INVESTIGACIONES ECONÓMICAS. vol. XXXIII (2), 2009, 303-335

ESTIMATION AND TESTING OF HOUSEHOLD LABOUR SUPLY MODELS: EVIDENCE FROM SPAIN

LAURA CRESPO
CEMFI

This paper provides an empirical contribution to the debate about the choice of the most appropriate model to analyse the labour supply decisions of multi-person households. I propose a parametric specification for couples' labour supply which allows for testing both the unitary model and the collective model. I also test the distribution factor independence of outcomes using differences in the education level between spouses as a distribution factor. The results based on Spanish data from the ECHP show that household labour supply outcomes are distribution factor dependent and that neither the unitary model nor the collective one fits these data.

Keywords: Household labour supply behaviour, collective model, unitary model.

(*JEL* J22, D13)

1. Introduction

The choice of a framework for modelling multi-person household behaviour has become an important topic in Family Economics. This question is of interest because it shapes our understanding of the household decision variables (i.e, consumption, labour supply, household production, fertility, savings and portfolio choices) when analysing policy evaluation issues. It is accepted that such a framework must satisfy a set of requirements, namely, that 1) it embeds a structural model

This paper is part of my Ph.D. dissertation at Departamento de Fundamentos del Análisis Económico, University of Alicante. I am most grateful to Lola Collado for her excellent supervision. I also wish to thank Javier Álvarez, Manuel Arellano, Stéphane Bonhomme, Martin Browning, Jorge González-Chapela, Thomas Siedler, Bernarda Zamora, two referees and the Co-editor Antonio Cabrales for useful comments and suggestions. Financial support from Fundación Ramón Areces, and from Marie Curie Training Site for a visit at the Centre for Applied Microeconometrics, Department of Economics, University of Copenhagen is gratefully acknowledged. All errors are mine.

based on a realistic notion of how a family behaves in the context of interest, 2) it is testable, and 3) it is integrable (i.e, the structural model can be recovered uniquely from observed individual behaviour).

Traditionally, the standard consumer theory model, the so-called *unitary model*, has been used to deal with the analysis of household behaviour assuming that the family as a whole is the basic decision-making unit. Although this setting seems to be very convenient from a technical point of view, there is a remarkable consensus in the literature that it does not provide an appropriate framework to model decisions of many person households. The reasons for this are basically two. First, it violates the most elementary principle of modern microeconomic theory, which states that each individual must be characterized by her own preferences. Second, it does not allow to raise any intra-household issue related to the distribution of welfare among family members. In particular, this question is crucial when performing welfare economic evaluations of policy reforms at household level as it is shown in Apps and Rees (1988), Beninger and Laisney (2002) and Bargain *et al.* (2006).

To overcome these limitations, various multi-person household models have been proposed in the literature, which treat the many person household decisions as the result of an interaction process among family members. Regarding how this intra-household decision process is modeled, these alternatives range from non-cooperative models (Ashworth and Ulph (1981), Browning (2000)) to cooperative models which include axiomatic bargaining models (Manser and Brown (1980), McElroy and Horney (1981)) and the so-called collective model (Chiappori (1988, 1992)). As Browning, Chiappori and Lechene (2006) state, among these alternatives it is not clear which model represents the most appropriate candidate to analyse multi-person household behaviour since a household may use different decision processes for different choices. Despite of this, the debate has been much focused on the collective model as the most plausible alternative to the unitary model for the analysis of household behaviour given its weaker assumptions. In particular, this model assumes that independently on how decisions are made, family outcomes are Pareto efficient. More fomally, the family is considered as a group of individuals characterized by their own preferences that interact among each other when making their decisions through a certain exogenous and unobservable decision process that yields to a Pareto efficient outcome. Therefore, the collective model does not impose any additional structure on the interaction process as opposed to axiomatic bargaining models, whose predictions are more difficult to test empirically.

Additionally, several papers have found evidence in favour of the collective model (Fortin and Lacroix (1997), Browning and Chiappori (1998), Chiappori *et al.* (2002), Vermeulen (2005)). Nevertheless, all of them agree that the choice of a framework for modelling household behaviour is still an open question and that more empirical work is required to confirm the robustness of that evidence using different datasets and different identification strategies. For Spain, Fernández-Val (2003) tests the unitary and the collective settings using data drawn from the European Community Household Panel (ECHP) for the period from 1994 to 1997 and concludes that the restrictions of the collective model can not be rejected. However, looking into his empirical results, we can see that the tests he performs only support statistically the validity of those restrictions at the 1 percent of significance level for the full sample of couples he considers. Given this unclear evidence, the present analysis stems from the need for a better comprehension of the validity of Chiappori's model to fit the Spanish household labour supply behaviour. Therefore, this paper provides an additional empirical contribution to the important debate *unitary vs. collective model* in the labour supply context. Similarly to Fernández-Val (2003), I adopt a parametric approach to estimate a household labour supply system and test the restrictions derived from both the unitary model and the collective one using Spanish data from the ECHP for the period from 1994 to 1999. However, the present analysis differs from that of Fernández-Val (2003) in the following important points: the identification strategy, the parametric specification and the estimation methodology. With respect to the identification strategy, I apply Chiappori *et al.* (2002)'s results on the testability and the integrability requirements based on the existence of *distribution factors* (DFs). These are variables that influence family behaviour only through their effect on the intra-household decision process but do not enter either the individual preferences or the household budget constraint. This strategy allows me to meet the identification and testability requirements of the collective model in a simple and robust way. Some examples that have been proposed in the literature are the sex ratio in the population, several features of the divorce laws (Chiappori *et al.* (2002)) and differences in incomes and ages between partners (Browning et al. (1994)). In this sense, I use differences in the education level between the husband and the wife as a potential distribution factor. Regarding the parametric model, I propose a new specification for the unrestricted labour supply system that presents several important advantages with respect to the specification used by Fortin and Lacroix (1997) and Fernández-Val (2003), and other specifications used in the literature. Finally, I perform a GMM estimation which does not need to impose any particular distributional assumption on disturbances.

Results from the estimation and tests show two interesting findings. First, differences in the level of education of spouses have a significant effect on both individuals' labour supplies according to the DF interpretation. Therefore, couples' labour supply choices are DF dependent. Second, the empirical tests suggest that neither the unitary model nor the collective model fits the Spanish data on household labour supply. Concerning the collective model, the restrictions imposed by this framework are rejected at the 5 percent of significance level. This contradicts the empirical findings provided by several papers in the literature, which support a similar version of this model using different datasets (Fortin and Lacroix (1997), Chiappori *et al.* (2002) and Vermeulen (2005)). However, these results are in line with the empirical tests provided by Fernández-Val (2003) for a similar sample of Spanish households drawn from the same dataset which confirms that the restrictions of the collective model are rejected by this data.

The structure of the paper is as follows. In Section 2, I provide a brief description of the theoretical models of interest. In the collective setting, I pay special attention to the assumptions that are considered to get identification of the structural model and to derive testable restrictions. In Section 3, I propose a particular parametric specification for the labour supply system and I derive testable restrictions from both the collective and the unitary models. Section 4 contains the empirical analysis and reports the estimation results. Section 5 reports the tests of the restrictions and some robustness checks whereas Section 6 concludes.

2. Two theoretical models of household labour supply

As a common framework, I consider households comprising two decision-making members (a couple) of working age, individual preferences are defined over consumption and labour supply and there is a unique private consumption good in the economy taken as numeraire. Household production is not considered since no data are available for the case of Spain. No questions related to public consumption (children, rent or other housing expenditures), household production or labour force participation decisions of individuals are raised in this setting. Even though the importance of such issues is undoubted, I restrict my attention to the simplest version of the collective labour supply model.

2.1 The Unitary Model

The standard consumer theory model has traditionally been applied for analysing family behaviour. In this framework, the family is treated as the basic decision unit even in the case of multiperson households. Hence, household preferences are represented by a unique, well-behaved utility function, U, that, according to the general assumptions, depends positively on household consumption, c,[1] and negatively on each spouse's labour supply, h^i, $i = m, f$, where m denotes the husband and f refers to the wife. Therefore, family behaviour is the result of the following maximization problem:

$$\begin{aligned} &\underset{\{c,h^m,h^f\}}{Max}\ U{=}U(c,h^m,h^f) \\ &s.t \qquad w_m h^m{+}w_f h^f{+}y \geq c \end{aligned} \qquad [P1]$$

where w_i, $i = m, f$, and y are exogenous variables that represent wages and household nonlabour income, respectively. The price of the private consumption good is normalized to one since it is taken as the numeraire.

