to be done at certain periods regardless of the expectations formed by the individual.

[138] In Spain, in general, every worker (specially civil servants) get two extra month salary per year (one in June and the other in July). Maybe we should investigate further if the arrival of a new child in the family coincides with the jumps that we observe in some of the demand goods analysed. Some of the jumps in expenditure may be related to the fact that a family anticipates the increase of income due to the extra payment. In a work in progress, presented at UCL in 1998 Browning gave some evidence, using this data set, of the fact that households fulfil the life-cycle expectations in the sense that consumption does not follow the jumps due to the extra payments.

3.4.3. Further results for some children related goods.

To further investigate the effects of children around birth date, we select some goods in which presumably these effects may potentially be more important. As pointed out earlier, the groups of non-durable goods can be classified, according to the effects of children birth dummies, into 3 sub-groups. The first group is composed by those commodities in which we get no effects at all for these dummies (i.e., *tobacco, house energy and services, transport* and *other non-durable goods*). In a second group we place those goods for which at least one dummy is significant, but we can not reject the null hypothesis that the 6 dummies are jointly equal to zero (i.e., *alcohol, adult clothing, health, out* and *entertainment*). And in the third group enter those goods for which the effects of the dummies are quite significant and where the six dummies to birth are jointly significant. As highlighted by Blundell, Pashardes and Weber (1993) demand patterns vary considerably across households with different household characteristics. Following their approach we model this variability by making the intercept in the demand equation to depend on demographics. The microlevel estimates in some equations are sensitive to the specification of interaction terms with household characteristics (in our case the six dummies to birth).[139] Given that our interest is to analyse the effects of new born children on demand, in the estimation of some goods (*food*, *adult clothing*, *children* and *baby clothing*, *entertainment* and *out*) we interact the dummies to birth with labour supply variables (husband and wife's participation dummies and with the multi-earners variable), prices and the interest rate. As some of the variables we interact are potentially endogenous we have also instrumented the interactions we introduce by interacting the instruments with the set of dummies to birth.

[139] In a traditional demand system, one would be interested, as in Blundell, Pashardes and Weber (1993), in income effects, substitution demand effects, etc. in order to asses aspects like separability and/or complementarities between goods. Thus, they interact demographic characteristics with income and prices.

Interactions with female participation would be indicative if significant of non-separabilities between female labour supply and demand. Significant interactions between prices and the presence (arrival) of children suggest that households respond differently to relative prices when children are present in the family. This could be interpreted as compatible with the idea of children re-scaling prices as in the model of Barten (1964). Having children makes some goods relatively more expensive and make other goods relatively cheaper. These changes in prices might be expected to cause substitution away from the relatively expensive goods, but also to amplify or dampen down household responsiveness to price depending on the nature of the scales. In an intertemporal context we might also expect re-scaling of intertemporal prices and changes in the estimated intertemporal substation elasticity. If children make some goods in some periods relatively more expensive than in other periods, household might be substituting away some of their expenditures from the more expensive periods.

We introduce interactions in six out of the 12 goods we model. The results are presented in tables 3.8 and 3.9,[140] and can be summarised as follows. For *food* at home, we have that without any interaction the dummies to birth start being significant 3 months before birth, in the quarter in which the baby is born and in the following quarter (see table 3.6). These three dummies are positive and significant suggesting that the arrival of a new child has implications on the demand for food even some time before the child arrives (necessities and nutritional effect). When interacting labour market variables with the set of dummies we get negative effects around child birth (*dwwifef*d_3* or *dwwifef*d3* or *dwwifep*d6*) and positive effects for the *d9* dummy interactions.[141] These results suggest that female participation variables or labour supply variables for all members of the household interact with the presence and/or arrival or children in

[140] We present two sets of results. In table 3.8 we report the interactions of the six dummies to birth with the female participation dummy and the interactions of d0 with both the own price and the interest rate. In table 3.9 we report the interaction of the six dummies to birth with: female participation dummies (full or part time dummies), the other earners dummy, the own price and the interest rate.

[141] Female labour transitions (see tables 3.3 to 3.5) show that around child birth there are important changes in the participation of women and these would affect, in turn, household demand.

affecting demand for *food*. Some of the interactions of *d0* with the interest rate and with the own price are significant, indicating, in line with the above discussion, that children re-scale prices faced by households, may affect household's responsiveness to relative prices and can have effects on the elasticity of intertemporal substitution.

The second good we have analysed with interactions is *adult clothing*. The interest comes from the fact that there are some changes in female labour supply around child birth from where we can extract some changes in expenditure of *adult clothing*. We have tried several interactions with *dwwife* and *dearn*, and with own price and interest rate, but we obtain non-significant effects almost everywhere, suggesting, somehow, that this may be a "pure" adult good. The interactions with the interest rate and the own price are not significant either. We have also tested the hypothesis of joint significance of the interactions (by groups) and we can not reject the null hypothesis in any case.

Although the distinction between *children clothing* and *baby clothing* is not very accurate in our data set we decided to model these two goods separately.[142] Looking at the results for children effects we have that none of the six dummies to birth is significantly different from zero (table 3.6a). Once we introduce the interactions, things start to come out, specially with female participation dummies. Interestingly, we get that the own price interaction with the arrival of children affecting the demand for *children clothing*. Interestingly, we get that the own price interaction with *d0* is positive and significant (table 3.8), indicating that children may affect household's responsiveness to prices and/or children re-scale relative prices as suggested by Barten's (1964) model.

We further analyse the effects of the interactions on *baby clothing*. For this good we get that four of the six dummies to birth are already highly significant (d_6, d_3 are positive and significant and d6 and d9 are negative and significant) indicating the strong and predictable effects of babies on this commodity. It is interesting to note that the highest effect of the six dummies is

[142] Baby clothing are all cloths and footwear for children of 0-3 years old and children clothing are items for children between 3-13 years old. In both cases we use the same index price.

precisely d_3, maybe indicating that most of the baby clothing expenditure is done during the last quarter before birth (see table 3.6a). Both the fact that parents know about the sex of the baby (which is usual in Spain) and the imminent birth itself makes them decide to start buying baby clothing. Apart from these 'plain' results we have also included interactions of the set of dummies with the female participation dummies, with the number of earners dummy and with the own price and the interest rate. As regards interaction with female participation variables (*dwwifef* and *dwwifep* or *dwwife*) and with the number of earners dummy (*dearn*) we get many significant results, indicating that labour supply variables interact with the presence (or arrival) of children in the demand for *baby clothing*. In the joint test of significance for groups of these variables we can not accept the null in any case. When the wife works, households spend more on (in some quarter or another). Interactions with the interest rate and the own price come out significant (see tables 3.8 and 3.9), suggesting, as discussed above, that both household's responsiveness to prices and the elasticity of intertemporal substitution are affected by children.

Finally, we present the results for the interactions of the six dummies to birth in the equation of the good *out*. In this case the only significant (negative) dummy we get is *d0* (table 3.7a), suggesting that the arrival of a child means a real constraint for the members of the household (both in terms of time and in terms of budget). When we introduce the interactions with labour supply variables the results indicate that before birth the effects are positive (*dwwife* interacted with *d_6* and *d_3*) and after birth the results are negative (although non significant). The interaction of *d0* with the own price is significant, indicating that children may affect household's responsiveness to prices.

3.5. Conclusions.

In this chapter we have estimate an unrestricted *Frisch* demand system for 12 commodities to address the question of how children affect household life-cycle expenditure patterns in the surroundings of child birth. During this period some potentially important changes are taking place in the household: changes in needs (nutrition effects, children clothing), changes in relation to labour supply (specially for the mother) and other possible changes due to the anticipation of the family to the event (saving and/or borrowing). We have also analysed the issue of intertemporal demographic separability and its relation to the measurement of children costs.

Among the main results, we must emphasise that while we observe important jumps in the consumption of some children related goods (*clothing, entertainment* and *food*), we observe no changes in the so called "adult" goods. We also find some effects when interacting dummies capturing the timing of birth with participation dummies, price and the interest rate. The needs and jumps we find seem to reflect that children are to some extent anticipated in the Spanish households within the life-cycle.

In this chapter and in chapter two we have looked at some aspects of the effects of children and, somehow, their relation to the identification and measurement of child costs. These costs are important politically and governments should account for them when designing social and other household related policies. A real life example of this is the Spanish 1999 fiscal reform. One of the aims of this reform is the improvement of child related benefits with a final objective to raise the Spanish fertility rate. We look at this reform and its potential effects in next chapter.

3.6. Appendix A: Estimating LDV models for panel data.

To estimate the equations for *tobacco* and *entertainment* we use a LDV model for panel data. Let us assume we have a random sample of observations on the characteristics of N individuals over T periods (in the typical situation that T is small and N tends to infinity). We begin by considering the following static model:

$$q^*_{iht} = \beta_i ' X_{iht} + \eta_{ih} + \varepsilon_{iht} \qquad (3.A.1)$$

where X_{iht} may include lagged regressors and non-time variant variables and β_i is the parameter vector, η_{ih} represents the individual heterogeneous effect and ε_{iht} a usual random term. q^*_{iht} is a latent dependent variable not directly observed. We observe q_{iht} which is related to q^*_{iht} by the following observability rule:

$$q^*_{iht} = g_i(q_{iht}) \qquad (3.A.2)$$

$g_i(.)$ being of the double-hurdle type in the case of tobacco and a p-tobit in the case of entertainment.

In the fixed effects LDV models it is not possible to devise estimators of the parameters that are not function of the effects and, since T is fixed the inconsistency in the estimation of η_{ih} carries through to the rest of the parameters. This does not seem to be an important problem in static Tobit type models, see Heckman and MaCurdy (1980). An alternative approach to the problem, which is only valid in this static case, consists in assuming the heterogeneous effects to be random and independent of the explanatory variables. But the model under the assumption of absence of correlation between effects and variables has limited interest in our problem, because if, for instance, unobserved heterogeneity contains fertility decisions, the effects and the household composition variables are correlated. If the regressors and the effects are correlated, we can still solve the problem of obtaining consistent parameter estimates using Chamberlain's suggestion of specifying a distribution for the effects conditional on the explanatory variables. Once observability assumptions for (3.A.2) are assumed as we do, and the reduced form of the model has been estimated, the structural parameters can be derived by imposing the cross-equation restrictions using a MD method. Instead, Bover and Arellano (1997) propose to implement a within-groups procedure, which provides inefficient estimates compared to the MD ones and a GMM method, which gives assymptotically efficient estimators (See Bover and Arellano (1997) or Labeaga (1998) for details).

Given the equation (A.1) and following Chamberlain (1980) we have,

(3.A.3) $$\eta_{ih} = \pi_{i0} + \pi_{i1}^{'} X_{ih1} + \ldots + \pi_{iT}^{'} X_{ihT} + \pi_{ir}^{'} R_{ih} + w_{ih}$$

where R_{ih} is a vector that includes non-time varying variables (Z_{ih}) as well as non-linear terms of X_{iht}, Z_{ih} and interactions. The reduced form of the model for each of the *k* demand equations can then be expressed in matrix notation as:

(3.A.4) $$q_{iht}^{*} = \Pi_i{}' W_{iht} + \xi_{iht} \qquad h = 1, \ldots, N$$

where $W_{ih} = \left[1, X_{ih1}^{'}, \ldots, X_{ihT}^{'}, R_{ih}^{'}\right]^{'}$ is a Px1 vector of exogenous regressors. The key assumptions are: i) the conditional expected value of the individual effect is linear; ii) the variables of this linear combination and the disturbance and iii) the distributional assumptions about ξ_{iht}. However, the reduced form specification will have all the variables in each cross-section, squared and cubed terms of some of them, lags and leads of exogenous time-varying variables and interactions among them. In any case, another useful feature of this approach is that we can check the specification at the level of the reduced form. Functional form and distributional hypotheses about disturbances can be tested when a satisfactory predictor $\hat{q}_{iht}^{*}$ (*i = 1, ..., N; t = 1, ..., T*) is available.

We use the fact that the distribution of q_{iht}^{*} conditional on the explanatory variables, but marginal to the effects, is of the same form as the joint distribution

[Chamberlain (1984)], in order to estimate each of the T cross-section specification. At a second stage and on the basis of the matrix of the previously calculated estimates for the reduced form, we derive the relevant vector of parameters using a first differences GMM procedure instead of a minimum distance approach. This method provides consistent estimates which asymptotically efficient Once Π_i, we obtain β_i as follows:

(3.A.5)

$$\hat{\beta}_{i3SGMM} = \left[\left(\sum_{h=1}^{H} \hat{V}'_{ih} K' W_{ih}\right) A_i \left(\sum_{h=1}^{H} W'_{ih} K \hat{V}_{ih}\right)\right]^{-1} \left(\sum_{h=1}^{H} \hat{V}'_{ih} K' W_{ih}\right) A_i \left(\sum_{h=1}^{H} W'_{ih} K I_0 \hat{\Pi} W_{ih}\right)$$

being A a weighting matrix and K a transformation matrix to first difference operator. We use as weighting matrix:

(3.A.6)

$$A_i = \hat{V}_{\beta_i}^{-1} = (K \otimes I_P)\left(\sum_{h=1}^{H} W_{ih} Q W_{ih}\right) \tilde{\Omega}_{1i} \left(\sum_{h=1}^{H} W_{ih} Q W_{ih}\right)(K' \otimes I_P)$$

with I_P an identity matrix of order P and $\tilde{\Omega}_{1i}$ the asymptotic covariance matrix of the reduced form estimates of equation i.

3.7. Appendix B. Data description of the variables.

The data we use in this chapter is a balanced panel drawn from the Spanish Panel of Family Expenditure Survey (*Encuesta Continua de Presupuestos Familiares*, ECPF) conducted by the Spanish Statistical Office since the first quarter of 1985 to the fourth quarter of 1995 (the last wave available). We only use information from the first quarter of 1986 onwards since there was no substitution in 1985. This is a quarterly rotating panel carried out over 3,200 households with a 12.5 per cent rotating rate to avoid attrition problems. This implies that the maximum number of collaborating periods for each household is eight. In the empirical application we have selected those households collaborating eight periods. We end up with a sample size of N = 7,718 and T = 8 (the number of observations is 61,744). As the structure of the sample used and that for all households collaborating for at least four periods seems to be the same, thus minimising the probability of attrition bias.

