A collective model of consumer behavior with private and public goods — Some empirical evidence from U.S. data

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Abstract

The collective approach to consumer behavior supposes that each household member is characterized by his/her own preferences and the decision process results in Pareto-efficient outcomes. In the present paper, we also assume that agents are egoistic and consumption is either private or public. The main results are based on a conditional demand framework where household demands are direcly derived from the first order conditions. We show that (i) household demands have to satisfy testable constraints and (ii) some elements of the decision process can be retrieved. These theoretical considerations are followed by an empirical application using the U.S. Consumer Expenditure Survey.

Keywords: Collective-Decision, Intrahousehold-Distribution, Labor-Supply, Demand-Analysis, Public-Good, Lindahl-Price, GMM.

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1 Introduction

In microeconomics, the household as a whole is usually considered as the elementary decision unit; in particular, it is characterized by a unique utility function that is maximized under a budget constraint. However, recent dissatisfaction with this so-called unitary approach arose in a large part from the weakness of its theoretical foundations. It seems clear that a household comprising several adult members does not necessarily behave as a single agent.

Several authors have recently challenged the unitary approach and attempted to explicitly taking into account the bargaining between the household members. In particular, Chiappori (1988, 1992) has developed a collective approach to household labor supply where each agent is characterized by his/her own preferences and the intra-household decisions result in Pareto efficient outcomes. When agents are egoistic and consumption is private, the key-idea of this model is simple. Under these assumptions, Pareto efficiency essentially means that the intra-household decision process can be decentralized by application of the Theorems of Welfare Economics. In a first step, members divide the nonlabor income according to some predetermined rule which depends on the household environment. In a second step, they maximize their utility subject to their own budget constraint. The main results are twofold:

a. The collective labor supply have to satisfy testable restrictions under the form of partial differential equations;

b. The sharing rule of the nonlabor income can be retrieved up to an additive constant from the observation of labor supply.

More recently, Fortin and Lacroix (1997) and Chiappori et al. (2001) show that these restrictions are not empirically rejected for Canada and the United-States. Contributors to the theory of collective labor supply also include Apps and Rees (1997), Chiappori (1997), Fong and Zhang (2001), Blundell et al. (2001) and Donni (2001a, 2001b).

The collective approach has also been generalized to the analysis of household consumption. To begin with, Bourguignon et al. (1995) provide the main theoretical results for the case of constant prices. Bourguignon et al. (1993, 1994) use French and Canadian expenditure data to estimate some of these models and test the collective approach. More recently, Browning and Chiappori (1998) extend this theoretical setting to the case of variable prices. In particular, they show that, under Pareto efficiency, the substitution matrix of the household demand system has to be equal to the sum of a symmetric matrix and an outer product. Broadly speaking, the collective models of household demand can be classified in two groups. In the most important group, it is assumed that household members are egoistic (or altruistic in a strict sense) and consumption is exclusively private. In this case, the decision process can be decentralized as previously and, under regularity conditions, the sharing rule can be retrieved from the observation of household demands. However, these results crucially relies on the fact that there is no public goods within the household (or at least that the public goods are separable from private ones). The exclusion of public goods is however a severe limitation. After all, the existence of joint consumption is one of the main 'economic' justifications for the formation of a couple; see Becker (1991) or Cigno (1995) for example. In a second group of models, it is assumed that household members are altruistic (in a general sense) and consumption is either public or private. If so, the demands for public and private goods have to satisfy a set of (rather weak) testable properties. Unfortunately, the sharing rule is not well-defined and it is not possible to identify structural elements of the decision process from observed behavior. This excludes an analysis of intra-household welfare; an important drawback.

In this paper, we suppose that agents are egoistic (or altruistic in a strict sense) and follow the most common line of research on collective models. However, the main innovation, in contrast with previous work described above, is that public goods as well as private ones are now considered.[1] We show that this setting permits to retrieve some elements of the household decision process. More precisely, the individual demands for private goods and the individual prices (or Lindahl prices) for public goods are partially identified. We also derive a set of very simple testable constraints (including a symmetry property). These constraints permit in principle to empirically discriminate between a private and a public consumption for each category of goods. To prove all these results, we use a second theoretical innovation, namely, a collective generalization of the marginal demands which were previously studied by Browning (1998) for the unitary approach. In these demands, either the quantity for private goods or the price for public goods are modeled as a function of the prices for private goods, the levels for public goods and the level of two reference goods. We assume that, in these relationships, one reference good is exclusively consumed by the husband and the other one by the wife. If these goods are normal, they represent a convenient indicator of individual welfare within the household. The advantages of this specification are twofold. For one thing, it provides a specially simple and intuitive way to describe the intra-household decision process. Furthemore, as it will be clearer below, the modelling of these within-period collective marginal demands is compatible with a life-cycle allocation rule and some controversial assumptions often made for intertemporal allocation.