Let $h^m(w_m, w_f, y)$ and $h^f(w_m, w_f, y)$ represent the system of labour supply functions -the Marshallian labour supplies-. For both functions to be the interior solutions of [P1] for some U,[2] they have to satisfy the standard restrictions of *symmetry* and *positive definiteness* of the Slutsky matrix given by the following expressions:

Symmetry restriction:

$$s_{mf} = s_{fm} \qquad [1]$$

Positive semidefiniteness:

$$s_{ii} \geq 0, \quad i = m, f \qquad [2a]$$

[1]Since both members of the couple face the same price of the unique private consumption good, I can apply Hicks' composite good theorem assuming that household's utility function depends on aggregate consumption.
[2]Non-participation decisions are excluded from the scope of this analysis.

$$s_{mm}s_{ff} - s_{mf}^2 \geq 0 \quad [2b]$$

where $s_{ij} = \frac{\partial h^i}{\partial w_j} - h^j \frac{\partial h^i}{\partial y}$, $i, j = m, f$, is the compensated substitution effect of the labour supply of member i with respect to the wage of member j. It is important to note that Slutsky conditions are necessary and sufficient conditions to recover a utility function for the household that rationalizes the data.

2.2 The Collective Model

In the collective setting household behaviour is characterized by two basic assumptions. First, the individual is the basic decision unit and is represented by her own preferences. Second, collective decisions lead to a Pareto efficient equilibrium. Therefore, the collective model describes the family as a group of two individuals with potentially different rational preferences.[3] These individuals interact with each other when making their decisions through a certain exogenous and unobservable decision process that yields a Pareto efficient outcome. It is important to note that under this framework the intra-household decision process is not explicitly modeled. It is just assumed that however decisions are made, household outcomes are efficient. Hence, the family's behaviour is represented by the following maximization problem:

$$\underset{\{c^m, c^f, h^m, h^f\}}{Max} W = \mu U^m + (1-\mu) U^f$$

$$s.t \quad w_m h^m + w_f h^f + y \geq c^m + c^f \quad [P2]$$

where U^m and U^f are the individual's utility functions and μ is a weighting factor. In the most general version of the collective model, individual preferences are assumed to be altruistic. Altruism implies that each member of the couple not only cares about her own choices but also about those of her partner, allowing for any type of externalities. Therefore, each member's preferences are represented by a utility function, $U^i = U^i(c^m, c^f, h^m, h^f)$, $i = m, f$, that is well-behaved in all its arguments. The weight component or the so-called Pareto weight, μ, represents the relative importance of each spouse in this generalized

[3]Notice that in this analysis I only consider the existence of two decision makers in the family: the husband and the wife. See Chiappori and Ekeland (2002) for a more general case in which the family is composed of a larger set of decision-making individuals.

household utility function. Under the collective setting, μ is a function that may depend on all variables that may affect the intra-household decision process such as wages, the household nonlabour income and other variables that do not enter the individual preferences. These are the so-called distribution factors (DFs)[4] and they are represented by s in this analysis. The Pareto weight is assumed to be continuously differentiable in all its arguments, $\mu(w_m, w_f, y, s) \in [0, 1]$. Therefore, w_m, w_f, y and s will determine the final location of the solution on the Pareto frontier since they influence the household utility function through the Pareto weight. However, as opposed to the axiomatic bargaining models, no bargaining equilibrium (like dictatorial, Nash-bargaining or Kalai-Smorodinsky solutions) is imposed to determine which point on the Pareto frontier will be chosen.

Even though it is possible to derive testable restrictions under certain conditions from this general framework,[5] the structural model is not uniquely identified. Therefore, in order to get identification of the structural model, Chiappori (1988) assumes that individual preferences are either egoistic or caring à la Becker. If members are egoistic, they only care about their own decision variables and, therefore, $U^i = U^i(c^i, h^i)$, $i = m, f$. If preferences are caring à la Becker, each member not only cares about her own decision variables but also about her partner's welfare and, as a result, her utility will have the following form: $W^i = W^i(c^i, h^i, \widetilde{U}^j(c^j, h^j))$, $i, j = m, f$; $i \neq j$. Although assuming that preferences are caring à la Becker seems more realistic in the family context, I consider egoistic preferences in order to simplify the notation since the same results concerning the testability and integrability requirements hold under both kinds of preferences (see Chiappori (1988), (1992)).

Under this separability assumption on individuals' preferences, Chiappori (1992) shows that Pareto efficiency implies that the intra-household collective process can be interpreted as a two-stage process. In the first stage, both members of the couple share the household nonlabour income according to an exogenous and unobservable sharing rule that represents the intra-household decision process. Specifically, that sharing rule is characterized by a function $\phi(w_m, w_f, y, s)$ which represents

[4] Also called *Extra-Environmetal parameter* (EEP) in terms of McElroy (1990).

[5] Specifically, testable restrictions can be derived in a parametric context if there are at least two distribution factors (see Bourguignon *et al.* (1995), Chiappori *et al.* (2002)) or five different commodities (Browning and Chiappori (1998))

the fraction of the nonlabour income that goes to the husband and that may depend on wages, the household nonlabour income and DFs. In the second stage, once the total nonlabour income has been allocated between the individuals, each member solves her own maximization problem given ϕ:

$$\begin{aligned} &\underset{\{c^i,h^i\}}{Max} \quad U^i(c^i,h^i) \\ &s.t \qquad w_i h^i + \phi^i \geq c^i \end{aligned} \qquad \text{[P3]}$$

where $i = m, f$, $\phi^m = \phi$, and $\phi^f = y - \phi$.[6] The interior solutions to these problems for labour supplies have the following form:

$$h^m(w_m, w_f, y, s) = h^{*^m}(w_m, \phi(w_m, w_f, y, s)) \qquad \text{[3a]}$$

$$h^f(w_m, w_f, y, s) = h^{*^f}(w_f, y - \phi(w_m, w_f, y, s)) \qquad \text{[3b]}$$

where $h^{*^i}, i = m, f$, are the Marshallian labour supply functions that correspond to the second stage of the problem.

Under this framework Chiappori *et al.* (2002) show that, assuming the existence of at least one distribution factor, the testability and integrability requirements hold in a more robust and simple way. In particular, this result provides a set of testable conditions that has to be satisfied for any pair (h^m, h^f) to be solution of [P3] for some sharing rule ϕ. Aditionally, if the conditions are satisfied, it is possible to recover the partial derivatives of the sharing rule with respect to all its arguments and both spouses' indirect utility functions from the system [3a] and [3b]. Furthermore, only one distribution factor is needed for these results to hold under egoistic preferences.[7] Regarding this, I consider one distribution factor in this analysis and I claim that the intra-household decision process depends on the differences in the education level between spouses. A deep explanation of the definition and the interpretation of this variable according to the distribution factor hypothesis is provided in the empirical part of the analysis.

[6] This interpretation relies on the Second Fundamental Welfare Theorem that states that, in the absence of externalities, any Pareto efficient allocation can be reached through a competitive equilibrium given an appropriate wealth distribution (represented by the sharing rule)

[7] See Proposition 3 in Chiappori *et al.* (2002) for a detailed formalization of this result.

As Chiappori *et al.* (2002) state, these results are nonparametric since no assumptions have been imposed on the functional form of the utility functions. However, the estimation and testing of such conditions is much easier if it is performed in a parametric framework considering a particular functional form for the model. Therefore, I propose a specific parametric specification for the labour supply system that allows me to test the restrictions derived from each model and to recover the underlying structural model if they were accepted.

3. Parametric specification

Under the parametric approach, the choice of the particular functional form for the unrestricted labour supply system should be based on several criteria. First, it should display a certain degree of flexibility in the responses of labour supplies to changes in wages in order to provide a proper characterization of the data. Second, it should not impose the restrictions of the collective model, and these restrictions must be empirically testable. Third, it should be possible to recover a closed-form for the underlying structural model under the collective setting.