This data set provides information of about 400 commodities, 14 sources of household income for different members of the household as well as other household members, labour and socio-demographic characteristics such as age, number of children by age and sex, occupation and labour status of both spouses in the family, education of the head of the household, size of the town of residence, etc. Table 3.A.1 presents a brief description of the commodities included in each category we model and tables 3.A.2 and 3.A.3 present some sample descriptive statistics of the variables used in the empirical analysis. Since we also conduct an exercise based on cohort data, we report the sample size of each cohort in Table 3.A.4.

Table 3.A.1.
Description of the commodity categories and proportion of zeros.

food	All food at home and non-alcoholic beverage categories.	0
alcohol	All alcoholic drink categories bought by the household to be consumed at home.	46
tobacco	Expenditure on all kind of tobacco and smoking accessories.	42
adult clothing	Adult clothing, underwear and footwear categories. Also expenditures on repairing these items.	12
children clothing	Children (between 6 months and 18 years old) clothing, underwear and footwear categories. Also expenditures on repairing these items.	66
baby clothing	Baby (between 0 and 6 months old) clothing and underwear categories.	94
house energy	Electricity, gas and water bill of the household; house services, cleaning products and other non-durables for the house.	0
health services	Medicines and other hygiene related products (i.e., nappies). Medical services and health insurance. Expenditures in hospitals. Nursering services.	39
transport	All types of public transport. Fuel. Other transport related nod-durable goods.	18
entertain.	Expenditures on cinema, theatre, concert, etc. tickets. Sport centres. Rental of videos and other entertainment related items.	45
out	Restaurants and bar expenditures (this includes alcohol out of home).	13
other	Postal services. Non-durable personal care commodities. Taxes (but non-income taxes). Education expenditures (including nurseries expenditures). Other non-durable commodities not reported in the above categories.	2

Table 3.A.2. Descriptive statistics of variables

	Whole sample		Sample newb=1	
Variable	**Mean**	**Std. dev.**	**Mean**	**Std. dev.**
food	1575.717	872.604	1524.615	883.480
alcohol	65.591	147.561	66.402	132.085
tobacco	94.616	135.203	110.047	145.006
adult clothing	558.785	763.778	483.720	734.551
children clothing	95.995	222.939	143.753	249.120
baby clothing	10.815	62.739	59.274	141.728
house energy	341.803	316.041	368.105	377.162
health	153.794	492.828	208.969	416.230
transport	434.062	728.759	466.024	488.374
entertainment	148.498	367.275	119.208	322.936
out	591.090	802.353	596.781	824.329
other non-durabl.	597.436	1104.666	483.571	588.985
husband's age	50.279	13.715	37.051	10.588
wife's age	40.844	19.249	31.683	11.525
male working	0.896	0.305	0.941	0.235
unemployed	0.048	0.214	0.055	0.229
self employ.	0.165	0.371	0.136	0.343
unskilled	0.022	0.147	0.031	0.172
non-active	0.265	0.442	0.071	0.257
blue-collar	0.092	0.289	0.132	0.338
white-collar	0.359	0.480	0.498	0.500
working wife f-t	0.171	0.376	0.226	0.419
working wife p-t	0.039	0.194	0.036	0.186
pensioner husb.	0.257	0.437	0.065	0.246
pensioner wife	0.012	0.108	0.006	0.078
num. of earners	0.576	0.494	0.495	0.500
low educated	0.220	0.414	0.135	0.342
high educated	0.078	0.269	0.127	0.333
rural area	0.187	0.390	0.165	0.371
city	0.385	0.487	0.324	0.468
second house	0.129	0.335	0.047	0.212
own house	0.829	0.377	0.749	0.434
nm0	0.017	0.130	0.207	0.413
nm1	0.019	0.140	0.099	0.299
nm2	0.021	0.149	0.049	0.217
nm3	0.022	0.148	0.054	0.225

Table 3.A.2. (Cont.)

	Whole sample		Sample new=1	
Variable	**Mean**	**Std. dev.**	**Mean**	**Std. dev.**
nm4	0.022	0.150	0.054	0.225
nm5_8	0.105	0.327	0.183	0.406
nm9_13	0.169	0.418	0.118	0.364
nm14_17	0.154	0.409	0.081	0.328
nf0	0.015	0.124	0.184	0.392
nf1	0.019	0.140	0.094	0.296
nf2	0.021	0.145	0.044	0.212
nf3	0.020	0.144	0.064	0.246
nf4	0.021	0.144	0.058	0.233
nf5_8	0.093	0.310	0.147	0.382
nf9_13	0.160	0.414	0.149	0.402
nf14_17	0.153	0.400	0.079	0.332
na1	0.504	0.785	0.352	0.715
na2	1.945	0.786	2.038	0.646
no	0.366	0.669	0.092	0.345
d0	0.008	0.089	0.126	0.332
d_3	0.007	0.083	0.109	0.311
d_6	0.006	0.077	0.093	0.291
d3	0.007	0.085	0.096	0.295
d6	0.008	0.088	0.087	0.282
dn_6	0.066	0.247	0.631	0.483
dn_3	0.060	0.237	0.543	0.498
dn0	0.054	0.227	0.455	0.498
dn3	0.047	0.213	0.349	0.477
dn6	0.043	0.202	0.272	0.445
dn9	0.038	0.192	0.204	0.403

Note:
1. newb = 1 means that a child is born in the household during the sampling period.

Table 3.A.3. Price indexes.

	Mean	Std. deviation
pfood	95.397	9.321
palcoh	93.594	13.381
ptobaco	94.509	20.406
padcloth	94.644	9.610
pchcloth	94.274	10.279
phoener	94.242	11.039
phealth	89.511	17.830
ptransp	92.417	15.906
penter	92.840	14.114
pother1	93.535	14.061
pout	91.535	15.822
R.P.I.	94.693	11.631

Note:
1. Year base = 1992.

Table 3.A.4.
Cohort sample sizes.

	Cohort									
year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1986	0	2	14	14	21	17	32	24	19	26
1987	0	65	187	199	314	324	354	338	243	407
1988	4	162	420	508	588	645	633	708	510	899
1989	13	205	530	683	667	710	594	724	592	999
1990	71	252	525	664	755	762	648	761	608	966
1991	106	324	577	581	749	823	650	834	609	918
1992	112	384	623	660	730	780	623	773	683	838
1993	156	402	650	753	763	708	694	769	706	729
1994	171	458	605	600	655	620	564	662	511	506
1995	68	191	262	223	253	271	202	272	184	181

Notes:
1. Each cohort has been constructed taking as reference the head of the household age.
2. We take five years bands as follows. Cohort 1 we have all those households whose head was born in 1946 or after, in cohort 2 we have those born between 1940 and 1946, in cohort 3 we have those born between 1936 and 1940, and so on.

3.8. Appendix C: Tables and figures.

Table 3.1.
New born children.

	boy	girl	boy & girl	total
one baby	255 (180)	234 (162)	0 (0)	489 (342)
twins	3	5	16	48
triplet	2	0	0	6
total	267 (196)	244 (172)	32 (32)	543 (396)

Notes:
1. Figures calculated using children born during the sampling period and 3 quarters before.
2. In parenthesis we report figures using only those children born during the collaborating period of the household.

Table 3.2.
Rates of female participation.

	6 moths before	birth	6 months later
Full-time	23.73%	19.56%	19.83%
Part-time	4.41%	3.26%	3.63%
Unempl.	71.69%	77.17%	76.54%

Notes:
1. Rates of participation are calculated for the sub-sample of women who give birth during our sampling period.
2. The participation rates of women for the whole sample are: 21.03% of women are full-time employed and 3.93% are part-time (25.76% of women work in our sample).

Table 3.3.
Transitions matrix from t-2 to t.

	Full-time	Part-time	Unemployment.
Full-time	(86,54)	(86,5)	(86,27)
Part-time	(14,3)	(14,4)	(14,7)
Unempl.	(268,1)	(268,3)	(268,264)

Notes to tables 3.3, 3.4 and 3.5:
1. t refers to the quarter in which the woman gives birth and t-2 and t+2 refer to two quarters before and after birth, respectively. Then we have transitions from 6 months before the baby arrives to 6 months after giving birth.
2. Sample of women who have a child during the sampling period.

Table 3.4.
Transitions matrix t to t+2.

	Full-time	Part-time	Unemployment.
Full-time	(69,41)	(69,3)	(69,25)
Part-time	(13,6)	(13,4)	(13,3)
Unempl.	(276,24)	(276,6)	(276,246)

Table 3.5.
Transitions matrix t-2 to t+2

	Full-time	Part-time	Unemployment.
Full-time	(74,32)	(74,3)	(74,35)
Part-time	(16,7)	(16,3)	(16,6)
Unempl.	(268,32)	(268,7)	(268,229)

Table 3.6a.
Demand system estimates.

	food	alcohol	tobacco	adult clothing	children clothing	baby clothing	house energy
d_6	56.090 (0.891)	17.940 (1.406)	0.307 (0.137)	34.192 (0.593)	-24.507 (-1.206)	10.691 (1.609)	7.217 (0.380)
d_3	88.572 (1.454)	-12.087 (-0.946)	0.423 (0.196)	-135.627 (-2.136)	23.380 (1.510)	62.151 (3.961)	5.356 (0.287)
d0	128.012 (2.187)	-24.116 (-1.823)	-0.112 (-0.045)	-11.599 (-0.231)	18.564 (1.134)	-4.861 (-0.278)	2.173 (0.099)
d3	147.935 (2.413)	10.982 (1.073)	0.638 (0.340)	41.319 (0.825)	1.945 (0.114)	-5.839 (-0.403)	30.772 (1.501)
d6	46.429 (0.739)	-8.647 (-0.678)	-3.189 (-1.880)	-16.220 (-0.286)	-2.670 (-0.113)	-16.223 (-1.438)	2.061 (0.098)
d9	-24.037 (-0.286)	21.412 (1.282)	3.456 (1.385)	-70.189 (-1.237)	22.743 (1.218)	-1.524 (-0.120)	-2.841 (-0.084)
$logp_i$	-112.222 (-1.932)	-17.855 (-1.435)	4.050 (1.987)	-316.259 (-5.116)	-40.540 (-2.370)	-3.909 (-0.773)	-8.354 (-0.455)
mean value	1575.72	65.59	94.62	558.78	95.99	10.814	341.80
EIS (s.e.)	-0.071 (0.037)	-0.272 (0.190)	0.043 (0.022)	-0.566 (0.110)	-0.422 (0.178)	-0.361 (0.468)	-0.024 (0.053)

Notes:
1. For d_6-d9 we present t values in parenthesis.
2. EIS = Elasticity of intertemporal substitution. Standard errors in parenthesis.
3. Mean value = sample mean.

Table 3.6b.
Diagnostic tests.

	food	alcohol	tobacco	adult clothing	children clothing	baby clothing	house energy
Wald(6)	22.124	8.592	5.205	7.689	11.034	45.183	3.060
Sargan(6)	4.683	4.371	227.453	9.363	14.058	13.567	4.797
Autocorr.	-1.012	-0.088	-0.749	5.610	4.177	0.409	-2.257

Notes:
1. We test for the join significance of the six dummies related to child birth by using a standard Wald test.
2. Sargan test accounts for the validity of the instrumental set. The Sargan test for baby clothing and children clothing has 12 degrees of freedom.
3. Autocorrelation test = test for second order serial correlation.

Table 3.7a.
Demand system estimates (cont.).

	health	transport	entertain.	out	other non-durables	nappies	rest health
d_6	-23.418 (-0.858)	-33.955 (-0.951)	-11.118 (-0.739)	62.214 (1.032)	-25.366 (-0.446)	-4.916 (-1.762)	-22.502 (-0.907)
d_3	38.505 (1.496)	-3.887 (-0.116)	-28.824 (-2.111)	-49.908 (-0.729)	14.935 (0.281)	6.333 (2.239)	24.794 (1.064)
d0	107.243 (3.281)	13.859 (0.338)	-27.580 (-1.629)	-80.188 (-1.302)	-97.582 (-1.639)	44.339 (10.817)	35.315 (1.217)
d3	-28.116 (-0.838)	18.095 (0.444)	10.153 (0.716)	65.004 (1.196)	-32.045 (-0.591)	-9.832 (-1.660)	-17.056 (-0.542)
d6	82.216 (1.467)	-28.689 (-0.808)	-28.549 (-2.349)	-73.239 (-1.299)	3.405 (0.064)	4.819 (0.743)	78.699 (1.402)
d9	-143.477 (-2.335)	19.359 (0.499)	-10.058 (-0.650)	-5.020 (-0.083)	-13.163 (-0.224)	-2.758 (-0.424)	-122.658 (-2.053)
$\log p_i$	4.498 (0.025)	-230.400 (-1.334)	-24.527 (-1.745)	128.894 (2.326)	-299.068 (-4.984)	-2.637 (0.667)	79.242 (1.065)
mean value	153.79	434.06	148.50	591.09	597.44	14.52	138.77
EIS (s.e.)	0.029 (1.144)	-0.531 (0.398)	-0.165 (0.094)	0.218 (0.093)	-0.501 (0.100)	-0.182 (0.272)	0.571 (0.535)

Notes:
1. For d_6-d9 and $\log(p_i)$ we present t values in parenthesis.
2. EIS = Elasticity of intertemporal substitution. Standard errors in parenthesis.
3. Mean value = sample mean.

Table 3.7b.
Diagnostic tests (cont.).

	health	transport	entertain.	out	other non-durables	nappies	rest health
Wald(6)	20.573	1.874	14.666	7.633	4.155	193.642	8.642
Sargan(6)	1.566	4.083	131.149	3.603	1.953	21.49	10.774
Autocorr.	-2.523	-1.744	0.189	0.218	0.579		

Notes:
1. We test for the join significance of the six dummies related to child birth by using a standard Wald test.
2. Sargan test accounts for the validity of the instrumental set. The Sargan test for baby clothing and children clothing has 12 degrees of freedom, and for nappies and rest health has 11 degrees of freedom.
3. Autocorrelation test = test for second order serial correlation.