This paper is structured as follows. In Section 2, we present the main theoretical results. We specify the assumptions, define the collective marginal demands and derive the testable properties that they have to satisfy. In Section 3, these theoretical results are extended to the following situations: altruistic agents, households with children, and observable heterogeneity. In Section 4, the statistical model is specified. In Section 5, the data are described and the estimates are presented. In Section 6, concluding comments are given.

[1] Chiappori and Ekeland (2001a, 2001b) use these assumptions in two recent theoretical contributions. Still, the approach adopted by these authors is completely different from ours. In particular, they study the abstract characterization of household demands for groups of persons and do not consider the empirical implementation of these results.

2 Theory — Basis

2.1 Preferences and Decision Process

The distinction between public and private goods is a familiar one. Although it may be reasonable to treat some goods as private (e.g., alcoholic beverages), there are some goods, in the household, that clearly have a strong public element (e.g., heating). However, the distinction between private and public is not very well defined if there is a good that only one person in the household cares about. We thus choose to categorize such a good separately as exclusive rather than public or private.[2] An example here would be clothing. If there are no externalities and the husband consumes only men's clothing and the wife consumes only women's clothing, then we can think of men's and women's clothing as two exclusive goods. This example is exploited in the empirical part of this paper.[3] It will be clear below that the concept of exclusivity is essential in what follows.

The main objective of this paper is to analyze consumption of private and public goods in a unified framework. To do that, we consider a model of consumption within a two-member household and assume that there are two exclusive goods, one for each person in the household. We suppose the lifecycle utility is weakly intertemporally separable and the within-period preferences of member i ($i = A, B$) can be represented by a well-behaved utility function:

$$u_i(X_i, Z_i, V),$$

where X_i, Z_i and V respectively denote an exclusive good, a K_1–vector of private goods and a K_2–vector of public goods consumed by member i (with $K_1 + K_2 = K$). Several points must be stressed at this stage. Firstly, the agents are said to be 'egoistic' in the sense that their utility only depends on their own consumption. However, the main results of this paper can be extended to the case of 'altruistic' agents, as defined in Section 3. Secondly, all the goods, either public or private, are assumed to be non-durable (or at least separable from durable ones). Thirdly, the key-assumption of this paper is that **each good can be unambiguously designated as public or private**.[4] The individual demand for private goods Z_i is then treated as unobservable and the demand for these goods is only observed at the household level $Z = \sum Z_i$. Nevertheless, this is not the case for public goods or the exclusive good whose individual demands V and X_i are observed.

[2] The distinction between a pair of exclusive goods and one assignable good (i.e., a private good whose individual consumption can be observed) is not always precise. See Browning et al. (1994) for a precise discussion of these definitions.

[3] Another example of exclusive goods is leisure. Still this is more debatable. For instance, Fong and Zhang (2001) assume that, for each partner in a marriage, there are two distinct types of leisure: one type is each person's independent (or private) leisure, and the other type is spousal (or public) leisure. This interpretation is clearly excluded from our analysis.

[4] More precisely, this excludes the case of 'composite' goods with a public and a private component as leisure in Fong and Zhang's (2001) view. However, public goods in this model may cover the case of intra-household consumption externalities. Therefore, we do not exclude the possibility that $\partial u_i / \partial V < 0$ for at most one person in the household.

We suppose that there is no domestic production. The household faces a linear budget constraint and non-negativity constraints. Thus, the within-period budget set is given by

$$\begin{gathered}\sum_i Y_i - \Delta \geqslant \sum_i X_i \cdot R_i + Z \cdot P + V \cdot Q, \\ Z \geqslant 0, \quad V \geqslant 0 \quad \text{and} \quad X_i \geqslant 0,\end{gathered} \tag{1}$$

where R_i, P and Q respectively denote the price for the exclusive good, a K_1–vector of prices for the private goods and a K_2–vector of prices for the public goods, Y_i denote member i's income and Δ the within-period variation in household assets.

The main originality of the efficiency approach lies in the fact that the household decisions are assumed to result in Pareto-efficient outcomes and that no additional assumption is made about the decision process. The relevance of this assumption is demonstrated by Browning and Chiappori (1998). We say that there exists a scalar ϕ such that the household behavior can be described as the solution of the following program:

$$\max_{\{X_A,Z_A,X_B,Z_B,V\}} \phi \cdot u_A(X_A, Z_A, V) + (1-\phi) \cdot u_B(X_B, Z_B, V), \tag{$\bar{\text{P}}$}$$

subject to (1). The scalar ϕ can be interpreted as a 'distribution of power' index. It generally depends on a set of variables which affect the intrahousehold distribution of power:

$$\phi = \phi(R_A, R_B, Y_A, Y_B, P, Q, S), \tag{2}$$

where S is a vector of distribution factors. By definition, these variables influence the decision process but do not affect the (within-period) budget constraint or the (within-period) preferences. Specifically, the state of the market for marriage and the specific features of the marriage contract are expected to have an impact on the intrahousehold distribution of power, as stressed by Becker (1991) and brilliantly illustrated by Chiappori et al. (2001) with US data. In a life-cycle context, the past or expected values of Y_i or S may also play a role in the decision process. For example, Thomas et al. (1997), using an indonesian survey, have shown that the distribution of wealth by gender **at marriage** has a significant impact on household behavior (more precisely, on children health).