According to these requirements, I propose a new parametric specification for the unrestricted labour supply system that is quadratic in wages:

$$h_m = \alpha_0 + \alpha_1 w_m^2 + \alpha_2 w_f^2 + \alpha_3 w_m w_f + \alpha_4 w_m + \alpha_5 w_f + \alpha_6 y + \alpha_7 s \quad [4a]$$

$$h_f = \beta_0 + \beta_1 w_m^2 + \beta_2 w_f^2 + \beta_3 w_m w_f + \beta_4 w_m + \beta_5 w_f + \beta_6 y + \beta_7 s \quad [4b]$$

where s measures the differences in the education level between the members of the couple. Regarding the previous requirements, this specification provides several advantages with respect to other specifications used in the literature. First, it provides a larger degree of flexibility since it includes the quadratic terms in wages which play an important role in labour supply equations as it will be shown below. Second, since the quadratic form is linear in parameters, it is straightforward to estimate the model and to provide a direct interpretation of wages and nonlabour income's parameters. Third, it allows to derive and test not only the collective model but also the unitary model.[8] In

[8] For example, the main restrictions imposed by the unitary model can not be tested using the semilogarithmic specification proposed by Chiappori *et al.* (2002). As

addition to this, it is possible to derive a closed-form for the structural model both under the collective and the unitary approaches (the household's indirect utility function for the unitary model and each member's indirect utility function and the sharing rule for the collective setting).

In particular, I test three different sets of restrictions. First, the symmetry of the Slutsky matrix, which characterizes the unitary model. Second, the hypothesis of non-existence or independence of DFs, that implies that the variable s does not affect spouses' labour supplies according to the DF interpretation. Finally, the set of restrictions derived from the collective model and based on the existence of at least one DF according to Chiappori et al. (2002)'s results. At this stage, it is important to clarify the relationship between the Slutsky conditions, the distribution factor independence (DFI) hypothesis and the validity of the unitary model. As I pointed out in Section 2.1, the Slutsky restrictions are necessary and sufficient conditions for a unitary model to hold. This result is based on the fact that the household utility function in the unitary context does not depend on prices or total income (as opposed to the collective model). Therefore, the empirical testing of this framework should be based only on the testing of the validity of the Slutsky restrictions. In fact, Browning, Chiappori and Lechene (2006) clarify that the terminology *unitary* should be used for any model that leads to labour supplies that satisfy the Slutsky conditions, independently on whether they also satisfy DFI. Therefore, according to these authors there may exist unitary models which do not satisfy the DFI hypothesis given that this restriction is neither necessary nor sufficient for a unitary model. However, such models have been traditionally considered in this literature as non-unitary models relying on the wrong idea that empirical rejections of DFI imply rejections of the unitary model.[9]

One particular DFI hypothesis that has received much attention in the literature and has been used to test the unitary model is that of *Income Pooling*. This condition states that who receives nonlabour income in the couple plays no role in household choices. However, contrary to

the authors note, the unitary model imposes very unrealistic restrictions on labour supply behaviour under this specification. Therefore, it does not make sense to test them.

[9] This point was raised by a referee of an earlier version of the paper, who provided the reference by Browning, Chiappori and Lechene (2006) that is gratefully acknowledged.

what has been very common in the literature, rejections of the *Income Pooling* can not be interpreted as rejections of the unitary model. Similarly, as stated by Browning, Chiappori and Lechene (2006) there could be models in which incomes are pooled but household choices depend on other DFs, and this is compatible with both unitary and collective models. Even though the ECHP contains information on nonlabour income at the individual level I will not use this information in the analysis as a potential DF. As a result, I will assume that the *Income Pooling* hypothesis holds under both theoretical frameworks. I proceed in this way because it is not clear at all from the ECHP data how couples that pool or jointly manage their financial issues answered questions about financial income at the individual level. As a result, this information might not reflect the real ownership of nonlabour resources in the couple and therefore might not be suitable for testing the *Income Pooling* hypothesis.

Next, I derive the restrictions and the structural model consistent with each framework under the proposed parametric specification. With respect to the unitary model, the system [4a] and [4b] is the solution of problem [P1] if and only if the symmetry conditions of the Slutsky matrix given by [1] hold. Imposing such conditions on [4a] and [4b], we obtain the following set of restrictions:[10]

$$\begin{aligned} \beta_1\alpha_6 &= \alpha_1\beta_6 \\ \beta_2\alpha_6 &= \alpha_2\beta_6 \\ \beta_3\alpha_6 &= \alpha_3\beta_6 \\ \beta_7\alpha_6 &= \alpha_7\beta_6 \\ \alpha_3-\alpha_6\beta_4 &= 2\beta_1-\alpha_4\beta_6 \\ 2\alpha_2-\alpha_6\beta_5 &= \beta_3-\beta_6\alpha_5 \\ \alpha_5-\alpha_6\beta_0 &= \beta_4-\alpha_0\beta_6 \end{aligned} \qquad [5]$$

If these equations are fulfilled, it is possible to recover the underlying structural model from the restricted labour supply system by solving the integrability problem. Following Stern (1986), I obtain that the household's indirect utility function takes the form

[10] Details are available upon request.

$$v(w_m, w_f, y) = e^{\theta_1 w_m + \theta_2 w_f}(y- \qquad [6]$$
$$-(\theta_3 + \theta_4 w_m + \theta_5 w_f + \theta_6 w_m^2 + \theta_7 w_f^2 + \theta_8 w_m w_f + \theta_9 s))$$

Applying Roy's identity on [6] ($h_i(w_m, w_f, y) = \frac{v_{w_i}}{v_y}$ $i = m, f$), we get the following restricted labour supply system:

$$h_m = -\theta_1\theta_6 w_m^2 - \theta_1\theta_7 w_f^2 - \theta_1\theta_8 w_m w_f - (\theta_1\theta_4 + 2\theta_6) \qquad [7a]$$
$$w_m - (\theta_1\theta_5 + \theta_8)w_f + \theta_1 y - \theta_1\theta_9 s - (\theta_1\theta_3 + \theta_4)$$

$$h_f = -\theta_2\theta_6 w_m^2 - \theta_2\theta_7 w_f^2 - \theta_2\theta_8 w_m w_f - (\theta_2\theta_4 + \theta_8) \qquad [7b]$$
$$w_m - (\theta_2\theta_5 + 2\theta_7)w_f + \theta_2 y - \theta_2\theta_9 s - (\theta_2\theta_3 + \theta_5)$$

From system [7a] and [7b], I can derive the structural parameters ($\theta_i, i = 1, ..., 9$) as functions of the reduced-form parameters ($\alpha_i, \beta_i, i = 0, ..., 7$) in [4a] and [4b] once we impose restrictions [5]. From these structural parameters I can get a full identification of household preferences [6] consistent with the unitary framework.

I now turn to the DFI hypothesis, which states that DFs do not affect outcomes. Therefore, this hypothesis implies in this context that differences in the level of education between spouses will have no effect on their labour supply choices. Applying this to the system [4a] and [4b], it means that

$$\alpha_7 = \beta_7 = 0 \qquad [8]$$

Finally, regarding the collective model I apply the theoretical result provided by Proposition 3 in Chiappori et al. (2002) to the unrestricted parametric model [4a] and [4b].[11] Therefore, the following parametric non-linear restriction is obtained:

$$\frac{\alpha_3}{\beta_3} = \frac{\alpha_7}{\beta_7} \qquad [9]$$

which is similar to the one obtained by Chiappori *et al.* (2002) using a semilogarithmic specification. This shows that the predictions of the

[11] Details are available upon request.

collective model are robust to both parametric specifications. Notice that this result relies heavily on the existence of at least one DF. Therefore, it can not be used to test this version of the collective model in case of not rejection of the DFI hypothesis [8].

If restriction [9] is satisfied, the partial derivatives of the sharing rule can be identified and take the following form:

$$\phi_y = \frac{\alpha_6\beta_3}{\Delta},$$

$$\phi_s = \frac{\alpha_7\beta_3}{\Delta},$$

$$\phi_{w_m} = \frac{\alpha_3}{\Delta}(2\beta_1 w_m + \beta_3 w_f + \beta_4),$$

$$\phi_{w_f} = \frac{\beta_3}{\Delta}(2\alpha_2 w_f + \alpha_3 w_m + \alpha_5), \qquad [10]$$

where $\Delta = \alpha_6\beta_3 - \alpha_3\beta_6$. Solving this system, I obtain the following expression for the sharing rule:

$$\phi(w_m, w_f, y, s) = \qquad [11]$$

$$= \frac{1}{\Delta}(\alpha_3\beta_1 w_m^2 + \alpha_2\beta_3 w_f^2 + \alpha_3\beta_3 w_m w_f + \alpha_3\beta_4 w_m +$$

$$\alpha_5\beta_3 w_f + \alpha_6\beta_3 y + \alpha_7\beta_3 s) + k$$

where k is a parameter that cannot be identified without additional assumptions and may depend on preference factors.