Table 3.8.
Parameter estimates for interactions I.

	Good				
Interactions	**food**	**adult clothing**	**children clothing**	**baby clothing**	**out**
d_6	35.23 (0.51)	29.75 (0.40)	-15.51 (-0.76)	10.65 (1.69)	-25.55 (-0.42)
d_3	98.44 (1.49)	-184.08 (-2.55)	12.18 (0.63)	66.95 (11.11)	-59.38 (-1.03)
d0	148.52 (2.11)	27.45 (0.32)	-0.58 (-0.03)	-2.76 (-0.44)	-55.44 (-0.95)
d3	140.00 (2.01)	55.78 (0.46)	7.24 (0.35)	-5.28 (-0.83)	103.69 (1.75)
d6	121.73 (1.68)	-55.11 (-0.70)	-22.46 (-1.05)	-10.57 (-1.60)	-38.93 (-0.62)
d9	2.75 (0.04)	-38.54 (-0.45)	25.08 (1.10)	24.17 (3.42)	2.27 (0.03)
d_6*dwwife	83.31 (0.82)	7.72 (0.07)	-26.37 (-0.88)	4.66 (0.50)	307.15 (3.18)
d_3*dwwife	-61.79 (-0.58)	219.36 (1.87)	13.62 (0.43)	-6.72 (-0.69)	177.65 (1.75)
d0*dwwife	1.73 (0.02)	-93.01 (-0.72)	79.39 (2.29)	35.59 (3.32)	-151.35 (-1.36)
d3*dwwife	79.82 (0.62)	-82.11 (-0.58)	-84.97 (-2.23)	0.15 (0.01)	-157.69 (-1.28)
d6*dwwife	-294.38 (-2.19)	210.62 (1.43)	82.18 (2.08)	27.79 (2.27)	-194.97 (1.53)
d9*dwwife	72.67 (0.51)	-239.70 (-1.55)	-77.46 (-1.86)	-56.06 (-4.36)	-87.70 (-0.66)
d0*p_i	-343.85 (-0.29)	300.75 (0.17)	1461.7 (2.98)	1228.5 (8.08)	-
d0*r	-113.99 (-0.72)	27.43 (0.16)	39.48 (0.85)	-39.98 (-2.78)	-

Table 3.9.
Parameter estimates for interactions II.

	Good			
Interactions	**food**	**adult clothing**	**children clothing**	**babyclothing**
d_6	786.147 (1.525)	41.452 (0.541)	-16.378 (-0.805)	25.425 (2.080)
d_3	-1557.947 (-2.988)	-180.642 (-2.482)	11.115 (0.575)	81.522 (6.631)
d0	782.912 (1.614)	19.414 (0.256)	-1.115 (-0.057)	-36.592 (-3.190)
d3	-245.090 (-0.461)	61.028 (0.795)	9.722 (0.490)	-18.017 (-1.652)
d6	990.774 (1.897)	-43.905 (-0.550)	-18.587 (-0.892)	13.382 (1.201)
d9	187.608 (1.345)	-27.054 (-0.316)	29.935 (1.339)	50.178 (3.967)
d_6*dwwifef	162.472 (0.826)	38.653 (0.262)	-41.748 (-1.084)	25.224 (1.397)
d_3*dwwifef	-451.692 (-2.134)	160.484 (1.067)	19.183 (0.547)	11.174 (0.572)
d0*dwwifef	195.936 (0.881)	-195.269 (-1.242)	636204 (1.896)	-18.306 (-0.900)
d3*dwwifef	-229.380 (-0.851)	40.056 (0.225)	-78.582 (-2.205)	-26.050 (-1.044)
d6*dwwifef	193.218 (0.719)	360.204 (1.877)	125.725 (2.480)	113.085 (-4.545)
d9*dwwifef	150.583 (0.516)	-442.542 (-2.007)	-149.469 (-2.657)	-26.256 (-0.978)
d_6*dwwifep	-5.488 (-0.012)	-364.147 (-0.710)	50.860 (0.405)	14.441 (0.341)
d_3*dwwifep	-58.254 (-0.113)	477.500 (0.873)	-28.015 (-0.205)	38.902 (0.833)
d0*dwwifep	379.978 (0.562)	783.992 (1.093)	94.812 (0.551)	-84.672 (-1.397)
d3*dwwifep	-1775.095 (-2.459)	-1125.091 (-1.442)	-208.725 (-1.035)	-194.764 (-3.009)
d6*dwwifep	-1171.599 (-1.228)	-1477.35 (-1.348)	-358.232 (-1.320)	-249.889 (-2.891)
d9*dwwifep	2930.614 (2.626)	1883.556 (1.395)	566.533 (1.750)	414.104 (4.083)
d_6*dearn	-128.683 (-0.426)	-	-	-39.118 (-1.421)
d_3*dearn	543.998 (1.780)	-	-	-38.046 (-1.365)
d0*dearn	-395.753 (-1.378)	-	-	94.305 (3.598)
d3*dearn	541.922 (1.664)	-	-	48.431 (1.626)
d6*dearn	-648.932 (-1.996)	-	-	-79.210 (-2.659)
d9*dearn	-550.037 (-1.454)	-	-	-85.150 (-2.456)
d_6*p_i	-99.311 (-0.035)	-	-	-
d_3*p_i	-7034.975 (-2.480)	-	-	-
d0*p_i	3784.938 (1.312)	300.752 (0.171)	-	1281.447 (8.244)
d3*p_i	149.464 (0.049)	-	-	-
d6*p_i	4341.154 (1.490)	-	-	-
d9*p_i	-1741.963 (-0.856)	-	-	-
d_6*r	-4441.682 (-1.300)	-	-	-
d_3*r	14374.27 (2.609)	-	-	-
d0*r	-13615.37 (-2.724)	27.431 (0.158)	-	-38.561 (-2.615)
d3*r	5131.578 (0.998)	-	-	-
d6*r	-6237.249 (-1.133)	-	-	-
d9*r	4703.373 (1.346)	-	-	-

Note:
1. t-values in parenthesis.

Figure 3.1(a). Life cycle log real total income.

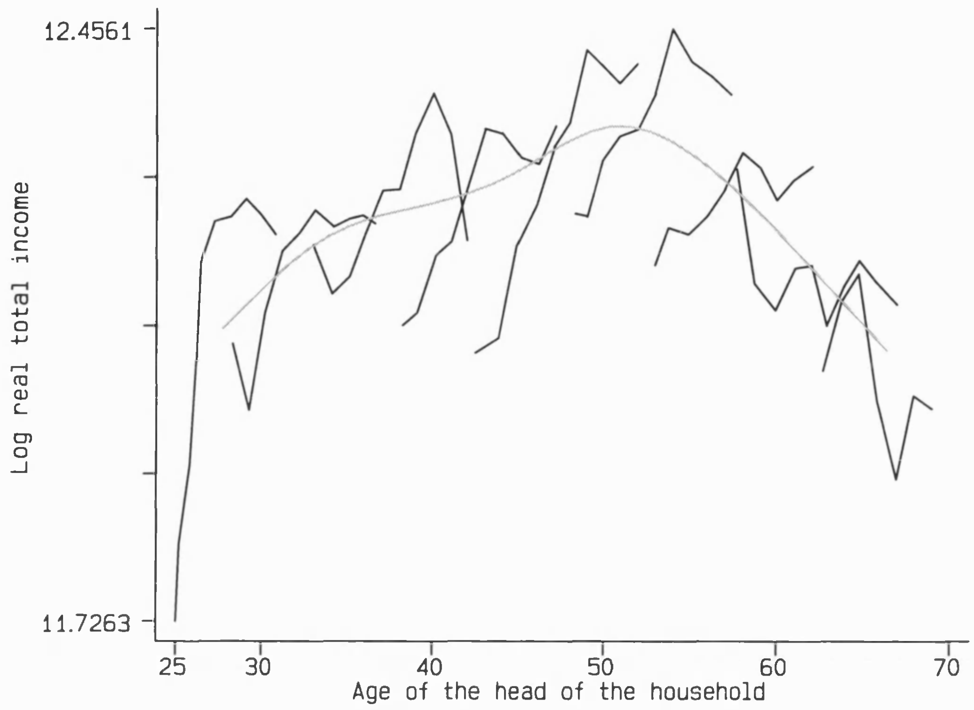


Figure 3.1(B). Life cycle log real total expenditure.

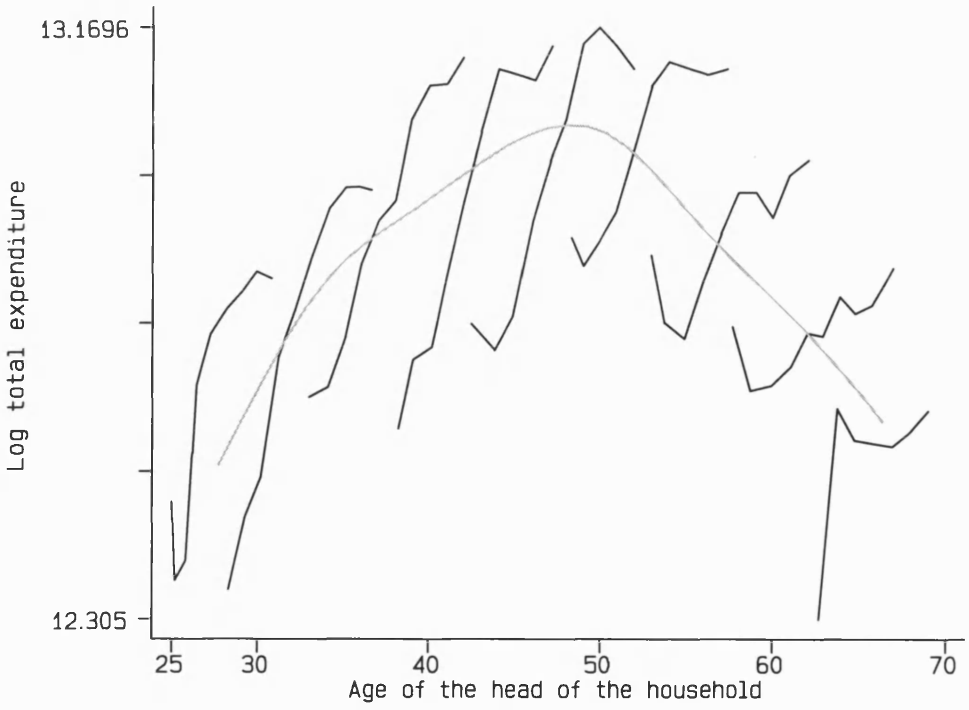


Figure 3.1(c). Life cycle number of children.

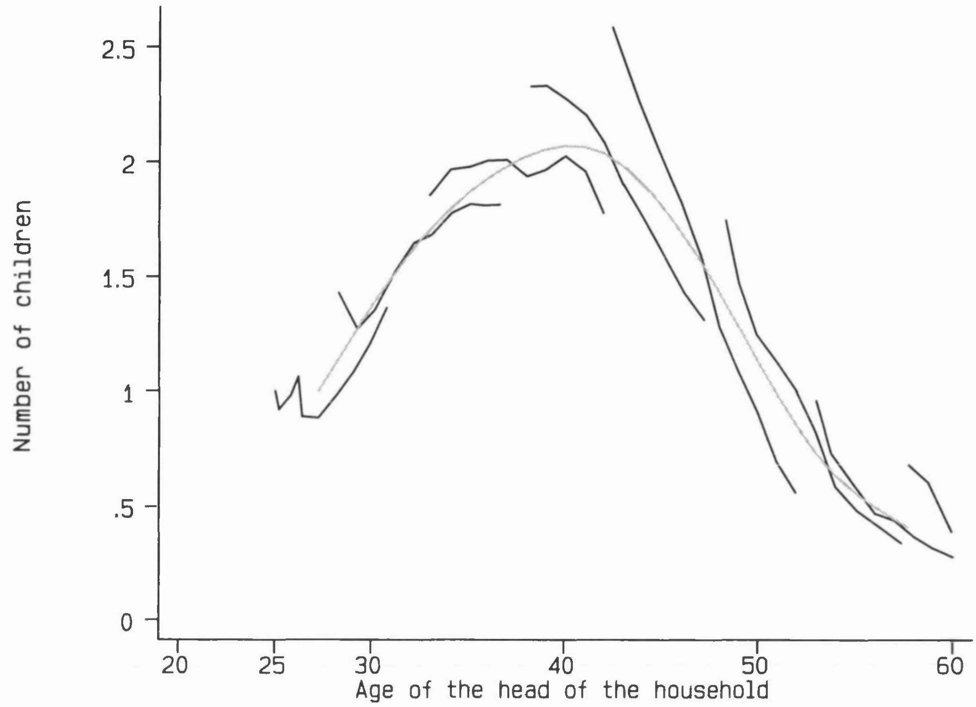


Figure 3.1(d). Life cycle number of young children.

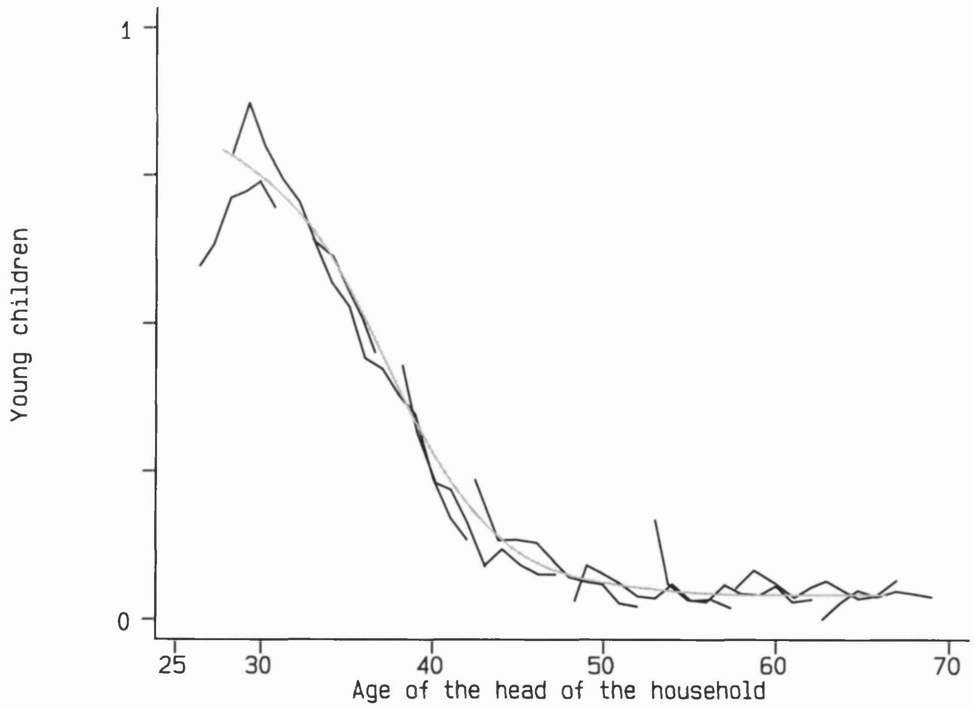


Figure 3.1(e). Life cycle number of old children.