2.2 Collective Marginal Demands

In the unitary approach, the marginal demand for a set of goods is defined as a function of the level of another reference good rather than total expenditure or the marginal utility of money. This concept has often been exploited (either explicitly or implicitly) in the life-cycle behavior analysis; see Altonji (1986) and Meghir and Weber (1996) for example. Moreover, their theoretical properties are studied in depth by Browning (1998). We show in what follows that the analysis of the household behavior in the collective setting is specially simple when a collective generalization of these demands is used. We denote by λ the Lagrangean multiplier of ($\bar{\mathrm{P}}$) for the budget constraint and we define $\phi_A = \phi$ and $\phi_B = 1 - \phi$. For an internal solution, the first order conditions of ($\bar{\mathrm{P}}$) are then given by

$$\frac{\phi_i}{\lambda}\frac{\partial u_i}{\partial X_i} = R_i \qquad \text{and} \qquad \frac{\phi_i}{\lambda}\frac{\partial u_i}{\partial Z_i} = P \tag{3}$$

for the allocation of the exclusive goods and the allocation of private goods, and

$$\textstyle\sum_i \frac{\phi_i}{\lambda}\frac{\partial u_i}{\partial V} = Q \tag{4}$$

for the allocation of public goods. We can now define the **collective marginal demands-quantity** (CMQ demands) for analyzing private consumption. To do that, we eliminate λ and ϕ_i in the first order conditions (3) and obtain the well-known allocation rule for private consumption:

$$\frac{\partial u_i}{\partial Z_i}\bigg/\frac{\partial u_i}{\partial X_i} = \frac{P}{R_i}. \tag{5}$$

We suppose that these equations can be uniquely solved for Z_i as a function of R_i, X_i, P and V. We obtain the individual CMQ demands:[5]

$$Z_i = \bar{Z}_i(R_i, X_i, P, V). \tag{6}$$

Since we generally do not observe individual consumption in surveys, we have the (aggregate) CMQ demands:

$$\bar{Z} = \textstyle\sum_i \bar{Z}_i(R_i, X_i, P, V). \tag{7}$$

We can also define the **collective marginal demands-price** (CMP demands) for analyzing public consumption. We eliminate λ and ϕ_i in the first order condition (4) and obtain the Samuelson's allocation rule for public consumption:

$$Q = \textstyle\sum_i R_i \frac{\partial u_i}{\partial V}\bigg/\frac{\partial u_i}{\partial X_i}. \tag{8}$$

If we eliminate Z_i in this expression with (6), we obtain the (aggregate) CMP demands:

$$\bar{Q} = \textstyle\sum_i \bar{Q}_i(R_i, X_i, P, V), \tag{9}$$

where $\bar{Q}_i$ is the individual CMP demands or the Lindahl prices, i.e., the price at which each member values his/her public consumption.[6] Finally, we can define the **collective marginal demands-mixte** (CMM demands) by using the following conventions:

$$D_i' = (Z_i', -Q_i') \qquad \text{and} \qquad M' = (P', V'),$$

[5] In the remainder of this text, a dash above a capital letter denotes a function of the variables X_i, R_i, P and V.

[6] Since the public good may be seen as an externality, the Lindahl price may be negative. See also Myles (1997) for a discussion of Lindahl prices.

and therefore,

$$\bar{D} = \sum_i \bar{D}_i(R_i, X_i, M).$$

The variables in the left-hand-side and the right-hand-side are observable. These relations can be directly estimated with usual techniques. Of course, in empirical work, we shall have to take account of the probable endogeneity of X_i and V.

A sufficient condition for the existence of the CMQ demands (and consequently the CMP demands) is the normality of the exclusive good (conditional on the level of public goods). The underlying intuition is that the demand for the exclusive goods, if normality is assured, can be seen as a satisfactory measure of the individual welfare in the household. For example, if a person in the household consumes a lot of her personal exclusive good and if this good is normal, then we can expect that this person will obtain a high level of welfare in the household and will consume a lot of private goods and attach a great value to the public goods. The CM approach is actually in line with the recent recognition that consumption may better reflect expected lifetime resources than current income. In addition, it is often mentioned that income reported in surveys may also be an insufficient indicator of material well-being because of misreporting, mismeasurement or (in-kind) transfers among extended families or friends. See Cutler and Katz (1991, 1992) and Slesnick (1993) for an exposition of this argument.