Following Stern (1986), it is possible to recover (up to an additive constant) each individual's indirect utility function from the reduced-form given by [3a] and [3b] under a quadratic specification in wages

$$\upsilon^m(w_m, \phi) = e^{aw_m}(\phi - (bw_m^2 + cw_m + d)) \qquad [12a]$$

$$\upsilon^f(w_f, y - \phi) = e^{fw_f}((y - \phi) - (gw_f^2 + hw_f + p)) \qquad [12b]$$

where $a = \frac{\Delta}{\beta_3}$, $b = \frac{\alpha_3\beta_1 - \alpha_1\beta_3}{\Delta}$, $c = \frac{2\beta_3(\alpha_1\beta_3 - \alpha_3\beta_1)}{\Delta^2} - \frac{\alpha_4\beta_3 - \alpha_3\beta_4}{\Delta}$, $f = -\frac{\Delta}{\alpha_3}$, $g = \frac{\alpha_3\beta_2 - \alpha_2\beta_3}{\Delta}$, and $h = \frac{2\alpha_3(\beta_2\alpha_3 - \beta_3\alpha_2)}{\Delta^2} + \frac{\alpha_3\beta_5 - \beta_3\alpha_5}{\Delta}$. Since the coefficients d and p may be functions of preference factors they cannot be identified without additional assumptions. Therefore, if the restrictions of the collective model are not rejected by the data, it is possible to obtain a characterization of the intra-household allocation process and the preferences of the individuals up to an additive constant. This characterization turns out to be a fundamental tool for family welfare analysis.

4. Empirical analysis

In this section I describe the main points of the empirical analysis: the data, the sample, the empirical model, several econometric issues and the estimation methodology implemented.

4.1 Data and sample selection

The data used in this analysis comes from the ECHP. This data set provides comparable statistical annual information about the labour status and welfare level of households in the EU-15 countries allowing their social and economic situation to be analysed. In particular, I focus on data from Spain for the period from 1994 to 1999. However, since income variables refer to the period prior to the interview and the remaining data refer to the current period, the last year is lost for the estimation. I select couples with both members aged less than 65, continuously working as employees throughout the year. In particular, the sample is composed of an unbalanced panel in which couples may appear a different number of periods.[12] Furthermore, in order to maximize the sample size and given that no intertemporal considerations are raised in this analysis, I use the observations as a pooled cross-section ignoring the longitudinal dimension of the survey.[13] As a result, I end up with a sample of 1879 couples on whom information about all the variables considered in the analysis is available.

4.2 Empirical model

According to the parametric specification in [4a] and [4b], I consider the following empirical model:

$$h_m = \alpha_0 + \alpha_1 w_m^2 + \alpha_2 w_f^2 + \alpha_3 w_m w_f + \alpha_4 w_m + \alpha_5 w_f + \alpha_6 y + \alpha_7 s + \alpha_8' z_m + \varepsilon_m \tag{13a}$$

[12] Using a balanced panel would dramatically reduce the sample size.

[13] I treat one household at different points in time as different observations. Since these observations will not be serially independent, I account for this serial correlation in the estimation procedure.

$$h_f = \beta_0+\beta_1 w_m^2+\beta_2 w_f^2+\beta_3 w_m w_f+\beta_4 w_m+\beta_5 w_f+\beta_6 y+\beta_7 s+\beta_8' z_f+\varepsilon_f \quad [13b]$$

where z_i, $i = m, f$, is a vector of observable sociodemographic characteristics and ε_m and ε_f are the error terms that include spouses' unobservables which are allowed to be correlated with each other.

The dependent variables are each spouse's weekly hours of work. With respect to the explanatory variables, hourly wage rates (w_m, w_f) are computed as the ratio of monthly net earnings and the number of hours of work per month. Annual household net nonlabour income (y) includes non-work private income (capital income, assigned property/rental income and private transfers received) and total social insurance receipts (old-age/survivors' benefits, family-related allowances, sickness/invalidity benefits, education-related allowances and any other personal benefits). All income variables have been deflacted by the annual mean of the Consumer Price Index (CPI) base 1992 and are expressed in euros. In addition to this, in order to control for observable individual heterogeneity I include in the labour supply of each member some sociodemographic characteristics such as age, age squared, a set of dummies for the education level -*Educ*1 for primary schooling or without schooling, *Educ*2 for high school and *Educ*3 for graduate and postgraduate studies-[14] and two household fertility variables, the number of children less than 6 years old and the number of children between 6 and 18 years old in the household. Finally, time dummies are included to account for changes in the labour market conditions during the sample period.

With respect to the distribution factors, I should remark that to find valid measures of the relative bargaining power of husbands and wives is not an easy task. Exactly which variables enter the Pareto weight should be determined by the explicit underlying decision process under consideration. However, the collective model does not impose explicit assumptions or structure on this. Under this framework it is only assumed that family members interact through a certain exogenous decision process (represented by the sharing rule) that leads to Pareto efficient outcomes. Therefore, the use of a particular variable as a distribution factor should rely on whether the empirical evidence supports this interpretation. Examples that have been used in the empirical literature are the sex ratio in the population, several features of divorce

[14] Since a constant term is included in the regression system, *Educ*1 is the default dummy.

laws (Chiappori *et al.* (2002)), and differences in incomes (Browning *et al.* (1994)). Additionally, as it is stated by Browning, Chiappori and Lechene (2006), there could be other variables as differences in ages and education between spouses that may affect the intrahousehold decision process or spouses' bargaining power by affecting their opportunities outside the marriage. Even though divorce laws and the sex ratio in the surrounding population are good proxies for the situation of the marriage market and represent natural candidates for DFs, they are not used in this analysis for two reasons. First, in Spain there is not variation in divorce laws since the same legislation applies for the whole country. Second, this survey just provides geographical information at the NUTS-1[15] level which for the case of Spain refers to large areas composed of several regions. Therefore, it is not possible to construct the sex ratio by region or province. As I pointed above, another potential factor that may influence spouses' bargaining power is given by differences in education as a measure of individuals' potential permanent income and expected well-being outside the marriage. This intuition is in line with Lundberg and Ward-Watts (2000) who point out that the relative level of education provides a good measure of potential income and control over household resources. In fact, they find empirical evidence on the effect of the differences in the education level (or in years of schooling) between members of the couple on household net worth accumulation according to the distribution factor theory for a sample of American couples from the Health and Retirement Study. Based on this evidence, I claim that differences in the level of education between spouses may affect their labour supply choices through the intra-household decision process. Therefore, this variable is the DF represented by s in this analysis[16] and is given by the following categorical definition.[17] Specifically, this variable is defined as follows

[15] NUTS stands for Nomenclature of Territorial Units for Statistics.

[16] I have tried with additional variables that could be seen as potential distribution factors for Spanish couples: differences in ages, in potential unemployment spell before the first interview year and in the number of years in the current position. However, none of these were significant in the estimations. Therefore, they could not be used as DFs.

[17] In this case, it is not possible to use the differences in the years of schooling since I only have information about the highest level of education of each individual.

$$s = \begin{cases} 1 & \text{if} \quad F = G \text{ and } M = P \\ 2 & '' \quad F = G \text{ and } M = H \\ 3 & '' \quad F = H \text{ and } M = P \\ 4 & '' \quad F, M = G \\ 5 & '' \quad F, M = H \\ 6 & '' \quad F, M = P \\ 7 & '' \quad F = H \text{ and } M = G \\ 8 & '' \quad F = P \text{ and } M = H \\ 9 & '' \quad F = P \text{ and } M = G \end{cases}$$

where F and M represent the highest level of education reached by the woman and the man, respectively. These variables can take three different values: G for graduate and postgraduate studies, H for high school or equivalent and P for primary schooling or no schooling. Therefore, with this particular definition of variable s,[18] I reflect not only that members' education levels may differ but also how big these differences are.[19]

Two possible objections to the use of a distribution factor based on individuals' level of education are the following. First, distribution factors are variables that do not enter preferences whereas the individual's education may be a preference factor. However, although one individual's level of education may enter his/her individual's own utility function, the spouse's level does not. As a result, differences in the level of education between spouses may be considered as a potential distribution factor. Second, the correlation between differences in the level of education and spouses' labour supplies could be explained by the existence of different levels of specializations in paid work and household production between the spouses according to their relative levels of education or skills. However, it is important to note that the

[18] I must point out that the choice of a discrete variable as a distribution factor is not compatible with the requirement of continuously differentiability of the sharing rule with respect to all its arguments. The natural solution to this problem would be to use continuous information on education (i.e, number of years of schooling). Unfortunately, such information is not provided by this survey. Therefore, as Chiappori *et al.* (2002) states, the test of the collective restrictions is approximative.