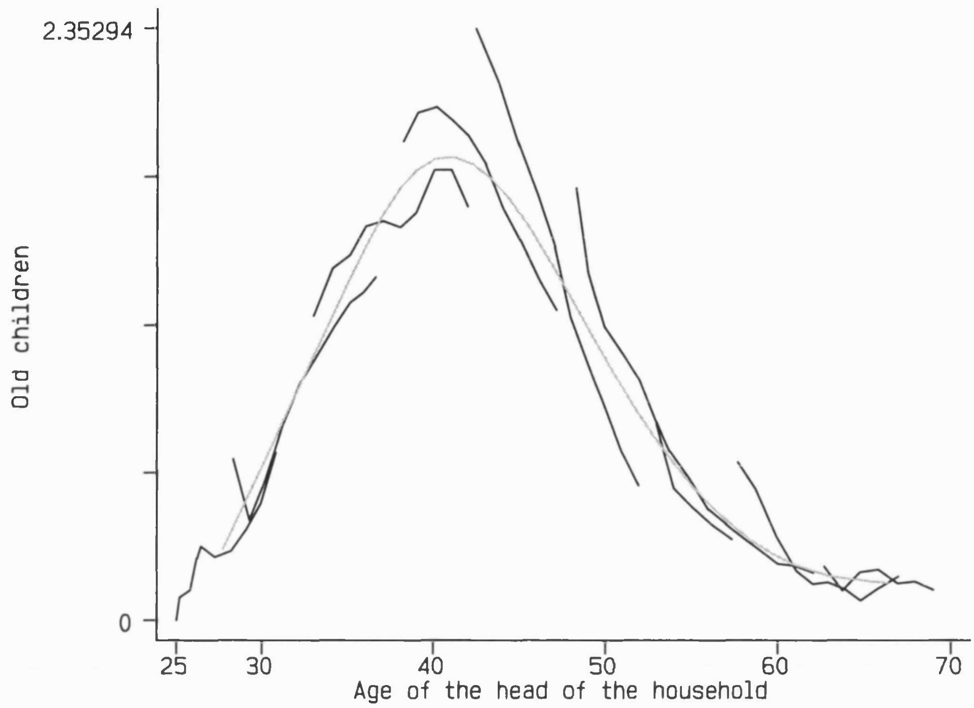


Figure 3.1(f). Life cycle labour supply of the wife.

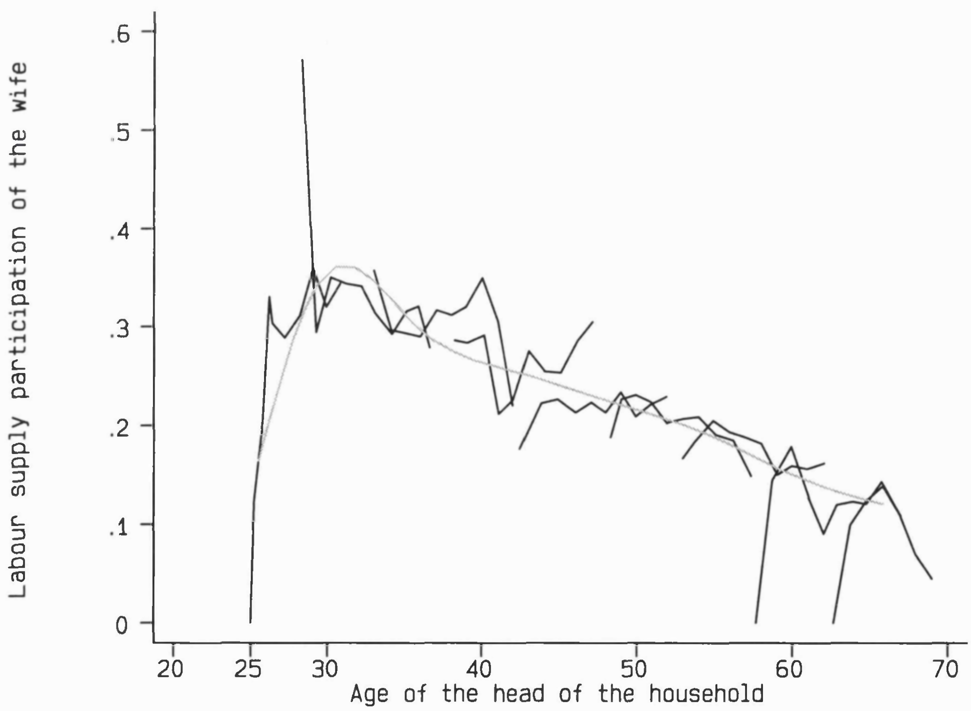
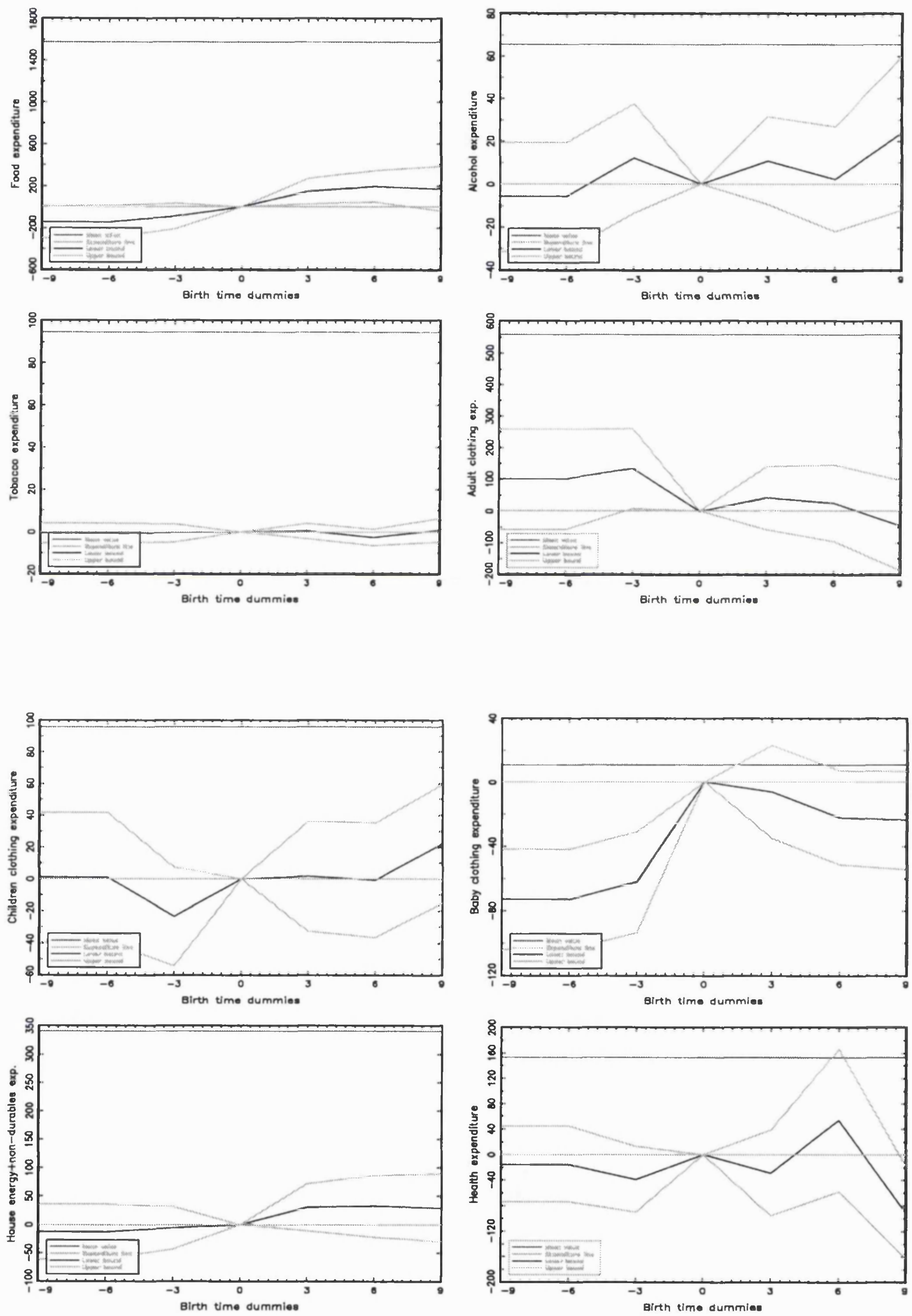
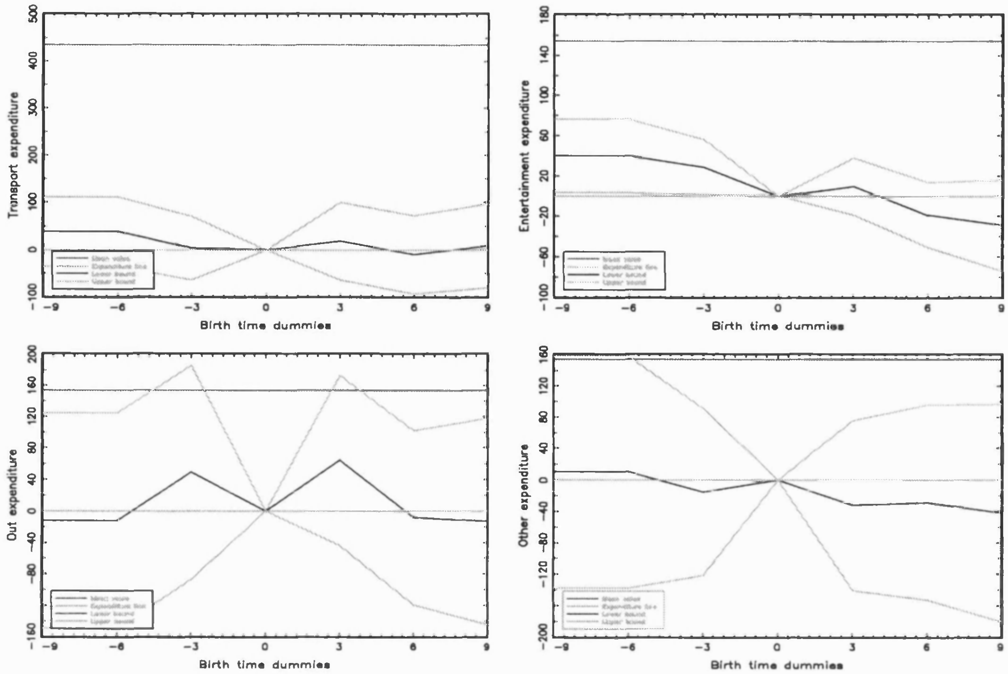


Figure 3.2. Effects of the set of dummies to birth on the intertemporal commodity demand.





Notes:

1. In each graph we plot the mean value of the corresponding commodity as a reference to anlalyse the evolution each expenditure across time.
2. The black line in each graph represents the evolution of each expenditure in periods before and after birth and in birth itself.
3. The dashed lines are the confidence intervals of the above line.
4. We also plot a dashed line in level zero.

Chapter 4

A microsimulation analysis of the distributive and incentive effects of the Spanish 1999 tax reform: a special focus on children benefits

4.1. Introduction.

Any tax-benefit system should aim at being dynamic and flexible, evolving and adjusting according to changes in social and economic conditions. The structure of the population changes across time. For instance, during the last decades there has been an increase in the number of divorces, single parents, couples where both spouses work, etc. There has also been a remarkable reduction in the birth rate, together with an increase of female participation the labour market. Fiscal policy should take into account all these changes and tax reform should move according to new social parameters. In a household survey conducted by the Spanish Social Research Centre (CIS) carried out in 1999, 47% of the people surveyed recognise that the number of children they have is less than they would like to have. The reason they give is that there are not enough children benefits or children related tax exemptions to help families, specially those with more than 2 children. In their opinion this explains why the Spanish fertility rate dropped from 3.4% in 1941 to

1.2% in 1999. The government has recognised its commitment in relation to increase children related benefits.

Fiscal reform is also an instrument of political economy. Beyond the basic purpose of raising revenue, fiscal policy is crucial in providing incentives both in the labour market and in the product market (on working hours/spare time allocation, on the purchase of some goods, on boosting housing market, on the number of children households have, etc.).[143] There is also a specific interest in raising family allowances related to children with a clear aim to increase the number of children that a household has or plans to have.

Given the potential effects of a fiscal reform, assessing its impact is of great interest and this is why simulation techniques are an important tool of fiscal policy. They allow to examine household behavioural responses to policy changes. This issue is important specially in the case of tax reforms designed to change individuals' behaviour (e.g. to provide incentives to work, to increase the fertility rate, to increase private saving or to discourage the consumption of harmful goods). Simulation techniques enable to calculate the impact of fiscal reform, not just on a number of examples or typical (representative) families, but on thousands of households. In addition, when the data source used is representative of the population, it is possible to infer the revenue implications and distributive effects of the tax reform on different groups of the population.[144] And this is important not only at individual (household) level but also at national level since the tax reform affects government revenue and can also be used to modify the welfare state.

Based on the 1978 act, the current Spanish income tax system has often been reformed.[145] The reforms have mainly affected tax deductions and the tax credits system, together with the level of exempted income. The Spanish income tax system after the 1978 act was based on the family as the tax unit. The tax rate was applied to

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[143] For example, Dickert-Colin and Chandra, 1999, analyze how the tax reduction of having a child may change the timing of births.