2.3 Testability and Identifiability

In what follows, we assume that the CMM demands exist everywhere. Naturally, these relations have specific properties that can be used to check ex post adequacy of the theory to observed behavior. The first result states that the CMM demands have to be homogeneous.

Proposition 1 *Under collective rationality,*
a) The CMQ demands for private goods $\bar{Z}(R_A, R_B, X_A, X_B, P, V)$ *are homogeneous of degree* 0 *in* R_A, R_B *and* P*;*
b) The CMP demands for public goods $\bar{Q}(R_A, R_B, X_A, X_B, P, V)$ *are homogeneous of degree* 1 *in* R_A, R_B *and* P*.*

Proof. A consequence of the definitions (7) and (9). ■

At this stage, one important point is that the homogeneity of $\bar{Z}$ and $\bar{Q}$ is not a consequence of the homogeneity of ϕ. We do not exclude the possibility that the intra-household distribution of power is affected by money illusion.

The other results are twofold. First, the separable structure of $\bar{Z}$ and $\bar{Q}$ have testable consequences under the form of partial differential equations. Second, the household behavior is characterized by a symmetry property, as in Browning and Chiappori (1998) or Donni (2001). We formally introduce the following proposition.

Proposition 2 *Under collective rationality, the CMM demands* $\bar{D}(R_A, R_B, X_A, X_B, M)$ *satisfy the following:*
a) [C–Separability]

$$\frac{\partial \bar{D}}{\partial R_A \partial R_B} = \frac{\partial \bar{D}}{\partial R_A \partial X_B} = \frac{\partial \bar{D}}{\partial X_A \partial R_B} = \frac{\partial \bar{D}}{\partial X_A \partial X_B} = 0,$$

b) [Symmetry]

$$\left(\frac{\partial \bar{D}}{\partial M'} + \sum_i \frac{\partial \bar{D}}{\partial R_i} \cdot \frac{\partial \bar{D}'}{\partial X_i} \right) \text{ is a symmetric matrix.}$$

Proof. See Appendix. ■

Several remarks are in order here. First, these constraints yield a particularly simple test of collective rationality under specific auxilliary assumptions (egoistic agents, absence of domestic production and absence of composite goods). Specifically, the first statement in Proposition 2 necessitates to check that four cross-terms in a second order approximation of the CMM demands are equal to zero. This may be realized with single equation methods (or even non-parametric ones). Second, the constraints could be transposed, in principle, to the more natural — but less convenient — specification:

$$Z = \tilde{Z}(R_A, R_B, X_A, X_B, P, Q) \qquad \text{and} \qquad V = \tilde{V}(R_A, R_B, X_A, X_B, P, Q),$$

where the variables in the right-hand-side are exogenous. However, it can be shown that the constraints imposed on $\tilde{Z}$ are quite different from those imposed on $\tilde{V}$. There are two implications: i) Analyzing public consumption in a framework initially developed for private consumption may be seriously misleading. ii) It is in principle possible to empirically discriminate between a public and a private use of some categories of goods.[7] Third, the second statement in Proposition 2 is a translation of the Slutsky symmetry in the CMM demands context. This condition generalizes in two directions a symmetry property for unitary marginal demands derived by Browning (1999): i) There are here two decision-makers in the household. ii) Some demands are represented with prices as the dependent variable. Finally, we may remark that the proposition above does not postulate a property of semi-definite negativeness for the CMM demands. The latter is more complicated to obtain.

The next important result of this section concerns the identification of structural elements of the decision process from the estimation of $\bar{Z}$ or $\bar{Q}$. To begin with, we define the invidual CM utility function as follows:

$$r_i(R_i, X_i, P, V) = u_i(X_i, \bar{Z}_i, V) = v_i(R_i, P, \bar{Q}_i, \bar{E}_i),$$

where v_i is the indirect utility function and $\bar{E}_i$ is the individual (virtual) endowment (a formal definition is given below). We can give the next proposition.

[7] To be more precise, it can be shown that $\tilde{Z}$ and $\tilde{V}$ have to satisfy the homogeneity and the symmetry retrictions as well as $\bar{Z}$ and $\bar{V}$. These functional structures have also to satisfy a particularly intricate constraint which is a transposition of the C-separability. This last constraint permits in principle to make such a discrimination.