[19] It could be argued that the order of the nine categories in s has been established in an *ad hoc* fashion. However, this order appears to be appropriate since equivalent predicted effects on individuals' labour supplies are obtained including the corresponding set of nine dummy variables in the regression system. Estimation and tests are repeated using an alternative measure of these differences as a robustness check. See Section 5 for more detail.

prediction of this alternative explanation runs counter to that of the collective model. In particular, this hypothesis predicts that a higher education will imply a stronger attachment to the labour market and therefore a relative higher number of hours of work. As a result, as s increases, the husband's level of education and attachment to the labour force is higher relative to that of his wife. As a result, he will choose a relatively higher number of hours of work. On the contrary, in order for s to be a distribution factor, and given that it is increasing in the relative education level of the man, it must affect the man's labour supply negatively and the woman's labour supply positively. The interpretation is as follows: as s increases, the man's education level increases relative to that of his spouse's level. This implies a higher relative decision power for the man which allows him to get a larger share of the household nonlabour income. This will lead to a lower number of hours of work for the man as a result of a standard income effect assuming that leisure is a normal good. The influence of s on the woman's labour supply function will have the opposite sign following the same argument. Therefore, since both theories have opposite empirical predictions, the results obtained allow us to discriminate between them.

4.3 Estimation methodology and empirical results

The main econometric problem that arises in this analysis is the potential endogeneity of wages. These variables have been computed as the ratio of monthly earnings and monthly hours of work giving rise to the so-called *division bias.* Moreover, potential measurement errors may arise in such reported variables and can be accumulated in the computation of hourly wage rates. In order to deal with this problem, I apply instrumental variables techniques for estimating the model. Specifically, following Fortin and Lacroix (1997) and Chiappori *et al.* (2002), I instrument wages using third-order polynomials in age, their interactions with the schooling dummies and, finally, the number of years the individual has been working at her current position (this variable is named *specific experience* by Fernández-Val (2003)). Even though there is no consensus in the literature about the exogeneity of household nonlabour income, children variables and experience, I treat them as exogenous given the empirical evidence for Spain in Fernández-Val (2003).

Table 1 presents some descriptive statistics of the variables used in this analysis. In general, this data shows that men are, on average, older, work more hours per week, earn higher wages and have more specific experience than women.

TABLE 1
Descriptive Statistics

	Mean		Std. Dev.		Min		Max	
	Men	Women	Men	Women	Men	Women	Men	Women
Hours of work (1)	42.46	36.80	8.10	7.84	20	15	91	72
Hourly wage (2)	6.19	5.24	3.17	2.47	0.71	0.42	27.17	18.59
Age	40	38	0.83	0.78	21	21	64	62
Educ1	0.38	0.37	0.48	0.48	0	0	1	1
Educ2	0.27	0.24	0.44	0.42	0	0	1	1
Educ3	0.34	0.38	0.47	0.48	0	0	1	1
Years of service	10.7	9.19	6.21	6.13	0	0	19	19
Households								
Children<6	0.31		0.55		0		3	
Children6-18	0.82		0.95		0		5	
Nonlabour income (2)	443.40		1404.27		0		24951.25	
Distribution Factor	4.91		1.99		1		9	

Note: Number of observations, 1879 couples. (1) Weekly hours of work. (2) Euros.

I estimate the system of equations [13a] and [13b] by the Generalized Method of Moments (GMM). Specifically, I use the Optimal GMM estimator based on two stage least squares residuals accounting for arbitrary form of heteroskedasticity, serial correlation and cross-correlation between ε_m and ε_f (see the technical appendix for more detail on this estimation technique). This procedure guarantees desirable asymptotic properties, i.e, efficiency under heteroskedasticity and autocorrelation and does not require any distributional assumptions on the error terms.

Given that this analysis focuses on interior solutions for both spouses' labour supplies, a sample selection bias correction should be performed. In particular, I implemented a two-stage Heckman procedure following Hamermesh and Donald (2008), which accounts not only for the potential correlation between each individual's labour force participation and his/her hours of work decisions but also for correlations between both spouses' labour force participation choices. However, when estimating the system including the corresponding inverse Mills ratios in both equations, many variables were not significant any more due to a collinearity problem between the inverse Mills ratios and the regressors. In order to avoid this problem and given that the estimation results of this model did not reject the hypothesis of no selectivity bias in both labour supply equations, I ignore this bias in the analysis and I present estimation results without this correction.

In addition to the full sample of couples, I also perform the empirical analysis using a sample of couples without children in pre-schooling age (less than 6 year old). These are couples for which the assumption of egoistic preferences seems more plausible given that children can be regarded as a public good and as an important source of non-separability in preferences.[20]

The estimation results and the Sargan statistic for testing the overidentifying restrictions are presented in Table 2 for the full sample.

TABLE 2
Unconstrained Labour Supply Model
Quadratic Specification. GMM Parameter Estimates
Full Sample

	Men (j=m)	*Women (j=f)*		*Men (j=m)*	*Women (j=f)*
Constant	57.8256***	33.9613***	$Educ2_j$	2.7919***	2.8096*
	(5.7325)	(6.8406)		(0.9877)	(1.6685)
w_m^2	0.1073***	0.0464	$Educ3_j$	2.4996	1.5170
	(0.0374)	(0.0489)		(1.5749)	(3.0953)
w_f^2	0.0078	-0.3967*	*Children < 6*	0.3526	-0.9119*
	(0.1315)	(0.2202)		(0.4373)	(0.5048)
$w_m w_f$	0.1438	0.4546**	*Children 618*	0.1806	-0.8013**
	(0.1394)	(0.1781)		(0.3421)	(0.3683)
w_m	-2.4499**	-4.4922***	s	-0.5393**	0.7089*
	(1.1088)	(1.2387)		(0.2487)	(0.3935)
w_f	-1.9556	2.5559	t_{94}	0.4856	-0.2070
	(1.2248)	(1.7755)		(0.5713)	(0.5527)
y	0.3891**	-0.0072	t_{95}	0.4904	0.2556
	(0.1531)	(0.1796)		(0.5163)	(0.5058)
Age_j	-0.0206	4.4751	t_{96}	0.7118	-0.1599
	(2.8672)	(3.3111)		(0.4628)	(0.4971)
Age_j^2	-0.0119	-0.5833	t_{97}	-0.1286	-0.6313
	(0.3229)	(0.4073)		(0.4726)	(0.4605)
Sargan Test	19.3183	(0.8880)	Sample	1879	

Note: Standard errors for parameter estimates and p-value for Sargan Test displayed in parentheses. The standard errors are robust to heteroskedasticity, cross-correlation between spouses and serial correlation. (*) Significant at 10%. (**) Significant at 5%. (***) Significant at 1%. Age has been divided by 10.

[20] It would be more desirable to use a sample of couples without children of any age to test this version of the collective model with egoistic preferences. However, this selection would reduce substantially the sample size.

First of all, it is important to notice that the Sargan statistic does not reject the overidentifying restrictions at any standard significance level, which confirms the validity of the instruments and the consistency of the parameter estimates. Furthermore, even though not all quadratic terms in wages are individually significant, they are jointly significant together with the cross-term and the linear terms in both equations at the 1 percent level.

Household nonlabour income is only significant for husbands' labour supply decisions although this effect is positive, whereas age is not significant for any spouse. With respect to the education level, the high school dummy variable is significant for both men and women with a positive sign. This means that individuals who have reached high school work more hours a week than those who only have primary schooling. However, the highest level of education does not seem to have a significant effect on the number of hours of work. In addition, fertility variables only have a negative and significant effect on women's labour supply and this effect is larger for children less than six years old. With respect to the differences in the level of education between spouses, the estimation results show that this variable is significant at the 5 percent level in husbands' equation and at the 10 percent level in wives' equation with signs that are consistent with the distribution factor interpretation under the collective model. In particular, these results suggest that as long as this variable increases, husband's hours of work decrease whereas those for the wife increase, as the DF assumption predicts.