[144] In spite of the lack of studies taking into account the real structure of the Spanish households, there has been a big controversy in the media about the effects of the reform on specific groups of households (case studies or typical families). With real data it is possible to approach much better the real impact of the tax reform.

[145] A discussion about the evolution of the Spanish income tax system across time can be found in Albi and García (1998).

taxable income (gross income net of social security contributions plus estimated income from owned occupied houses). Deducting tax credits gave the tax liability, the main tax credits being a fixed deduction for elderly relative, per elderly person in the family unit and per child, and a deduction (without limit) for mortgage interest payments to all houses owned by the family.

In 1989 the tax system changed to a more complex system based on individual taxation, although a joint scheme was still available (with some differences between both schemes in terms of tax types and general exemptions). The establishment of a system based on individual taxation (leaving the joint scheme as an option) was the result of two decisions (in 1988 and in 1989) approved by the Spanish Constitutional Court that declared the joint scheme as unconstitutional.[146] The main changes of the 1989 reform were a reduction in the number of tax rates (from 28 to 18), the introduction of a specific labour income deduction of 2% of gross income and some restrictions (upper limit) in the mortgage tax deductions. There were no significant changes in the family tax credit system and the main tax credit was the earner's tax credit, that was a fixed amount for those who are employees. A second reform took place in 1996, and the main changes were the transfer of some taxes from the state to the Autonomous Communities and the reduction in the number of tax rates (from 18 to 8).

In 1999 a new reform of the income tax system was carried out (which will have its effects in 2000). The aims of this reform, according to the government, are to simplify the administration and cost of the income tax, to fight fraud and tax evasion, to reduce the tax burden and at the same time to increase the progressiveness of the tax. The reform also attempts to converge to the "European tax-benefit system". The income tax reform implies a move towards the current British income tax system (and therefore away from the so called "Latin tax system"). However, the reform does not develop the income benefit system (housing, health, unemployment).

The aim of this chapter is to evaluate the effects of the 1999 Spanish income tax reform on a sample of households drawn from the Spanish Family Expenditure

[146] In 1989, 27.7% and 58.3% of the tax payers where under the individual and joint scheme, respectively, whereas in 1996 54.3% where under the individual scheme and 35.3% under the joint scheme.

Survey (*Encuesta de Presupuestos Familiares, EPF*) for 1990/91 using simulation techniques.[147] Using a sample that is representative of the population, and assuming that the Spanish socio-demographic structure in 1999 is the same than the one in 1990-91, these techniques allow to predict the cost of the reform in terms of aggregate revenues, to make inferences about the revenue implications of specific changes and to analyse the distributive effects of the reform on different groups of households. Over this constant population of households, we simulate and compare the current income tax system and the changes that the 1999 reform will bring. In particular, we carry out several simulation exercises. First, we programme both the income tax system in 1998 and the system after the 1999 reform. To apply these systems we have previously calculated gross income (as the data only provide net income). We estimate tax duties for all the individuals in our sample under both systems and assess for each individual (household) whether the reform implies a reduction in taxes. We can evaluate this figure both individually (by household) and at national level as we have grossing-up factors in our data. The evaluation of the effects of the reform will allow us to assess if the new income tax system is more progressive or more regressive than the old one. According to our results, there is a reduction in income taxes of around 2.5% for the whole population. But this general reduction affects differently to different groups of individuals. For low income individuals (from decile 1 to decile 5) there is an increase in the taxes they pay, whereas for individuals falling in the 6th to the 10th decile of the income distribution, there is a positive saving in terms of income taxes. The estimated cost of the reform in terms of aggregated revenue is 1.115 billions of 1999 Spanish pesetas (6,701 millions of euros).

It is reasonable to assume that sooner or later, individuals will pay for this reduction in taxes. The government has several ways to recover the revenue loss due to this reduction in taxes. In this what follows we assume that there would be an increase in indirect taxes that completely offsets the reduction in revenue. A change in the structure of relative prices that a household faces will affect her welfare. Therefore, with both the effects of the income tax reform and the effects of the

[147] The EPF is a cross-section of Sapnish households conducted every 10 years approximately, to calculate the Spanish Retail Index Price weights. The last wave available was 1990-91.

changes in the VAT types we can give some evidence of who are the losers and the gainers of the reform, assuming that the government is going to increase indirect taxes to finance the income tax reform.

In relation to the simulation of the 1998 and 1999 income tax systems, we also address two important questions. First, we evaluate if the new children related benefits, introduced in the 1999 reform, make an improvement with respect to the old system. The results of our simulation suggest that these benefits are similar under both systems, and thus, the announced incentives to increase the fertility rate are not so. Second, there are incentives in the new system, for married women who work part time, to leave the labour market as there is a minimum exemption (under the joint scheme) that is higher than half the guaranteed minimum wage. This would potentially affect 38.53% of the employed women of our sample.

The rest of the chapter is organised as follows. In section 4.2 we outline the Spanish income tax system and the 1999 reform. In section 4.3 we discuss the data, methodology and simulations carried out. The results are presented in section 4.4. Finally, section 4.5 concludes.

4.2. The Spanish income tax system and the 1999 reform.

In this section we outline the structure of the Spanish income tax system. The current tax system has its origins in the tax reform that began in 1978 and has been the subject of a number of changes ever since. In the 1978 system, based on the family as the tax unit,[148] gross income above a general exemption level is subject to income tax. The tax rate is applied to taxable income (gross income net of social security contributions plus estimated income from owned occupied residences). Total income tax due is calculated as the tax liability after tax credits have been deducted. Taxes are collected at source through the Pay as You Earn (PAYE) system. In addition to income tax, individuals pay employee social security contributions, which are fully deductible from gross income.

[148] Family unit is defined as a married couple, with or without dependant children, or a single parent with dependant children. Dependant children are children aged under 18 living in the household.

In 1989 some important changes took place. The tax unit moved to the individual, although a joint scheme for family units is still available. Income tax is paid by individuals only on earnings above a general exemption level. The differences between the joint and individual schemes can be summarised as follows. The general exemption is 20% higher for the joint scheme, there are specific tax rates with lower tax cutbacks, in general, for the joint scheme than would result from an income splitting system, and there is a higher tax-credit for low-income tax units contributing under the individual scheme for multiple earners families.

The general exemption level is increased in 1989 in real terms. The number of tax rates is reduced from 28 to 18, and the average tax rate is decreased for individuals with low-income, while increased for individuals with middle and high income (the maximum tax rate being 56%). There is a specific labour income deduction of 2% of gross income (with an upper limit). Tax deductible mortgage interest payments on house purchases are restricted to the main residence and apply to an upper limit, whereas the previous system applied to all houses owned by the household with no upper limit. There were no major changes in the family tax credit system, which maintained is negligible importance.[149] Finally, the main tax credit is the earner's tax credit (a fixed amount for those who are employees).

In 1996 a second main reform took place. Although the recognition of the Autonomous Communities as participants in the income tax system started early in the 80s, it is now when the most important transfer of some taxes from the state to them takes place. The summary of the main features of the system in 1996 are the following. Both the deduction 2% of gross labour income (with an upper limit) relating to work expenses and the fixed deduction returns of capital income (29,000 pesetas) are maintained. Included as earnings there is an imputed income from owners occupied houses (2% of registered council property value). As before, mortgage interest payments on house purchase are deductible from gross income (when the house is the earner's main residence and with an upper limit of 800,000 pesetas under the individual scheme, and of 1 million pesetas under the joint scheme). There are four

[149] Until 1996 the family tax credits were a fixed amount per child, per elderly living in the household and per old aged person.

sets of tax rates: two for Estate taxes and two for Autonomous Communities taxes. Two apply to individual income and the other two correspond to the joint scheme (which is the sum of earnings of all family members). In each of these sets, there are eight different tax rates, which are applied to 8 different levels of income (the maximum tax rate is 56%=47.60%+8.40%, corresponding to the Estate rate and the Autonomous Community rate, respectively).

The main tax credits are the following. First, there is the earner's tax credit, deductible for those whose income is labour related, including social security pensions and benefits. Second, there is a family tax credit, consisting of a fixed amount for dependant child (which increases with the number of children), per dependant ancestor with rents below a given level, per elderly relative aged 65 or above, and per disabled, invalid or blind member of the family unit.[150] Third, there is a tax credit for expenses related to sickness, house renting (when the house is main residence, and childcare (per dependant children aged under 3). Finally, there is a tax credit for private investment, including life insurance contracts, purchase of main residence, purchase of special properties (declared to be of cultural interest), donations to certain Fundations, incentives to professional or business investment, among others. Finally, there are some specific Autonomous Communities exemptions that apply to individuals or households living in the corresponding Community.

Table 4.1 presents the main changes to the income tax system (as it was in 1998) that the 1999 reform will bring, which we summarise in what follows. The minimum exemption for labour related income rises from 1,200,000 to 3,500,000 pesetas. The deduction of 5% of gross labour income (with an upper limit of 250,000 pesetas) is eliminated. Instead, new deductions from labour income are introduced, depending on the level of labour income. Labour income will be reduced by the following amounts: for those earners whose labour income is up to 1,350,000 pesetas: 500,000 pesetas; for those earners whose labour income is between 1,350,000 and 2 million pesetas: 500,000 pesetas minus the result of multiplying by 0,1923 the

[150] The definition of children when calculating the tax credit differs from that used to define the family unit. Single dependant children living in the household aged under 30 with gross income below a certain level are allowed to tax credit. We should stress that the 1996 reform did not change significantly the importance of the family tax credits.

difference between labour income and 1,350,000 pesetas; finally, for those earners whose labour income is above 2 million pesetas (or with non-labour income above 1 million pesetas): 375,000 pesetas. The deduction on gross income concerning mortgage interest payments on house purchase (earner's main residence) is also eliminated and a new tax credit is introduced instead. Regarding capital income, the reform eliminates the imputed rent from owner occupied dwelling (2% of the registered council value of the property) and taxable capital income related to life insurance contracts is reduced in 30% when the income has been generated in more than two years. For deductions from the returns to capital income, the "minimum income exemption" of 29,000 pesetas is eliminated.

One of the main novelties of the tax reform is the introduction of two "minimum income exemptions", the first personal and the second familiar, which reduce the taxable income as follows. The minimum personal exemption is 550,000 pesetas, 650,000 pesetas when the earner is aged above 65 and 850,000 or 1 million pesetas in case of a disabled person.[151] The minimum familiar exemption involves the following: (i) 100,000 pesetas per dependant ancestor with rents below a given level, aged above 65. (ii) per dependant children aged under 25, with rents below a given level, as follows: 200,000 pesetas per child for the first two children, and 300,000 pesetas per child after the third child. These quantities will increase in (i') 25,000 pesetas per child aged between 3 and 16, for school equipment related expenses, (ii") 50,000 pesetas per child under 3. Finally, per disabled dependant person included in (i) or (ii), either descendant or ancestor, independently of their age and with rents below a given level, 350,000 or 450,000 pesetas. These quantities are deductions that apply to gross income and therefore they are eliminated as tax credits relating to the same issues.

Regarding tax rates, the joint tax rates scheme applying to family units is eliminated and the number of tax rates is reduced from 8 to 6, the minimum rate decreases from 20% to 18% (from the first peseta), and the maximum rate decreases from 56% to 48%.

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[151] The minimum personal exemptions for the joint scheme are: 1,100,000 pesetas when both spouses are younger than 65 years, 1,200,000 if one of them is older than 64 years and 1,300,000 if both are older than 64 years.

As regards to tax credits, most of them are eliminated and some of them transformed into income deductions (this is the case of family tax credits or earner's tax credits, as explained above). Tax credits for house renting, childcare and sickness expenses are also eliminated. Instead of the deduction from gross income for mortgage interest payments on main residence purchase (which is eliminated), a new tax credit is introduced. This is a tax credit for investment on main residence, either purchase or restoration. This tax credit only applies when the dwelling purchased or restored is the main residence of the earner. In this case, one of the following tax credit may be applied: (i) 15 % of the invested amount, including interest and capital payments and related expenses, to be applied over a maximum investment of 1,500,000 pesetas. (ii) When the investment is financed through a mortgage, the percentages of tax credit defined in (i) are as follows: during the first two years after the purchase, 25% of the first 750,000 pesetas and 15% of the remaining investment up to 1,500,000 pesetas; from the third year onwards, the above percentages will be 20% and 15%, respectively. (iii) 15 % of the amount deposited in special housing bank accounts, with a limit of 1,500,000 pesetas.

To complete the picture of the current Spanish tax-benefit system we should describe the benefit system. Table 4.2 presents the three main benefits (labour or social related) that any individual may receive. The system works as follows. When an individual becomes unemployed she receives 70% of her previous salary as unemployment benefits for a maximum of two years (depending on how long she was employed). After two years she may perceive either a social salary (state administrated) or a guaranteed minimum income (administrated by the Autonomous Communities). The amount of the social salary depends on the age and the number of dependants in the household.

Finally, in table 4.3 we present the VAT types for the non-durable goods that we explicitly model in the demand system. Column one presents the VAT types before 1996 and column two reports the current VAT types. When more than two types are introduced in a given cell means that different VAT types apply to different goods composing the category.

4.3. The data and some methodological issues.

4.3.1. The data.

We use two data sets, both conducted by the Spanish statistical office (Instituto Nacional de Estadística, INE). First, we use the Spanish EPF, recorded during 1990-1991 to estimate the 1998 and 1999 tax-benefit systems. Second, we use the Spanish Panel Expenditure Survey (ECPF) for 1985-1995 to simulate some of the reforms, to estimate the demand system and to calculate the reaction of households to changes in indirect taxes.