Proposition 3 *Assume that* $\bar{D}(R_A, R_B, X_A, X_B, M)$ *is a complete system of CMM demands. Then, under collective rationality,*
a) The individual CMQ demands for private goods $\bar{Z}_i(R_i, X_i, P, V)$ *can be retrieved up to an additive function of* P *and* V*;*
b) The individual CMP demands for public goods $\bar{Q}_i(R_i, X_i, P, V)$ *can be retrieved up to an additive function of* P *and* V*;*
c) The individual CM utility function $r_i(R_i, X_i, P, V)$ *of each member can be retrieved up to composition by an increasing function of* P *and* V*.*

Proof. The proof is straightforward. To begin with, the derivatives of the individual demands for private goods can be retrieved. We obviously have:

$$\frac{\partial \bar{Z}_i}{\partial R_i} = \frac{\partial \bar{Z}}{\partial R_i} \qquad \text{and} \qquad \frac{\partial \bar{Z}_i}{\partial X_i} = \frac{\partial \bar{Z}}{\partial X_i},$$

where the right-hand-side of these expressions is observed. Similarly, the derivatives of the individual prices for public goods can be retrieved as well. We also have:

$$\frac{\partial \bar{Q}_i}{\partial R_i} = \frac{\partial \bar{Q}}{\partial R_i} \qquad \text{and} \qquad \frac{\partial Q_i}{\partial X_i} = \frac{\partial \bar{Q}}{\partial X_i},$$

where the right-hand side of these expressions is observed. Finally, the CM utility function is defined from the usual utility functions as follows:

$$r_i(R_i, X_i, P, V) = u_i(X_i, \bar{Z}_i(R_i, X_i, P, V), V).$$

The derivatives of this relation with respect to R_i and X_i are given by:

$$\frac{\partial r_i}{\partial R_i} = \frac{\partial u_i}{\partial Z_i} \cdot \frac{\partial Z_i}{\partial R_i} \qquad \text{and} \qquad \frac{\partial r_i}{\partial X_i} = \frac{\partial u_i}{\partial X_i} + \frac{\partial u_i}{\partial Z_i} \cdot \frac{\partial Z_i}{\partial X_i}.$$

Using the first order condition $\partial u_i/\partial Z_i = (\partial u_i/\partial X_i) \cdot P/R_i$, we obtain:

$$\frac{\partial r_i}{\partial R_i} = \alpha \cdot \left(\frac{P}{R_i} \cdot \frac{\partial Z_i}{\partial R_i}\right) \qquad \text{and} \qquad \frac{\partial r_i}{\partial X_i} = \alpha \cdot \left(1 + \frac{P}{R_i} \cdot \frac{\partial Z_i}{\partial X_i}\right).$$

where $\alpha = \partial u_i/\partial X_i$. That is, the partial derivatives of r_i are defined up to a multiplicative positive function and therefore r_i is defined up to composition by an increasing function of P and V. ■

This result is particularly attractive for several reasons. We may note for the moment that differences in tastes between the husband and the wife can be revealed by the estimation of the CMM demands. Consequently, we may envisage a welfare policy specifically targeting the husband or the wife in the household. This point of view is completed in Section 3 where we assume that the demands for the exclusive goods are jointly estimated as a function of the set of exogenous variables.

In the CMM demands approach, we do not explicitly postulate the existence of a sharing rule as in the large majority of papers on collective models. However, we could define the (virtual) endowment of each member as a function of R_i, X_i, P and V:

$$\bar{E}_i(R_i, X_i, P, V) = X_i \cdot R_i + \bar{Z}_i(R_i, X_i, P, V) \cdot P' + \bar{Q}_i(R_i, X_i, P, V) \cdot V'.$$

The latter is a generalization of the well-known sharing rule for the presence of public goods. This can be used as an indicator of the intra-household distribution of welfare and its derivatives with respect to R_i and X_i can obviously be identified if a complete system of CMM demands is estimated. In particular, we have:

$$\frac{\partial E_i}{\partial R_i} = X_i + \frac{\partial \bar{Z}}{\partial R_i} P' + \frac{\partial \bar{Q}}{\partial R_i} V' \quad \text{and} \quad \frac{\partial E_i}{\partial X_i} = R_i + \frac{\partial \bar{Z}}{\partial X_i} P' + \frac{\partial \bar{Q}}{\partial X_i} V'.$$

This result is a reminiscent of previous results on the identification of the sharing rule when there is at least one exclusive good (see Browning et al. (1994), Bourguignon et al. (1995) or Donni (2001c) for instance). We can also define the Marshallian demands for leisure, for private goods and for public goods as follows:

$$X_i = \chi_i(R_i, P, Q_i, E_i), \; Z_i = \zeta_i(R_i, P, Q_i, E_i), \; V = \upsilon_i(R_i, P, Q_i, E_i). \qquad (10)$$