Table 3 shows the results for the same estimation using the restricted sample of couples without pre-school children.

As it can be seen, very similar qualitative conclusions are obtained. Specifically, the measure of differences in the level of education affect both spouses' labour supplies in the same direction as before although this effect is not very precisely estimated for women in this sample.

TABLE 3
Unconstrained Labour Supply Model.
Quadratic Specification. GMM Parameter Estimates
Sample without Pre-school Children

	Men (j=m)	Women (j=f)		Men (j=m)	Women (j=f)
Constant	61.5490***	35.7894***	$Educ2_j$	2.1932**	1.2044
	(5.8839)	(6.5766)		(0.9574)	(1.7706)
w_m^2	0.1104***	0.0559	$Educ3_j$	2.8780*	-1.4910
	(0.0419)	(0.0517)		(1.5469)	(3.5309)
w_f^2	0.1237	-0.4384*	*Children 618*	0.4195	-1.0054**
	(0.1471)	(0.2377)		(0.3801)	(0.4055)
$w_m w_f$	0.0706	0.4678***	s	-0.6174**	0.3482
	(0.1407)	(0.1765)		(0.2754)	(0.4053)
w_m	-2.2166**	-4.3688***	t_{94}	0.6420	-1.2791*
	(1.0400)	(1.0508)		(0.7371)	(0.6561)
w_f	-2.7618*	3.0192	t_{95}	1.0161*	-0.3931
	(1.3727)	(1.8767)		(0.6122)	(0.5811)
y	0.2948	-0.1360	t_{96}	0.9803*	-0.3454
	(0.1920)	(0.1922)		(0.5716)	(0.5750)
Age_j	-1.3081	4.4950	t_{97}	0.1594	-1.1410**
	(2.8807)	(3.2762)		(0.5160)	(0.5566)
Age_j^2	0.1439	-0.6190			
	(0.3294)	(0.4157)			
Sargan Test	21.9832	(0.7821)	Sample	1386	

Note: Standard errors for parameter estimates and p-value for Sargan Test displayed in parentheses. The standard errors are robust to heteroskedasticity, cross-correlation between spouses and serial correlation. (*) Significant at 10%. (**) Significant at 5%. (***) Significant at 1%. Age has been divided by 10.

In order to check if these results reasonably describe household labour supply behaviour in Spain, Table 4 reports some statistics of the predicted labour supply elasticities for both samples.

For men, wage elasticities are on average close to zero since they react slightly to changes in economic conditions in the labour market. However, even though the elasticities are not very large for women either, they reflect the fact that married women are more sensitive to wage variations than men. Furthermore, on average, both kinds of individuals work more hours when their own wages increase and reduce their labour supply when the spouse's wages increase. In addition, elasticity with respect to household nonlabour income is zero, which means that neither men's nor women's labour supply decisions are affected by changes in the nonlabour income in the household.

TABLE 4
Predicted Labour Supply Elasticities.
Full Sample

		Mean	Std. Dev	Median	25^{th} Quantile	75^{th} Quantile
Men	$\varepsilon^m_{W_m}$	0.0141	0.2477	-0.0615	-0.0991	0.0312
	$\varepsilon^m_{W_f}$	-0.1088	0.0728	-0.1061	-0.1408	-0.0768
	ε^m_{y}	0.0041	0.0130	0.0002	0.0000	0.0025
Women	$\varepsilon^f_{W_m}$	-0.1928	0.2562	-0.2195	-0.3033	-0.1134
	$\varepsilon^f_{W_f}$	0.0820	0.4157	0.1346	0.0488	0.2238
	ε^f_{y}	-0.0001	0.0003	0.0000	-0.00006	0.0000
Sample without Pre-school Children						
Men	$\varepsilon^m_{W_m}$	-0.0016	0.2478	-0.0732	-0.1015	-0.0094
	$\varepsilon^m_{W_f}$	-0.0861	0.0947	-0.1117	-0.1332	-0.0735
	ε^m_{y}	0.0030	0.0101	0.0002	0.0000	0.0017
Women	$\varepsilon^f_{W_m}$	-0.1312	0.2999	-0.1888	-0.2666	-0.0487
	$\varepsilon^f_{W_f}$	0.1055	0.4175	0.1531	0.0632	0.2448
	ε^f_{y}	-0.0017	0.0069	-0.0001	-0.0010	0.0000

These results are close to the ones provided by Fernández-Val (2003), who uses the same database for Spain, although he obtains a larger own-wage elasticity for women (0.309). This difference can be explained by the fact that I restrict this sample to couples with both members continuously working throughout the period whereas Fernández-Val (2003) extends the selection to couples in which both individuals work a positive number of hours a year. As a result, it seems reasonable to think that for such a wider sample, women are on average more sensitive to wage variations.

5. Tests of the unitary and collective models

Based on the empirical results reported in Table 2 and Table 3 for the unrestricted labour supply system [13a] and [13b], I perform some tests to determine whether the unitary and collective models' predictions are adequate or not for analysing Spanish household labour supply behaviour. Specifically, I test separately the symmetry of the Slutsky matrix [5], the non-existence of distribution factors or DFI hypothesis [8] and restriction [9] for the collective model.

TABLE 5
Inference Results

	Full Sample		Restricted Sample	
	Statistic	P-value	Statistic	P-value
DFI				
Wald	7.6555	0.0217	5.5583	0.0621
Pseudo-likelihood	7.6558	0.0217	5.5586	0.0621
Symmetry (LR)	20.8315	0.0019	22.9767	0.0008
Collective (LR)	3.8985	0.0483	4.4521	0.0348

Note: The DFI hypothesis is tested using a Wald test and a Pseudo-likelihood ratio test.
The symmetry restrictions for the unitary model and the restriction from the collective model are tested using a Pseudo-likelihood ratio test.

Table 5 presents the statistics and the p-values for the tests of these coefficient restrictions for both samples.

For the DFI hipothesis I perform a Wald test and a Pseudo-likelihood ratio test since [8] is a linear restriction. However, since the restrictions derived from the unitary model and the collective one are non-linear and the Wald test is not invariant to reparameterizations, I just perform a Pseudo-likelihood ratio for each of them.[21] These tests show the following. First, the DFI hypothesis is rejected at the 5 percent level for the full sample and at the 10 percent level for the restricted sample. This shows that both spouses' labour supplies are affected significantly by differences in their level of education according to the distribution factor interpretation. Second, concerning the validity of the unitary model, the symmetry restrictions of the Slutsky matrix are also rejected for both samples at any standard significance level.[22] Given that these are necessary and sufficient conditions for the unitary model, this implies an empirical rejection of this framework. Finally, a Pseudo-likelihood ratio test also rejects the restriction derived from the collective model at the 5 percent level suggesting that this setting does not seem to fit the empirical evidence shown by the sample.

[21] As Wooldridge (2002) states, this lack of invariance cannot be ignored since it may explain the poor finite sample properties of the Wald statistic for testing nonlinear hypothesis. For a further discussion see Gregory and Vell (1985) and Phillips and Park (1988).

[22] For both samples, only the first six restrictions in [5] could be tested using the Pseudo-likelihood ratio. When imposing also the last restriction, then a problem of convergence in the restricted model estimation emerges due to the high degree of non-linearity of the system. However, the rejection of these six restrictions can be considered as a rejection of the unitary model.

Given this last result, one could argue that the rejection of this version of the collective model may be considered as a rejection of the egoistic preferences assumption rather than a rejection of the Pareto efficiency. However, as it is shown in Table 5 this restriction is also rejected at the 5 percent level for the sample of couples without pre-school children, for which the egoistic preferences assumption seems more plausible. Therefore, this confirms that the Spanish household labour supply behaviour shown by this sample is consistent with a DF dependent non-unitary model. However, the collective model does not seem to provide either an appropriate framework to fit this data.

Finally, as a robustness check the same tests have been repeated for a an alternative definition of the differences in the level of education between spouses and for a different parametric specification. Concerning the first point, I compute for each spouse a categorical variable that takes value 1 if the individual has primary schooling or without schooling, 2 for high school and 3 for graduate and postgraduate studies. The alternative measure is defined as the difference between the husband's level of education and that of his wife such that the resulting variable, denoted by s^*, is increasing in the relative level of husband. Therefore, under this measure it is assumed for example that the wife has the same relative bargaining power in a couple where she is graduate and her husband has secondary education as in a couple where she has secondary schooling and he has primary schooling. The first two rows of Table 6 contain the results of the tests for the three different sets of restrictions.