The EPF is a survey carried out every 10 years approximately aiming at constructing the Spanish RPI. In this survey 21,155 households are interviewed (72,123 individuals accounting for all members in the household). This sample of households is randomly extracted from all Spanish Autonomous Communities by a stratification process that makes it representative of the Spanish economic, demographic and social structure. For each individual in the sample there is a grossing-up factor indicating the number of households this individual represents at a national level. There is comprehensive information about socio-demographic characteristics, income sources,[152] bank debts and other liabilities, mortgage payments in which the household is involved, information about the house in which the household lives and other houses owned by the household (physical state and characteristics, and economic value of the premises) and, finally, there is detailed information about household expenditures (covering 919 expenditure categories). This information makes the survey unique in order to calculate the complex 1998 Spanish tax-benefit system and the extent of the 1999 reform. Furthermore, the representativeness of the sample of households and the grossing-up factors provided allow to calculate the effects of the reform at a national level, giving precise monetary costs in terms of revenue, and to calculate

[152] There are 21 different sources, being mainly labour income, self-employed income, pensions, social salary, unemployment benefits, scholarships, earning for shares, prizes, interest from bank accounts, earnings from other investment, etc.

the effects by demographic breakdown (e.g., income levels, number of children, etc.).

The second data set used in this chapter is a balanced panel of households drawn from the ECPF from the first quarter of 1985 to the fourth quarter of 1995. A description of this data set can be found in the data appendices in previous chapters.

4.3.2. Methodological issues.

In this chapter we first simulate the 1998 tax-benefit system in order to assess some of the effects of the 1999 income tax reform.[153] We assume no behavioural responses of the individuals to the reform (static analysis), although some behavioural responses might be observed to occur after the reform takes place.[154] In table 4.1 we present the main changes in the new tax-benefit system. We calculate which would have been the individual's (household) tax liability under both tax systems assuming that every individual in the household pays her tax duties. However, as highlighted in Mercader (1994) there are several reasons to expect that individuals do not contribute as they should, i.e. there is tax evasion or avoidance (specially from individuals in low income households).

We use the Spanish RPI to update the data. This seems to be the most appropriate method of updating our data since these data are collected to construct the RPI. In the data, both labour and investment income are recorded net of pay as you earn (PAYE) taxes and net of employee's social security contribution. Therefore, to compute individuals' taxes we need to calculate gross values. In order to do so, previously to the calculation of the individual's tax liability, we create a programme that calculates the individual's PAYE and accounts for the social security contributions for each job category.[155]

[153] For a more detailed discussion on some methodological issues related to microsimulation of tax systems see Sutherland (1991) and Giles and McCrae (1995).
[154] The static analysis would be inadequate for policy reforms specially designed to change the behaviour of the individuals. However, this is not our case.
[155] To calculate the PAYE under the 1998 tax regime it is only needed to account for family demographic structure (number of children) and the expected individual's income for the

As regards house deductions or exemptions, the 1998 system includes a deduction for mortgage interest payments and a tax credit of 15% for investment in main residence. Owners should also impute the 2% of registered council property value as income. The 1999 only maintains a tax credit of 25% of the investment amount (both mortgage interest and capital payments). The only reliable information of the data set about housing is that concerning the capital payments but not the information about mortgage interest payments. We only calculate the 2% imputed income and the corresponding tax credit for the 1998 tax. For 1999 we only take information about the capital payments to calculate the corresponding tax credit.

For each individual in the household we calculate taxes both under the joint scheme and under the individual scheme, and select the cheapest one, assuming households would choose to pay less. The results obtained can be evaluated at national figures by using the individual's grossing-up factor provided in the data. This aggregated revenue is calculated as follows,

$$(4.1) \qquad TR = \sum_{i=1}^{N} g_i tax_i$$

where *TR* is the national income tax revenue, g_i and tax_i are the *i*-th individual's grossing-up factor and income tax duty, respectively.

4.4. Tax simulations.

4.4.1. A theoretical framework.

The 1999 income tax reform is an important reform that has been the subject of a big debate in the Spanish media because of its potential effects on some specific household groups and some specific issues (revenue reduction at a national level, minimum family exemption, children related exemptions, etc.). The main concern

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incoming year. Calculations for the 1999 PAYE are more complex but have also been calculated. Different income sources have different deductions and these have been accounted for when calculating the gross figures. Finally, we have also taken into account, in our calculations, the fact that employee's social security changes across occupations.

in this chapter is to provide an evaluation of the impact of this reform using simulation techniques.

The new income tax system in itself is much simpler than the old one but it is quite complex in its application given that it attempts to adjust the PAYE, as much as possible, to the individual's final tax liability (duty). Should the household or individual's situation change across the year (for example becoming unemployed or having a child) there is a mechanism to adjust to these changes. Also, there are some complexities in determining who is in the zero tax liability category. Once all these questions are solved, the tax procedure is quite straightforward.

To make some assessments about the effects of the reform we simulate, for the same sample of households (individuals), both the previous tax system and the system after the reform. On the grounds of these two sets of estimates we give some evidence on the progressiveness of the new tax system, the estimated revenue cost of the reform, who loses and who gains with the new income tax system, the extent of the new children related exemptions, etc. We calculate the cost of the reform in terms of revenue at national level as we have the grossing-up factors that make our sample representative of the Spanish economy. This figure should then be a good estimator of the real one.[156] We also calculate by household group, by demographic breakdown and by deciles the losers and gainers of the reform. Furthermore, we compare children related benefits to assess in both sets of results whether the improvement in these benefits could be an incentive to increase the number of children for the Spanish household. Finally, we analyse whether the minimum personal exemption under the joint scheme of the tax system may be an incentive to reduce married women's participation in the labour market.

We create two programmes (one for the 1998 income tax system and one for the 1999 system) that account for all individual's socio-demographic variables (age, job category, houses owned, number of dependants, etc.) and for all source

[156] A way to check the reliability of microsimulation models is to compare the simulated outcomes to the survey 'actuals', Pudney and Sutherland (1994). In this line, if possible we compare our simulated results to the real ones.

of (taxable) income that the individual perceives. As explained before we transform all kinds of income to gross income. We apply both the 1998 and the 1999 tax procedures to these gross figures to calculate tax duties.[157]

The cost of the reform (expressed in 1999 pesetas) may be calculated computing the changes in individual's tax liability due to the income tax reform and using the grossing-up factors. The results of the 1999 tax reform simulation suggest that there would be an important reduction in the state tax revenue. Presumably, this change in revenue will eventually be transferred to consumers by, for example, a reduction in the supply of public goods or an increase in other taxes. In what follows we assume that the state uses an increase in indirect taxes to finance the reduction in the individual income taxes. This increase in the VAT types implies a change in the structure of the relative prices for all commodities. On these grounds, we could model this double reform (the change in the tax-benefit system and the change in the VAT structure) as being revenue neutral. Once we know the revenue cost of the reform, and using the information on individuals' allocations of expenditures (on non-durable goods) we can estimate the increase in VAT types (for all goods) needed to compensate the revenue cost of the tax reform. Up to this point we assume that household expenditure shares (on the non-durable goods modelled) remain unchanged (static analysis).

The next step is to allow households to react (increasing or reducing their expenditures) to the increase in VAT types using both income and price elasticities calculated in chapter two.[158]

In the analysis of the effects of the VAT increase we follow Symons and Walker (1989) in the treatment of expenditures not included in the behavioural demand system. Since this group is composed basically of durable commodities

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[157] The programming of the tax system (using Stata 5.0) has been done in the same spirit than similar packages developed in Spain (see García, Labeaga and López, 1997) and in other countries (i.e., Bourguignon and Chiappori, 1998, for France, Keane and Moffitt, 1991, for the US and Giles and McCrae, 1995, for the UK). Some other issues have been programmed using GAUSS 2.0. All these programmes are available from the author upon request.

[158] We estimate a 9 non-durable demand system using the ECPF from 1985 to 1994 using the Quadratic Almost Ideal Demand System (QUAIDS) model of Banks, Blundell and Lewbel (1997). The results of this demand system are used to calculate price and income elasticity for all individuals in our sample. The ECPF and the EPF data sets are fully compatible and therefore combining both data sets is not a problem to the analysis.

we assume that the tax reform does not affect the quantities consumed on these goods. This is a reasonable assumption when looking at short run effects. Therefore, given that new indirect taxes will cause more expenditure to be devoted to these rationed commodities, we let changes in their prices to induce lump sum subtractions to the expenditure devoted to the modelled system commodities. Formally, this assumption implies the following mapping of the household's budget constraint

(4.2) $\{s^0, e^0, p_s^0, p_e^0\} \rightarrow \{s^1, e^1, p_s^1, p_e^1\}$

(4.3) $s^0 + e^0 = s^1 + e^1$

where s are non-durable (system) expenditures, e are durables (excluded) commodities, and p_s and p_e are their respective prices. The 0,1 subscripts refer to pre- and post-reform situations.

To calculate the effect on prices of the income tax reform we assume that the loss in total revenue is distributed among all prices (equally or weighted). This implies an increase in each commodity VAT type. To construct the new prices for the demand system commodities one has to bear in mind that each good within the 9 categories has a different tax rate, and thus we weight each of them by their contribution to the composite category. Furthermore, if $p_i^0 = (1+t_i^0)(\overline{p}_i + c_i^0)$ is the pre-reform price for the i_{th} commodity, where t_i^0 and c_i^0 are the initial VAT and excise rates, respectively, and $\overline{p}_i$ is the net of taxes producer price, then the post reform increased price is given by $p_i^1 = (1+t_i^1)\left(c_i^1 - c_i^0 + p_i^0/(1+t_i^0)\right)$.[159] With the increase in prices we account how much each household spends on each commodity.

Assuming that household total expenditure remains unchanged we can calculate (using our estimates for the non-durables demand system) the new household shares after the change in the VAT types. In order to do so, we first calculate (following Baker, Mackay and Symons, 1990) the share prediction

[159] In some cases, it is not possible to evaluate the exact figure for some of the goods we model as different taxes apply to different varieties in the same category (e.g., alcohol or tobacco) and therefore we use an approximation to calculate the new price.

error, that is the component of the household share not explained by prices and total expenditure

(4.4) $\hat{e}_{ih} = w^0_{ih} - w_{ih}(p^0, x_h, \hat{\beta}_i, \hat{\gamma}_{ij})$ y=1,...,9; j=1,...,9 and h=1,...,N.

Thus, the post-reform shares are defined as

(4.5) $w^1_{ih} = \hat{w}_{ih}(p^1, x_h, \hat{\beta}_i, \hat{\gamma}_{ij}) + \hat{e}_{ih}$

With these new shares we evaluate the extra VAT revenue due to the changes in the VAT types, and assess households' reaction to changes in relative prices. Households change their expenditure shares to changes in the structure of relative prices in order to avoid the relatively more expensive goods. After these households reactions the VAT revenue will change and will not be enough to offset the cost of the income tax reform. We then calculate a new increase in VAT types that will produce an increase in indirect taxes sufficient to cover the cost of the income tax reform. Again, there will be household reactions to this second increase in indirect taxes. We follow this process until we get convergence, i.e. the VAT collected completely compensates the reduction in income taxes.

Finally, we also provide a measure of welfare effects from the simulated changes in the structure of prices. Despite its various conceptual drawbacks (see Banks, Blundell and Lewbel, 1996) we measure the change in household welfare through the equivalent loss, a money-metric impact of price changes. This concept is defined as the amount of income that needs to be given (subtracted) to (from) the household in order to obtain the post-reform level of utility while keeping the initial price vector. Since we estimate a cost function this measure of welfare can be calculated straightforward.[160] First we calculate the equivalent income, which is implicitly defined as

[160] We follow King's (1983) methodology to calculate the distribution of gains and losses after a fiscal policy change.

$$(4.6) \quad v(p^r, y^e) = v(p, y)$$

where $v(.)$ is the indirect utility function and p^r is a reference price vector.[161] Inverting the above expression we get

$$(4.7) \quad y^e = c(v, p^r) = c(p^r, p, y)$$

that is the amount of income which at the reference price level (initial values in our case) is equivalent in terms of utility to the actual household income at final prices.[162] Thus, the equivalent gain (loss) for any household is obtained as $EG_h = y_h^0 - y_h^1$ where y_h^0 is the initial level of household income. We follow King (1983) in computing this measure, although we adapt the formula to the QUAIDS model used to estimate the demand system (for details see Banks, Blundell and Lewbel, 1997).

4.4.2. The results.

In table 4.4 we summarise average figures of the main results from the simulation of the 1999 income tax reform. The mean taxable income decreases in real terms by 35.5% between 1998 and 1999. This result is mainly due to the introduction of the deduction from gross labour income and the personal and children related exemptions (see table 4.1 for details). There is also a reduction in the average tax margin and a substantial increase (32%) in the number of households falling in the zero tax duty category. The changes introduced in personal and children exemptions and tax credits complicate the comparison of the two regimes, and therefore we only compare the mean tax due. There has been an important reduction (25%) in the average tax due between 1998 and 1999. The main conclusion that can be drawn from the results in table 4.4 is that the 1999 income tax reform will reduce, on average, income taxes that the Spanish individuals will

[161] Note that the use of a linear budget constraint makes that the equivalent income is independent of preferences.

[162] An alternative definition can be found in Deaton and Muellbauer (1981).

pay in 2000. Now, we calculate how much would cost the implementation of the reform in terms of aggregated revenue. The last row in table 4.4 reports the estimated total revenue for both the 1998 and 1999 income tax systems. At a national level, we estimate a reduction in tax income revenue of 1,115 billions of 1999 pesetas (around 6,701 millions of euros). Some institutions and economic authorities have predicted (speculated) this figure, although we claim, and the real figure in 2000 will confirm this, that our estimated figure is the most precise calculated, so far, about how much the income tax reform will cost.[163]

Behind these averaged figures we further investigate the distributive effects of the reform on specific groups of individuals. Table 4.5 shows the reduction (increase) of tax duties for all individuals, by income deciles and using sub-samples corresponding to some socio-demographic variables. The column headed "tax reduction" reports the reduction (increase) in taxes due to the reform and the column headed "income" reports households' taxable income. On average, all households have to pay less (36,748 pesetas, i.e. 3.06% less than in 1998 in relation to taxable income), but this figure hides a non-equal change in the distribution of the reductions. For example, for the first five deciles of the distribution[164] there has been an increase of the tax duties after the reform, whereas for the rest of the individuals in the sample there is a reduction in income taxes. It is also observed that, in general, the higher the individual's income the greater her tax reduction. This evidence confirms, contrary to the government announcements, that the new income tax system is less progressive than the previous one. In 1999 in the Spanish media echoed a long debate on the impact of the reform on different groups of households. Different analysts tried to show either the progressiveness or the regressiveness of the new system by using "typical families". However, as poited out by Giles and McCrae (1995), the use of such methods carries with the temptation to choose the "appropriate" household

[163] None of these studies has a representative sample of the Spanish economy using the grossing-up factors provided by our data. These studies predict reductions in the tax income revenue that range from 3,005 to 4,508 millions of euros.