Still, the functions χ_i, ζ_i and υ_i cannot generally be identified. However, a particularly interesting counter-example must now be considered. We remark that, if there is no private goods, the linear-homogeneity of the individual CMP demands implies:

$$\bar{Q}_i = R_i \cdot \frac{\partial \bar{Q}_i}{\partial R_i}.$$

That is, the individual CMP demands $\bar{Q}_i(R_i, X_i, V)$ are exactly identified. Once these elements are retrieved, the (virtual) budget constraint of each member is exactly identified:

$$\bar{E}_i(R_i, X_i, V) = X_i \cdot R_i + \bar{Q}_i(R_i, X_i, P, V) \cdot V'.$$

Individual preferences and Marshallian demands can be retrieved as well. For instance, we may straightforwardly obtain the Marshallian demand for the exclusive good by inversion of the individual endowment:

$$\bar{E}_i(R_i, X_i, P, V) = E_i \Longleftrightarrow X_i = \chi_i(R_i, Q_i, E_i).$$

A complete characterization of this model with only public goods is however beyond the scope of this paper. This case and others are considered in Chiappori and Ekeland (2001a, 2001b).

3 Theory — Extensions

3.1 Preference Factors

The present model can be generalized in several ways. To begin with, the preferences of each agent generally depends on a set of socio-demographic characteristics. Therefore, we may assume:

$$u_i(X_i, Z_i, V; F_i, F_H),$$

where F_i and F_H are referred as 'preference factors'. We must make an important distinction between factors such as F_i which are related to a specific individual in the household (as the age, the race or the level of education) and factors such as F_H which are common to both agents (as the number and the age of children, the state/country of the household). The next step is to define, as previously, the CMM demands 'extended' with preference factors:

$$\bar{D} = \sum_i \bar{D}_i(R_i, X_i, P, V; F_i, F_H).$$

Naturally, the distinction between common and specific preference factors generates further testable restrictions. This is formally expressed in the following proposition.

Proposition 4 *Under collective rationality, the CMM demands* $\bar{D}(R_A, R_B, X_A, X_B, M; F_A, F_B, F_H)$ *satisfy the following [P-Separability]:*

$$\frac{\partial \bar{D}}{\partial F_A \partial R_B} = \frac{\partial \bar{D}}{\partial F_A \partial X_B} = \frac{\partial \bar{D}}{\partial F_A \partial F_B} = \frac{\partial \bar{D}}{\partial R_A \partial F_B} = \frac{\partial \bar{D}}{\partial X_A \partial F_B} = 0.$$

Proof. Straightforward from the definition of $\bar{D}$. ■

If there exists a clear distinction between specific and common preference factors, this proposition provides a very simple test of the collective approach with egoistic agents. In addition, the effects of the specific preference factors on the individual CMM demands can be identified as well.

3.2 Altruism and Children

The assumption that agents are egoistic is quite restrictive. However, altruism (à la Becker) may be introduced without fundamentally altering the conclusion of the model. We assume that agents actually maximize some 'altruistic' index:

$$U_i(u_A(X_A, Z_A, V), u_B(X_B, Z_B, V)),$$

where $U_i(\cdot)$ is a continuous, increasing and quasi-concave function. A fundamental remark is that any decision that is Pareto efficient within this new setting would be Pareto efficient as well, were the agents egoistic. This conclusion is not really surprising. The important property of this setting from which most of the results derive is the separability of the welfare index in ($\bar{\text{P}}$). See Chiappori (1992) for a discussion of this point.

Furthermore, this idea allows us to generalize the model to the presence of children. To do that, we assume that households comprise one child C and agents maximize the following index:

$$U_i(u_A(X_A, Z_A, V), u_B(X_B, Z_B, V), u_C(X_C, Z_C, V)),$$

where $u_C(\cdot)$ is the utility function of the child. This specifications follows Bourguignon (1999) where each parent is assumed to take care of his/her child in his/her preferences. Briefly, we can describe some important consequences of this generalization. First of all, if there is at least one exclusive good X_C for each child (for example, children's clothing), it easy to show that the CMM demands with one child has now three components:

$$\bar{D} = \sum_{i=A,B} \bar{D}_i(R_i, X_i, P, V) + \bar{D}_C(R_C, X_C, P, V),$$

where $\bar{D}_C$ is the individual CMM demands for the child. The results previously derived can straightforwardly be extended. If such an exclusive good does not exist, the demand for the child will be a complex function of R_A, R_B, X_A and X_B. The separability which is the basis of the preceding analysis vanishes. However, we conjecture in this context that specific tests can be derived but it is beyond the scope of this paper.

3.3 Relationships with Unconditional Models

Generally, the collective models that are used in empirical applications are unconditional in the sense that each demand is represented as a function of prices, incomes, distribution factors and preference factors.[8] However, the properties of the CMM demands that we develop above can be expressed in terms of these traditional collective models. To do that, we have to specify the form of the demands for the exclusive goods. Typically, the (unconditional) demands for the exclusive goods depend on all the variables in the budget constraint and the bargaining function:

$$X_i = \check{X}_i(R_A, R_B, Y_A, Y_B, M, S, \Delta),$$

where for convenience the preferences factor are disregarded in the remainder of this section. These relations have theoretical properties which are studied in depth in Chiappori et al. (2001). In particular, they generate a set of testable restrictions and allow to identify some elements of the decision process.