TABLE 6
Inference Results
Full Sample

	s*		Semilogarithmic	
	Statistic	P-value	Statistic	P-value
DFI				
Wald	8.8567	0.0119	8.1568	0.0169
Pseudo-likelihood	8.8564	0.0119	8.1578	0.0169
Symmetry (LR)	20.0180	0.0012	-	-
Collective (LR)	5.1470	0.0233	6.3824	0.0115

Note: The DFI hypothesis is tested using a Wald test and a Pseudo-likelihood ratio test.
The symmetry restrictions for the unitary model and the restriction from the collective model are tested using a Pseudo-likelihood ratio test.

In particular, they show that the same qualitative conclusions hold using the alternative definition of differences in the education level of spouses since all sets of restrictions are clearly rejected at the 5 percent level.[23] As for the parametric specification, I repeat the analysis using a semilogarithmic specification similar to Chiappori *et al.* (2002) which gives rise to the same parametric restrictions for the DFI hypothesis and the collective model. However, the unitary model can not tested under this specification since it imposes very unrealistic behaviour on spouses' labour supplies (see Chiappori *et al.* (2002) for more details). Specifically, rows 3 and 4 of Table 6 show that very similar evidence is obtained under the semilogarithmic specification for the DFI hypothesis and the collective model's restriction.[24]

6. Conclusions

This paper provides an empirical contribution to the wide *unitary vs. collective* model debate that has arisen over the past 20 years in Family Economics. In particular, I test the parametric restrictions imposed by these two competing frameworks. On the one hand, I test the symmetry conditions imposed by the unitary model on the Slustsky matrix. On the other hand, I test the restrictions imposed by the collective model developed by Chiappori (1988, 1992) using the differences in education level between spouses as a potential distribution factor. To the best of my knowledge, this is the first attempt to use this kind of information on education to test this version of the labour supply model due to Chiappori. I propose a particular parametric specification for the unrestricted system of individuals' labour supply that presents several advantages with respect to other specifications used in the literature. Specifically, this parametric model allows me to test not only the restrictions imposed by the collective model but also the restrictions imposed by the unitary model.

I test both sets of conditions using data drawn from the Spanish version of the ECHP for the period from 1994 to 1999. I conclude that this sample clearly rejects the restriction of non-existence of distribution factors. In particular, it is shown that the differences in education play

[23] In this case, only five of the seven restrictions in [5] could be tested due to convergence problems in the estimation of the restricted model. However, the rejection of these five restrictions also implies the rejection of the unitary model.

[24] In fact, the predicted elasticities obtained from these two different estimations are very similar to those shown in Table 4. Estimation results are available upon request.

an important role in both members' labour supply decisions according to the distribution factor interpretation. Furthermore, empirical evidence against the unitary model is provided since the symmetry restrictions of the Slutsky matrix are also rejected. This result is in line with previous studies that indicate that the unitary model should not be used to analyse many person household behaviour. However, I also reject the restriction imposed by the collective model with a distribution factor and egoistic preferences at the 5 percent level. This outcome suggests that even though there are variables that can influence household behaviour through their effects on individuals' decision power, the collective setting is not adequate for modelling such intra-household considerations.

Furthermore, these results are in line with the outcomes of the tests performed by Fernández-Val (2003) for the restrictions of the collective model using data from the ECHP for Spain. In particular, his tests reject these restrictions not only for the full sample of couples at the 5 percent of significance level but also for a sub-sample of couples without pre-school children at any significant level. Therefore, according to this evidence, we should reject the validity of the collective model to fit Spanish household labour supply data.

Additionally, the present study contradicts several papers in the literature that have found empirical evidence from different datasets supporting the same version of the collective model (Fortin and Lacroix (1997), Chiappori *et al.* (2002), Vermeulen (2005)). As a result, it shows that more empirical research is needed in order to reach a definite consensus about the appropriateness of the collective model for analysing intra-household behaviour.

Finally, we should highlight two interesting directions for future research in this literature. First, the consideration of female non-participation using results in Blundell *et al.* (2007) and Donni (2003) for the collective model. This represents a specially interesting extension in the case of Spain where female labour participation is still relatively low. Second, to set down the collective model into an intertemporal framework given that individuals' decisions depend on their discounted lifetime wage rates and income profile.

Appendix A1. A note on the Generalized Method of Moments Estimation applied to this context.

In this appendix I provide a detailed description of the methodology implemented in the estimation of the household labour supply system. A more general and comprehensive review of this technique can be found in Arellano (2003).

Let us consider the model for the couple's labour supply system:

$$\begin{aligned} h_{mi} &= x_{mi}\alpha + \varepsilon_{hi} \\ h_{fi} &= x_{fi}\beta + \varepsilon_{fi} \end{aligned} \quad \text{[A1.1]}$$

where:

h_{ji} $(j = m, f)$ is a $T_i \times 1$ vector of hours of work of spouse j of couple i for all periods (T_i) that the couple appears in the panel. Notice that in order to maximize the sample size, the sample in this analysis is composed of an unbalanced panel of couples where T_i is the number of periods that each couple appears in the panel and $T_i = 1, ...5$. Additionally, the observations are used in the estimation as a pooled cross-section ignoring the temporal dimension of the survey.

x_{ji} $(j = m, f)$ is a $T_i \times k$ matrix of regressors in the equation of spouse j of couple i for all consecutive periods T_i.

α and β are $k \times 1$ vectors of parameters for the husband and the wife, respectively.

ε_{ji} $(j = m, f)$ is a $T_i \times 1$ vector of unobserved components that could affect hours of work of spouse j of couple i for all consecutive periods T_i.

Given the potential endogeneity of wages in this context, intrumental variables techniques are applied in the estimation of the model. Therefore, the following assumptions are considered:

$$\begin{aligned} E(z'_{mi}\varepsilon_{mi}) &= 0 \\ E(z'_{fi}\varepsilon_{fi}) &= 0 \end{aligned} \quad \text{[A1.2]}$$

where z_{ji} $(j = m, f)$ is a $T_i \times r$ matrix of instruments with $r > k$. Therefore, in this particular case there are $2r$ moment conditions which can also be expressed as

$$E(z_i'\varepsilon_i) = E(z_i'(h_i - x_i\theta)) = 0 \quad \text{[A1.3]}$$

where we are using the notation $z_i = \begin{bmatrix} z_{m_i} & 0 \\ 0 & z_{f_i} \end{bmatrix}$, $x_i = \begin{bmatrix} x_{m_i} & 0 \\ 0 & x_{f_i} \end{bmatrix}$, $h_i = (h_{mi}^{'}, h_{fi}^{'})'$ and $\theta = (\alpha', \beta')'$.

Using the sample of N couples $\{h_{ji}, x_{ji}, z_{ji}\}_{i=1}^{N}$, $j = m, f$, the estimation of θ is based on the sample counterpart of [A1.3] given by

$$b_n(c) = \frac{1}{n}\sum_{i=1}^{N} z_i'(h_i - x_i c) \qquad \text{[A1.4]}$$

where $n = \sum_{i=1}^{N} T_i$ is the total number of observations in the sample and c represents admissible values of θ such that c$\in \Theta$, the parameter space. However, this problem is overidentified since we have that $r > k$. Therefore, there is not solution to the system $b_n(\theta) = 0$ and we choose as an estimator of θ the value that minimizes the quadratic distance of $b_n(c)$ from zero:

$$\widehat{\theta} = \arg\min_{c \in \Theta} b_n(c)' A_n \; b_n(c) = (\frac{1}{n}\sum_{i=1}^{N} z_i'(h_i - x_i c))' A_n \; (\frac{1}{n}\sum_{i=1}^{N} z_i'(h_i - x_i c)) \qquad \text{[A1.5]}$$

where A_n is in this case an $2r \times 2r$ non-negative definite weight matrix with rank$\geq k$. The solution to this problem, $\widehat{\theta}$, is a GMM estimator of θ.

With respect to the asymptotic properties of $\widehat{\theta}$, see Arellano (2003) for detailed proofs of the consistency and the asymptotic normality of this class of estimators. In particular, it can be shown that under certain regularity conditions GMM estimators are distributed asymptotically according to

$$\sqrt{n}(\widehat{\theta} - \theta) \xrightarrow{d} N(0, W_0) \qquad \text{[A1.6]}$$

where W_0 is given by the formula

$$W_0 = (D_0' A_0 D_0)^{-1} D_0' A_0 V_0 A_0 D_0 (D_0' A_0 D_0)^{-1}$$

and A_0 is a positive semi-definite matrix such that $A_n \xrightarrow{p} A_0$, $D_0 = E[z_i' x_i]$ and $V_0 = E[z_i' \varepsilon_i \varepsilon_i' z_i]$ in this context.