[164] These deciles of the distribution are mainly composed by low income individuals, 80% of them are heads of households, 17% are single individuals living with their parents and 3% are pensioners.

to highlight the point, rather than one representative of the current Spanish population. In all cases the information given was misleading as there was no reference to the real family structure of the Spanish economy. Conditional on the assumption that the Spanish socio-demographic structure is the same than in 1990-91 our simulation enlightens the effects of the reform both on different groups of households and on national revenue.

It is to be expected that sooner or later individuals will have to pay back any reduction in their income taxes, either via a reduction in the public goods they enjoy or via an increase in other taxes (for example indirect taxes). As explained in the previous section we have carried out an exercise that predicts the increase in the VAT types (by commodity group) that completely offsets the predicted cost of the reform. When indirect tax rates change households react according to their price and income elasticities, substituting the relatively more expensive goods to the relatively cheaper ones. Their reaction will change the VAT revenue and therefore the former increase in the VAT should be modified accordingly to offset the cost of the income tax reform. Again, there would be consumer's reactions to the changes in VAT, etc. We follow up this process until convergence is achieved (actually, to completely offset the income tax reform via an increase in the VAT types we have carried out this process three times). Table 4.6 presents the effects that, in terms of equivalent loss (gain), the increase in the VAT types imply to households, by demographic breakdown and by total expenditure deciles.[165] The column headed "VAT tax" reports the increase in indirect taxes paid by households and the column headed "Equivalent loss" reports the money metric measure of utility change.[166] We also report the equivalent loss as a percentage of pre-reform total expenditure. Finally, the column headed "Total expenditure" presents the pre-reform household's expenditure in the nine non-durables goods.

In table 4.7 we present children related benefits both under the 1998 and

[165] We evaluate these figures at household level as we only have expenditure information at household level in our data.
[166] All figures are equivalent losses as the reform leads to price increases in all demand system commodities.

the 1999 income tax systems. In the 1998 system there was a specific tax credit for dependant children and in the current system children related benefits take the form of a deduction from gross income. The government announced its concern about: one, increasing children benefits, specially for households with more than two children and, two, providing incentives (through the income tax system) to increase the natality rate. In our simulations we compare households' tax duties under the 1998 tax system with tax duties that would result if children related benefits had taken the form of the 1999 tax income children system deductions from gross income. The results show that the difference between the two sets of taxes are quite small on average (there is a saving in taxes of 2.59%). Only when a household has three or more children the saving in taxes is higher than 5% (these households represent a 26.3% of households with children and 14.9% of all households). Indeed, households with more than two children get higher benefits than the other households with children in the 1999 tax system, but these benefits are far from being significant. As a percentage of total household income this figure ranges from 0.43% to 1.37%. In relation to children allowances, we could compare the equivalence scales estimated in chapter 2 with the 1999 tax system children related benefits. The determination of the so called "living minimum" was the centre of a big controversy when the 1999 income tax reform was first presented by the government. A living minimum is no more than an equivalent scale. Thus, we can compare these equivalent scales implicitly designed in the tax system with the equivalent scales that we have obtained previously. The implicit equivalent scales are below the equivalent scales calculated in chapter 2 (by 17.40%). Clearly, this children's minimum living has been underestimated by the policy maker when the 1999 income tax reform was designed. Also the more children a household has the higher the underestimation of the children's minimum living. Therefore, the introduction of the children related benefits in the new income tax system to compensate households with children and as an incentive to increase the fertility rate seems to be quite limited.

For married women working part time, the minimum exemption scheme can have negative incentives to participate in the labour market. The minimum guaranteed wage in Spain for 1999 is 969,780 pesetas, and the minimum personal exemption for spouses if a household chooses the joint scheme is 550,000 or 650,000 pesetas (depending on the woman's age). It seems from these figures and from our results that married women working part time or perceiving a salary less than the minimum exemption level, would decide to stay at home as her market salary would be less than the benefit they can get if her husband is working. In table 4.8 we present information about these incentives. There are 3,452 women who work up to the 16,600 married women of our sample (3,425 are younger than 65 years). If we compare the salary they get with the minimum exemption level they can perceive under the joint scheme we have that 1,330 of these women would be better off if they decide to drop from the labour market, i.e., 38.53% of women working have incentives to leave their jobs. Also most of them belong to households with children aged less than 13 years.[167] One is tempted to consider this evidence as a complementary incentive to increase the Spanish fertility rate.

4.5. Conclusions.

Any tax system should aim at being dynamic and flexible adjusting according to changes in social and economic conditions. Fiscal policy should take into account all these changes and tax reform should move according to new social parameters. Given the distributive effects of any fiscal reform, assessing its potential impact, both in terms of aggregated revenue and on different groups of households, or individuals, is of great interest. This makes simulation techniques an important tool of fiscal policy. This chapter evaluates the effects of the 1999 Spanish income tax reform using simulation techniques on a sample of households drawn from the Spanish Family Expenditure Survey (EPF) for 1990/91. As the sample analysed is representative of the population, it is possible to predict the cost of the reform in terms of national income tax revenue, to make inferences about the aggregate revenue implications of specific changes and to analyse its impact on different

[167] Although it is out of the scope of this chapter, it would be interesting to evaluate the dynamic effects on women labour supply implied by the 1999 system.

groups of households.

The main results obtained are the following. First, our results show that the mean taxable income decreases in real terms by 35.5%, mainly due to the introduction of the deduction from gross labour income, and there is a substantial increase in the number of households exempted to pay income tax. Moreover, we estimate a reduction in the average tax due of about 25%. Beyond these average figures, we further investigate the effects of the reform on specific households groups and obtain a non-equal change in the distribution of the tax reduction. Thus, there is some evidence that the new income tax system is less progressive than the previous one. Second, the national revenue cost of the reform, according to our simulations, is estimated in 1.115 billions of 1999 pesetas (6,701 millions of euros). We claim that this figure is a very good estimate of the real cost of the reform given that we have used a representative sample of the Spanish economy.

Third, assuming that the loss in revenues due to the reduction in income taxes will have to be compensated by increase in other taxes, e.g. the VAT, we calculate the increase in VAT rates needed to finance the cost of the income tax reform. We also give a metric measure of the effects on welfare (equivalent loss) of this change in the indirect taxes. On average, there is a loss in terms of welfare of around 5.6% in terms of household total expenditure.

Fourth, we investigate child benefits and the incentives for working married women to leave the labour market. Changes in children related benefits or exemptions in the new income tax system are quite small (there is a 2.59% reduction in the taxes paying by households with children, *ceteris paribus*), and only for households with 3 or more children the saving in taxes is higher than 5%. Also, the minimum living related to children, implicitly designed into the 1999 income tax system underestimates the equivalence scales estimated for Spain in chapter two. Finally, it seems that the personal minimum exemption from gross income may be an incentive for married women working part time to drop from the labour market as her market salary is below the minimum exemption. This may be interpreted as an complementary incentive to increase the Spanish fertility rate.

4.6. Appendix A: Tables.

Table 4.1.
The 1998 tax income system and the 1999 reform.

	The 1998 Income Tax System	1999 Reform
Minimum exemption for labour related income	1,200,000 pesetas.	3,500,000 pesetas.
Deductions on gross income: minimum personal exemption	None.	The minimum personal exemption is 550,000 pesetas per person o per spouse (650,000 pesetas when the earner is aged above 65 and 850,000 or 1 million pesetas in case of a disabled person).
Deductions on gross income: familiar minimum exemptions	None.	- 100,000 pesetas per dependant ancestor aged above 65. - per dependant children as follows: 200,000 pesetas per child for the first two children, and 300,000 pesetas per child after the third child. In addition (i) 25,000 pesetas per child aged between 3 and 16, for school equipment related expenses, (ii) 50,000 pesetas per child under 3. - per disabled dependant person 350,000 or 450,000 pesetas.
Deductions from gross labour income	5% of gross income, with an upper limit of 250,000 pesetas.	-500,000 when labour income is up to 1,350,000 pesetas. -up to 375,000 for income between 1,350,000 and 2,000,000. - 375,000 for income above 2 million pesetas or when the individual has income from other sources (different from labour) above 1000000 pesetas.
Capital income	There is a "minimum capital exemption" of 29,000 pesetas.	Taxable capital income is reduced in 30% when generated in more than 2 years.
Tax rates	There are two schemes: one individual tax rates scheme and one joint tax rates scheme. For each scheme, there are 8 tax rates, with a minimum of 20% and a maximum of 56%. In both cases, the tax rates are the result of combining the Autonomous Community and the State tax schemes.	There are 6 tax rates, with a minimum of 18% and a maximum of 48%. These 6 tax rates are the result of combining the Autonomous Community and the State tax schemes. Although the new income tax system is individually based, the joint scheme is also available.
Tax credits	- per earner. - per dependant children, elderly or disabled. - per child custody expenses. - for sickness expenses. - for house renting.	Some of previous tax credits (per earner, per dependant children and per elderly) are transformed into income deductions (personal and family related). Other are eliminated (house renting, sickness and child custody expenses). The main tax credit remaining is for investment on main residence (purchase or restoration).
House deductions	- There is a deduction from gross income for mortgage interest payments on house purchase (only when the house is the earner's main residence and with an upper limit). - Owners' occupied houses have to impute as income the 2 % of registered council property value. - There is a tax credit of 15% for investment on main residence.	-Income deduction for mortgage interest payments is eliminated. - The 2% value of the owners' occupied property is not imputed as income. - There is a tax credit of 25% of the sum of mortgage interest payments and capital invested on main residence, with a limit of 750,000 pesetas, and of 15% of further 750,000 pesetas, for the first two years. From the third year onwards the tax credits are 20% and 15%, respectively.

Table 4.2.
The Spanish benefit system.

Type of benefit	Description
Unemployment benefit	First 2 years unemployed: 70% of previous salary. After 2 years: either the social salary or the guaranteed minimum income offered by the Autonomous Communities.
Social salary	75% of guaranteed minimum wage if aged<45 100% of guaranteed minimum wage if aged>45 with two dependants. 120% of guaranteed minimum wage if aged>45 with three or more dependants.
Guaranteed minimum income offered by the Autonomous Communities.[1]	For individuals who do not receive social salary or unemployment benefits: 35,838 pesetas monthly for families with one child. 60,925 pesetas monthly for families with two or more children.

Notes:
1. Guaranteed minimum income is an average for all the Autonomous Communities.

Table 4.3.
Indirect tax system (VAT) before and after the 1996 reform.[1]

Commodity category	VAT type before 1996	VAT type in 1999
food[2]	6%, 3%, 0%	7%, 4%
alcohol[3]	excise duty (special type)	excise duty (special type)
tobacco[4]	excise duty (special type)	excise duty (special type)
clothing and footwear	15%	16%
house energy[5]	15%, 6%, 4.864%	16%, 7%, 4.864%
out	6%	7%
entertainment	6%	7%
personal care	15%	16%
health[6]	6%, 3%	7%, 4%
private and public transport[7]	6%, special	7%, special

Notes:
1. The VAT system started in Spain in 1986, although some time before the former indirect tax system was adapting to the VAT system. The VAT types can be classified in: general, reduced, super-reduced and special types (for alcohol, tobacco, electricity among other goods).
2. In food we should take into account that for bread, milk, eggs, fruit and vegetables the VAT type is 4% in 1999.
3. There are specific excise duties depending on the percentage of alcohol in the alcoholic drinks.
4 After 1996 there are 4 types (12.5%, 22.5%, 37.5% and 54.5%) and one excise duty of 500 pesetas/1,000 cigarettes.
5. For water consumption the VAT type is 7% and for electricity the type is 4.864%.
6. For health services the VAT type is 7% and for medicines the type is 4%.
7. For fuel and similar there is a special VAT type.

Table 4.4.

Main figures under the 1998 and 1999 tax income systems.

	1998 Income tax system.	1999 Income tax system.
Mean taxable income	1,201,288	774,631
Mean personal and children minimum exemption	-	708,559
Mean deduction from gross labour income	-	442,499
Mean tax liability	186,480 (15.52%)	113,945 (14.71%)
Mean tax credits	37,978 (3.16%)	10,800 (1.39%)
Mean tax due	147,559 (12.28%)	110,811 (14.30%)
Mean tax type	0.13%	0.12%
Number of people in the 0 tax category	37,479 (51.96%)	49,423 (68.52%)
National revenue	5,790	4,675

Notes:

1. All figures are in 1999 pesetas.
2. The national mean income in 1999 was 1,320,000. This figure compares well to the sample mean income, 1,223,626.
3. National revenue are in billions of pesetas. These figures are 34,799 and 28,097 millions of euros, respectively. The real 1998 figure was 34,707 millions of euros.

4 Mean tax type calculated with those who pay taxes.

5 Figures in parenthesis are the percentage of each figure with respect to taxable income in each year.

Table 4.5.

Tax reductions after the 1999 tax income reform.

Group of individuals	Tax reductions	% of saving	Income
All individuals	36,748	(3.06 %)	1,201,288
Age < 65	33,863	(2.83 %)	1,195,709
Age ≥ 65	54,195	(4.40 %)	1,231,727
0 children	42,341	(3.25 %)	1,302,764
1 child	37,679	(3.03 %)	1,243,759
2 children	33,102	(2.95 %)	1,122,039
3 children	25,561	(2.68 %)	954,033
4 children	21,800	(2.64 %)	825,018
> 4 children	20,687	(2.89 %)	716,862
Decile 1	-3,433	(-7.49 %)	45,809
Decile 2	-2,145	(-3.22 %)	66,595
Decile 3	-3,289	(-2.33 %)	141,150
Decile 4	-5,841	(-2.68 %)	217,965
Decile 5	-4,414	(-1.25 %)	353,302
Decile 6	13,715	(2.00 %)	686,177
Decile 7	48,826	(4.61 %)	1,058,262
Decile 8	74,752	(4.78 %)	1,563,905
Decile 9	77,720	(3.34 %)	2,330,138
Decile 10	171,718	(3.94 %)	4,355,016

Notes:
1. All figures are individual data in 1999 pesetas.
2. In column two we report the percentage of reduction in income tax with respect to total income.
3. Income = individual income.