The underlying difficulty is that the (unconditional) demands for the exclusive goods may be functions of numerous variables which are not necessarily observed by the economist (e.g., the past or expected values of R_A, R_B, Y_A or

[8] These demands may also be expressed as a function of the level of public goods. This is due to the non-separability between private and public consumption in preferences. See Browning and Meghir (1991) for a discussion of this point in the unitary approach.

Y_B). However, if these demands were estimated, they could be introduced in the individual CMM demands to give their corresponding unconditional demands:

$$\check{D}_i(R_A, R_B, Y_A, Y_B, M, S, \Delta) = \bar{D}_i(R_i, \check{X}_i, M). \tag{11}$$

Clearly, it is easy to compute, from Proposition 3, the effect of most exogenous variables on the unconditional demands. For example, differentiating this equation with respect to Y_j yields:

$$\frac{\partial \check{D}_i}{\partial Y_j} = \frac{\partial \bar{D}_i}{\partial X_i} \frac{\partial \check{X}_i}{\partial Y_j}, \tag{12}$$

where the right-hand-side derivatives are known. This relation allows us to measure the impact of a change in Y_j on $\check{D}_i$. Other derivatives of $\check{D}_i$ can be identified.

At this stage, three points must be stressed. First, the constraints given in Proposition 3 have necessarily a transposition under the form of restrictions on the partial derivatives of the unconditional demands. Still these restrictions are quite complicated. Second, it can be shown that the unconditional demands have to satisfy additional constraints. The underlying idea is that several variables, such as Y_i, S and Δ, influence the CMM demands only through a variation in the levels of the exclusive goods. For example, using (12) and assuming $\partial \check{X}_i / \partial Y_i \neq 0$, we obtain:

$$\frac{\partial \check{D}_i}{\partial Y_j} = k \cdot \frac{\partial \check{D}_i}{\partial Y_i},$$

where $k = \left(\partial \check{X}_i / \partial Y_j\right) / \left(\partial \check{X}_i / \partial Y_i\right)$. This **distribution property**, in Browning and Chiappori's (1998) terminology, will be implicitly used for the construction of the instruments in the empirical part of this paper. Third, in the litterature on collective models, there exists another concept of conditional demands. In the y-demands (see Bourguignon et al. (1994) and Donni (2001) in particular), the quantity of goods is function of various exogenous variables, the total income and one exclusive good. The properties of these demands can also be related to the CMM demands.

4 Statistical Specification

4.1 A Flexible Functional Form

In this section we take a parametrization for the CMM demand system and derive the implications implied by the collective setting. We suppose that unobservable heterogeneity in the collective marginal demands is generated by a random utility model. This requires that the stochastic components enter the utility function directly.[9] The standard interpretation of these models states

[9] These models can be seen as an extension of McFadden (1974). See also McElroy (1987), Brown and Walker (1989) and Brown and Matzkin (1998) for other examples.

that although the individual may know what affects his utility, the econometric investigator cannot observe all the relevant factors. In the CMM approach, things are specially simple. We suppose for convenience that error terms are introduced in the marginal rate of substitution:

$$\frac{\partial u_i}{\partial Z_i} \bigg/ \frac{\partial u_i}{\partial X_i} = g(X_i, Z_i - e_i, V)$$

$$\text{and} \qquad \frac{\partial u_i}{\partial V} \bigg/ \frac{\partial u_i}{\partial X_i} = h(X_i, Z_i - e_i, V) + \frac{u_i}{V},$$

where e_i and u_i are vectors of stochastic terms and g and h are deterministic functions. These equations can be easily solved to obtain the CMM expenditures as a function of an additive stochastic term:

$$\begin{array}{rcl} P \odot Z_i & = & \sum_i P \odot z_i(X_i, R_i, P, V) + \varepsilon_z, \\ V \odot Q_i & = & \sum_i V \odot q_i(X_i, R_i, P, V) + \varepsilon_q, \end{array}$$

where z_i and q_i are deterministic functions and $\varepsilon_z = \sum_i P \odot e_i$ and $\varepsilon_q = \sum_i u_i/R_i$. More compactly,

$$M \odot D_i = \sum_i M \odot d_i(X_i, R_i, P, V) + \varepsilon,$$

with $d_i' = (z_i', -q_i')$ and $\varepsilon' = (\varepsilon_z', -\varepsilon_q')$. Traditionnally, it is assumed that, conditional on right-hand-sides variables, the heterogeneity terms have zero mean. This permits to use NLS estimation techniques. However, this assumption is inadequate for the present model. In particular, we are incited to think that