The corresponding sample counterparts for D_0 and V_0 are

$$\widehat{D} = \frac{1}{n}\sum_{i=1}^{N} z_i' x_i$$

$$\widehat{V} = \frac{1}{n}\sum_{i=1}^{N} z_i'\widehat{\varepsilon}_i\widehat{\varepsilon}_i' z_i = \frac{1}{n}\sum_{i=1}^{N} \begin{bmatrix} z_{mi}'\widehat{\varepsilon_{mi}\varepsilon_{mi}}' z_{mi} & z_{mi}'\widehat{\varepsilon_{mi}\varepsilon_{fi}}' z_{fi} \\ z_{fi}'\widehat{\varepsilon_{fi}\varepsilon_{mi}}' z_{mi} & z_{fi}'\widehat{\varepsilon_{fi}\varepsilon_{fi}}' z_{fi} \end{bmatrix}$$

With respect to A_n, we can see from the form of the GMM criterion and the asymptotic variance of $\widehat{\theta}$ that different choices of A_0 will imply different GMM estimators with different precisions. In this specific analysis we compute an optimal GMM estimator, which guarantees the asymptotic efficiency of the estimation given the orthogonality conditions specified. This optimal GMM estimator is based on an optimal choice of A_n such that $A_0 = kV_0^{-1}$, where k is an arbitrary positive multiplicative constant. In this particular case, we choose as the optimal weight matrix $A_n = (\widehat{V})^{-1}$. It is clear that in order to obtain this optimal estimator we need first a consistent estimate of V_0. In this context, we compute this matrix based on 2SLS residuals.[25]

Therefore, the estimated asymptotic variance matrix of the optimal GMM estimator is given by

$$\widehat{Var}(\widehat{\theta}) = \widehat{W}_n/n = (\widehat{D'}(\widehat{V})^{-1}\widehat{D})^{-1}/n = (\widehat{D'}(\frac{1}{n}\sum_{i=1}^{N} z_i'\widehat{\varepsilon}_i\widehat{\varepsilon}_i' z_i)^{-1}\widehat{D})^{-1}/n$$

The squared root of the diagonal elements of this matrix are the standard errors of the components of $\widehat{\theta}$. Notice that these standard errors are robust to any arbitrary form of heteroskedasticity, serial correlation and cross-correlation between ε_m and ε_f.

Finally, given that we are considering an overidentified system $(r > k)$, it is possible to perform a Sargan test. This allows us to test the null hypothesis of the validity of the instruments or the overidentifying restrictions imposed. The Sargan statistic is equal to the minimized optimal GMM criterion scaled by n and has an asymptotic chi-square distribution with $2r - 2k$ degrees of freedom:

$$nb_n(\widehat{\theta})'(\widehat{V})^{-1}b_n(\widehat{\theta}) \xrightarrow{d} \chi^2_{2r-2k}.$$

[25] These residuals are calculated in a first stage applying the same framework and using as weight matrix

$$A_n = n(\sum_{i=1}^{N} z_i' z_i)^{-1}$$

References

Apps, P.F. and R. Rees (1988): "Taxation and the household", *Journal of Public Economics* 35, pp. 355-369.

Arellano, M. (2003), *Panel Data Econometrics* Oxford University Press.

Ashworth, J. and D. Ulph (1981): "Household models", in C.V. Brown (eds.), *Taxation and Labour Supply,* London: Allen & Uwin.

Bargain, O., M. Beblo, D. Beninger, R. Blundell, R. Carrasco, M-C. Chiuri, F. Laisney, V. Lechene, N. Moreau, M. Myck, J. Ruiz-Castillo and F. Vermeulen (2006): "Does the representation of household behaviour matter for welfare analysis of tax-benefit policies? An introduction", *Review of Economics of the Household* 4, pp. 99-111.

Beninger, D. and F. Laisney (2002): "Comparison between unitary and collective models of household labor supply with taxation", ZEW Discussion Paper, No. 02-65.

Blundell, R., P-A. Chiappori, T. Magnac and C. Meguir (2007): "Collective labor supply: Heterogeneity and non-participation", *Review of Economic Studies* 74, pp. 417-445.

Bourguignon, F., M. Browning and P-A. Chiappori (1995): "The collective approach to household behaviour", Working Paper no. 95-04. Paris: DELTA.

Browning, M. and P-A. Chiappori (1998): "Efficient intra-household allocations: A general characterization and empirical tests", *Econometrica* 66, pp. 1241-78.

Browning, M. (2000): "The saving behaviour of a Two-person Household", *Scandinavian Journal of Economics* 102, pp. 235-251.

Browning, M., P-A. Chiappori and V. Lechene (2006): "Collective and unitary models: A clarification", *Review of Economics of the Household* 4, pp. 5-14.

Browning, M., F. Bourguignon, P-A. Chiappori and V. Lechene (1994): "Income and outcomes: A structural model of intrahousehold allocation", *Journal of Political Economy* 102, pp. 1067-1096.

Chiappori, P.A. (1988): "Rational household labor supply", *Econometrica* 56, pp. 63-89.

Chiappori, P.A. (1992): "Collective labor supply and welfare", *Journal of Political Economy* 100, pp. 437-67.

Chiappori, P-A., B. Fortin and F. Lacroix (2002): "Marriage market, divorce legislation, and household labour supply", *Journal of Political Economy* 110, pp. 37-72.

Donni, O. (2003): "Collective household labor supply: Non-participation and income taxation", *Journal of Public Economics* 87, pp. 1179-1198.

Fernández-Val, I. (2003): "Household labor supply: Evidence for Spain", *Investigaciones Económicas* 27, pp. 239-275.

Fortin, B and G. Lacroix (1997): "A test of the unitary and collective models of household labour supply", *The Economic Journal* 107, pp. 933-955.

Gregory, A.W. and M. R. Veall (1985): "On formulating wald tests for non-linear restrictions", *Econometrica* 53, pp. 1465-68.

Hamermesh, D.S. and S.G. Donald (2008): "The effect of college curriculum on earnings: An affinity identifier for non-ignorable non-response bias", *Journal of Econometrics* 144, No. 2, pp. 479-491.

Lundberg, S.J. and J. Ward-Batts (2000): "Saving for retirement: Household bargaining and household net worth", Michigan Retirement Research Center Working. Discussion Paper No. 00-04.

Manser, M. and M. Brown (1980): "Marriage and household decision making: A bargaining analysis", *International Economic Review* 21, pp. 31-44.

McElroy, M. and M. Horney (1981): "Nash bargained decisions: Towards a generalization of theory of demand", *International Economic Review* 22, pp. 333-49.

Phillips, P.C.B. and J. Y. Park (1988): "On the formulation of wald tests for nonlinear restrictions", *Econometrica* 56, pp. 1065-83.

Stern, N. (1986): "On the specification of labour supply functions", in Blundell, R. and I. Walker (eds.), *Unemployment, Search and Labour Supply,* Cambridge: Cambridge University Press.

Vermeulen, F. (2005): "And the winner is... An empirical evaluation of unitary and collectove labour supply models", *Empirical Economics* 30, No. 3, pp. 711-734.

Wooldridge, J.M. (2002), *Econometric Analysis of Cross Section and Panel Data* MIT Press.

Resumen

Este trabajo representa una contribución empírica al debate sobre la elección del modelo más apropiado para analizar las decisiones de oferta de trabajo en hogares de múltiples individuos. Se propone una especificación paramétrica para la oferta de trabajo de las parejas que permite contrastar el modelo unitario y el modelo colectivo. También se contrasta la independencia de factores de distribución de las ofertas de trabajo usando las diferencias en el nivel educativo de los miembros de la pareja como factor de distribución. Los resultados, basados en los datos para España del ECHP, muestran que las decisiones de oferta de trabajo dependen del factor de distribución y que ni el modelo unitario ni el modelo colectivo se ajustan bien al comportamiento reflejado en estos datos.

Palabras clave: Comportamiento de la oferta de trabajo del hogar, modelo colectivo, modelo unitario.

Recepción del original, abril de 2007
Versión final, diciembre de 2008