Table 4.6.

Changes in VAT payments and equivalent loss after the increase in consumer prices.

Group of households	VAT increase	Equivalent loss	% loss	Expenditure
All households	83,945	136,886	5.649	2,423,252
Age < 65	83,485	139,191	5.774	2,410,586
Age ≥ 65	85,255	139,091	5.656	2,459,342
0 children	84,513	138,107	5.661	2,439,824
1 child	84,387	143,745	5.901	2,435,928
2 children	82,666	130,840	5.483	2,386,278
3 children	83,507	124,161	5.155	2,408,449
4 children	77,529	112,779	5.030	2,242,136
> 4 children	76,284	99,669	4.524	2,203,113
Decile 1	16,478	21,213	4.425	479,374
Decile 2	30,838	42,202	4.729	892,436
Decile 3	42,781	61,233	4.954	1,235,965
Decile 4	53,781	79,465	5.115	1,553,486
Decile 5	65,197	99,142	5.267	1,882,350
Decile 6	77,152	119,901	5.384	2,227,087
Decile 7	91,518	146,084	5.535	2,639,262
Decile 8	109,961	180,775	5.700	3,171,747
Decile 9	137,447	230,990	5.827	3,963,947
Decile 10	214,245	387,789	6.269	6,185,584

Notes:
1. All figures are household data in 1999 pesetas.
2. "% loss" = Equivalent loss as a percentage of pre-reform household total expenditure.
3. Expenditure = Household total expenditure in the 9 non-durable goods.

Table 4.7.

Changes in children related benefits under the 1998 and 1999 regimes.

Group of households	Number of households	Taxes 1	Taxes 2	(% difference)	Tax 99	Income
All households	21,155	503,066	490,024	-2.59	377,782	3,060,050
Household with children	11,994	601,902	577,134	-4.11	454,237	3,657,726
1 child	4,061	587,731	571,958	-2.68	449,267	3,257,689
2 children	4,780	639,070	613,980	-3.93	488,199	3,847,260
3 children	2,078	573,516	537,131	-6.34	427,482	3,868,356
4 children	730	604,966	561,012	-7.27	420,778	4,010,831
> 4 children	345	453,554	402,608	-11.23	274,137	3,724,725

Notes:
1. All figures are household data in 1999 pesetas.
2. "Taxes 1" = household 1998 taxes.
3. "Taxes 2" = household 1998 taxes with 1999 children related benefits.
4. The third column presents the difference between taxes when using the two different children related income tax benefits. This difference is reported as a percentage of total income.
5. Children are defined as those dependants aged less than 25 years whose income is below an upper limit.
6. See table 4.1 for details in children related benefits.

Table 4.8.

Implicit equivalent scales related to children's minimum living.

	Number of households with children	Minimum exemption related to children	"Children's minimum living"	Equivalent scales
All households	11,994	464,422	1.15	1.35
1 child	4,061	201,773	1.07	1.16
2 children	4,780	421,506	1.13	1.39
3 children	2,078	719,646	1.22	1.46
≥ 4 children	1,075	1,154,093	1.35	1.68

Notes:
1. All figures are in 1999 pesetas.
2. "Minimum living" associated to the minimum exemption related to children. We calculate this figure as the percentage of the children's minimum exemption with respect to household income.
3. Equivalent scales are calculated in chapter 2.

Table 4.9.
Minimum personal exemption for women under the 1999 income tax system and incentives to leave the labour market.

	Number of women	Taxable income	Labour income	Number of women with children
Married women	16,600	266,223	254,668	7,531
Married working women	3,452	815,819	1,102,557	2,188
Married working women aged < 65	3,425	198,660	1,104,683	2,188
Married working women aged ≥ 65	27	210,646	832,879	0

Notes:
1. Minimum personal exemption: 550,000 if aged less than 65 years and 650,000 if aged 65 or more years.
2. Minimum personal exemption under the joint scheme: 1,100,000 if both spouses are aged less than 65 years, 1,200,000 if one of them is aged less than 65 and 1,300,000 if both are aged 65 or more years.
3. Number of women in the sample: 36,708 (50,9% of the sample). 22,074 of them are aged between 18 and 64 years and 7,586 are working (34,4%).

Conclusions and further research

The aim of this thesis is the analysis of household demand patterns (chapter one) and the (static and lifetime) effects of children on these patterns (chapter two and three). We also assess the effects of the 1999 Spanish fiscal reform on household welfare, especially focusing on children related benefits (chapter four).

In chapter one we discuss several classes of bivariate limited dependent models. These may be used as alternatives to the Tobit model in the analysis of household consumption behaviour for goods that present some infrequency in their purchase. We especially analyse the Infrequency of Purchase Model (IPM) where zero values occur due to the "durability" of a commodity for which the expenditure observations are drawn. In this chapter we extend the IPM to panel data and provide an empirical application for the demand of clothing, a good for which the main reason behind a zero record can be attributed to infrequency of purchase. The extension of the IPM to panel data leads to the sample selection panel data models, as the decision to purchase can be seen as a selection equation and the equation of interest is the demand equation. For the demand equation we use and extension of we use an extension of Heckman's (1979) sample selection technique.

Most of the empirical applications of the IPM models use cross-sectional data although it is crucial to control for individual heterogeneity and price variation in this context. In our application we account both for unobserved individual heterogeneity and for price variation. We estimate the demand for clothing consumption using two alternative panel data estimators. First, a time aggregated estimator that is robust to any frequency of purchase structure and allows for heteroscedasticity. Second, a two step sample selection panel data estimator with two alternatives for the estimation of the equation of interest (second step), i.e. the demand for clothing.

We estimate these models using a panel of households drawn from the Spanish Family Panel Expenditure Survey (ECPF) for the period 1985 to 1991.

Our main concern to estimate an IPM with panel data is to compare its results to the case where the infrequency of purchase model is estimated using cross-sectional data. We also carry out some diagnostic tests using Hausman (1978) and Mroz's (1987) approaches. We test the panel data model against the cross-section model in our empirical application. We also test for the exogeneity of the fixed effects. The comparison of the panel data model against the cross-sectional model and results of test for exogeneity of the fixed effects suggest that it is crucial to account for heterogeneity in the IPM, and this would affect the estimates of the demand for clothing and the calculation of price and income elasticities.

The effects of children on household demand are important both empirically and politically, being a fundamental element in Government welfare policies. We analyse these effects using two complementary approaches. In the first one we focus on a contemporaneous dimension (static) of child effects. In the second approach we look at the effects of children in a life cycle context, highlighting that child effects are indeed spread over the household's lifetime.

It is known that children affect consumption of different goods in different ways. In chapter two we investigate the (static) effects of children on household demand. The notion of demographic separability, introduced by Deaton, Ruiz-Castillo and Thomas (1989), is useful in structuring ideas about the (different) effects of children on demands for goods. The arrival of children do not remove a household's budget constraint and responses to a demographic change related to children include income effects even on goods little affected by children (adult goods). However, the idea of demographic separability is that for these goods these may be the only effects. The idea of adult goods can also be found in the literature on child costs, particularly in the way it stands behind the Rothbarth (1943) method. Under a specific interpretation of this method, it can be seen as a special case of demographic separability, allowing for the identification of child costs.

In this chapter we estimate a demand system over eight possible adult goods using the QUAIDS model of Banks, Blundell and Lewbel (1997) on a panel of households drawn from the Spanish Panel Expenditure Survey, form 1986 to 1994. The use of microeconomic data to estimate the demand system raises the problem of the zero records. In this respect, before estimating the model, we have discussed several ways to minimise the impact of the zero records over the estimated coefficients. We deal, in the empirical work, with this problem using different strategies (e.g. selection of different samples and aggregation). We also investigate to what extent the errors in variables problem derived from infrequency of purchase is a problem in the estimation of the demand system.

Our main results confirm that it is necessary to account for possible reasons behind zero records, especially those due to infrequency of purchase. Also, it seems that it is relevant to control for unobserved individual heterogeneity. With the estimation results we test for demographic separability. The result of this test allows to calculate Spanish equivalence scales, under the interpretation of the Rothbarth method that we use. These estimated equivalence scales seem to be in line with previous scales obtained for neighbouring countries.

We should also highlight that in the estimation of the QUAIDS model, when we control both for individual heterogeneity and for the presence of zero records, we do not reject the restrictions of symmetry and homogeneity that come from the theory of individual demand.

A further investigation related to demographic separability would be to empirically test some other implications over and above demographic separability when there is price variation in the data. By using an alternative preference function (see equation 2.9 in chapter two) and with price variation it is possible to derive a new demand system that will allow to carry out these tests (see equation 2.11). Price variation would also improve the potential to distinguish between different types of demographic separability with very different welfare implications. We leave these aspects for future research.

As acknowledged by many authors, the effects of children on household behaviour may start even before the child is born, in anticipation of this event (e.g. parents may be saving for their future children), and last some time after the child has left the family. Therefore, the use of contemporaneous analysis to draw conclusions about the effects of a household feature with a life cycle dimension would be misleading. In chapter three we take this view to look at the effects of children in the surroundings of child birth by using an intertemporal setting (i.e. Frisch demands). In this context it is also interesting to discuss a lifetime measure of child costs. In this sense, we analyse the links between demographic separability and Frisch demand and derive the condition under which both Rothbarth demographic separability (chapter two) and Frisch demographic separability are compatible. This would allow to identify lifetime child costs.

In chapter three we then estimate a Frisch demand system over 12 commodities to address the question of how children affect household life-cycle expenditure patterns in the surroundings of child birth, using a panel of households drawn from the ECPF from 1985 to 1995. These data seems to be quite useful for the aim we pursue in this chapter, as it is possible to detect and follow many households in which a child arrives during the sampling period. To capture the effects of the new born children in the surroundings of child birth we include a set of time dummies that account for some periods before and after birth and for birth itself.

Our results suggest that for some of the commodities we model (*tobacco, house commodities* and *house energy, transport, out* and *other non-durables goods*) the set of dummies capturing children effects are not significant, this may indicate that these are pure adult goods as new children have no effect on them, apart from the effects on the marginal (lifetime) utility. It is as if children were completely anticipated. For other commodities (*clothing, entertainment* and *food*) we get significant effects. These effects are also graphically reported as significant "jumps" in the figures that look at the effects of the dummies to birth on commodity demand (see figure 3.2). It is as if household can not avoid the expenditure of some (children related) goods when children are around. This can be interpreted as the increase in *needs* when children are born (nappies, food, etc.). We further investigate some goods affected by the set of dummies to birth, by including interactions of these dummies with female and other members of the household participation dummies, with prices and with the interest rate. Our results suggest that labour participation dummies interact with the presence and/or arrival of children in affecting the demand for *food*, *children* and *baby clothing* and *out*. This suggests that there are significant non-separabilities between labour supply and demand. We also get significant results when we interact the dummies to birth with prices and the interest rate, indicating that children re-scale household's prices as in the model of Barten (1964) and children affect the estimated intertemporal substitution elasticity. These will make household substitute away from the relatively more expensive goods and from the relatively more expensive periods, respectively. Therefore, we get some empirical evidence that indicates that children affect household demand even before they are born. Summarising, these results seem to reflect that children are to some extent (except for the non avoidable expenditures) anticipated in the Spanish households.

Further research in relation to this topic will go in the direction of defining a compatible lifetime measure of child costs, using the results of this chapter, in the context of Frisch demand. We have some empirical evidence that children affect intertemporal household demand, and thus any measure of child cost should account for this fact.

The effects of children and the measurement of children costs are important politically and play a fundamental role in government policies. An example of this is the Spanish 1999 income tax reform that is meant to increase the children related benefits and, in turn, the Spanish fertility rate.

Given the distributive effects of any fiscal reform, assessing its potential impact is of great interest, in terms of aggregated revenue and on different groups of households. In chapter four we evaluate the effects of the 1999 Spanish income tax reform using simulation techniques on a sample of households representative of the population.

The results predict a reduction in the average tax due of about 25%, although beyond the average figure, there is, according to our results, a non-equal change in the distribution of the reduction on tax income. Thus, contrary to the government announcement, the new income tax system is less progressive than the previous one. The national revenue cost of the reform, according to our simulations, is estimated in 1.115 billions of 1999 pesetas (6,701 millions of euros). This is a very precise estimate of the real cost of the reform given that we have used a representative sample of the Spanish economy.

To compensate the reduction in total revenue we calculate the increase in VAT types needed to finance the cost of the income tax reform, and report measure of the effects on welfare (equivalent loss) that the change in the indirect taxes will bring. On average, there is a loss in terms of welfare of around 5.6% in terms of household total expenditure.

The main interest of this chapter is to investigate how are the new child benefits (embodied in the new tax system) and the incentives for working married women to leave the labour market. Changes in children related benefits or exemptions in the new income tax system are quite small (there is a 2.59% reduction in the taxes paying by households with children, *ceteris paribus*), and only for households with 3 or more children the reduction in taxes is higher than 5%. It seems then this little change in children related benefits would not be enough to incentive to the Spanish fertility rate. We also compare the *minimum living* related to children, implicitly designed into the 1999 income tax system, in relation to the equivalence scales estimated for Spain in chapter two. It seems, as the results show, that this minimum living underestimates the costs of children estimated in chapter two. Finally, it seems that the personal minimum exemption from gross income may be an incentive for married women working part time to drop from the labour market as her market salary is below the minimum exemption. This may be interpreted as an complementary incentive to increase the Spanish fertility rate.

Further research in this topic would be to analyse the Spanish benefit system in relation to the income tax system. In chapter four we have only focused in on side of the coin. To complete the figure we should also allow people to reactions to these changes (dynamic view), as people may decide to change their labour supple to changes in taxes. To carry out this we need to incorporate the whole benefit system to the analysis.

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