$$E(\varepsilon | X_A, X_B, V) \neq 0.$$

The reason for this endogeneity is that the choice of the level X_A, X_B and V is determined as a function of the preferences heterogeneity.[10] However, we have a natural assumption on the stochastic terms:

$$E(\varepsilon | R_A, R_B, Y_A, Y_B, P, Q, S) = 0. \tag{13}$$

Specifically, Y_A, Y_B and S constitute a set of instruments which permit the econometric identification of this model. Finally, the heterogeneity terms are easily incorporated in a coherent way; in particular, the CMM approach disentangles in the household behavior equations what is due to husband's taste and what is due to wife's taste. Moreover, the heterogeneity related to the decision process is directly summarized by the conditioning variables. See Blundell et al. (2001) for a fully stochastic collective model of labor supply explicitly accounting for the heterogeneity in the sharing rule.

[10] There is another important reason. In surveys, these variables are generally contaminated by the infrequency of purchases. These errors in variable may create another from of endogeneity which is not formally accounted in this paper. See Meghir and Robin (1991) for an elegant treatment in the traditional framework.

The next step is to conveniently choose the deterministic component of the CMM demands d_i. When we estimate a system of Marshallian demands, we usually model budget shares. Here we model relative shares, i.e., the ratio of expenditures on the good to be modelled to expenditure on the reference good. When choosing a demand system it is important to allow for as much flexibility as possible, since tests of symmetry may be biased if the form is too restrictive a priori. We use the following notation:

$$\xi = \begin{pmatrix} \exp(1), & X_A, & X_B, & R_A, & R_B, & M' \end{pmatrix}'.$$

After considerable experimentation, we suppose that the relative share of good for each member is characterized by the following very general functional form:

$$d_A \odot M = X_A R_A \cdot \left(\frac{A \cdot \log \xi}{\alpha' \cdot \log \xi} + \psi_A \right)$$

$$\text{and} \quad d_B \odot M = X_B R_B \cdot \left(\frac{B \cdot \log \xi}{\beta' \cdot \log \xi} + \psi_B \right),$$

where

$$A = \begin{pmatrix} A_0' \\ A_x' \\ A_x^{*\prime} \\ A_r' \\ A_r^{*\prime} \\ A_m' \end{pmatrix}', \quad B = \begin{pmatrix} B_0' \\ B_x^{*\prime} \\ B_x' \\ B_r^{*\prime} \\ B_r' \\ B_m' \end{pmatrix}', \quad \alpha = \begin{pmatrix} \alpha_0 \\ \alpha_x \\ \alpha_x^* \\ \alpha_r \\ \alpha_r^* \\ \alpha_m \end{pmatrix}, \quad \beta = \begin{pmatrix} \beta_0 \\ \beta_x^* \\ \beta_x \\ \beta_r^* \\ \beta_r \\ \beta_m \end{pmatrix},$$

are conformable matrix of parameters and ψ_A and ψ_B are functions of preference factors. We may note that the denominator is the same for all the relative share equations of each member.[11] This system is reminiscent of the basic Translog for Marshallian demands of Christensen, Jorgenson and Lau (1975) but it represents different preferences. This functional form maintains the flexibility and, as seen below, does not incorporate unrealistic behavior when theoretical constraints on parameters are incorporated.[12] However, this general form is a starting point. In the empirical section, we consider a more constraint system of shares.

We have to allow for the fact that different people will have different tastes. To do that, we suppose that ψ_A and ψ_B are functions of preference factors. We adopt a linear specification:

$$\begin{aligned} \psi_A &= \theta_A \cdot F_A + \vartheta_B \cdot F_B + \mu_A \cdot F_H, \\ \psi_B &= \vartheta_A \cdot F_A + \theta_B \cdot F_B + \mu_B \cdot F_H, \end{aligned}$$

[11] We use a positive translation of X_i and V in the functional form. The reason is that, for some households, the observed expenditure on X_i and V is equal to zero because of the infrequency of purchases.

[12] Browning (1998) uses a functional form for the unitary version of the marginal demands which is reminiscent of the Quadratic AI Demand System (QUAIDS) of Banks, Blundell and Lewbel (1997). In our opinion, this form introduces too strong constraints on individual behavior.

where $\theta_A, \vartheta_A, \theta_B, \vartheta_B, \mu_A$ and μ_B are conformable matrix of parameters. Typically, the variables include the level of education of each member, the age, the region, the race and so on.

Finally, to be consistent with the theory previously developed, the parameters of these equations have to satisfy several constraints. To show that, we partition the matrix

$$A_m = (A_p, A_v) \qquad \text{and} \qquad B_m = (B_p, B_v)$$

where A_p and B_p respectively correspond to the K_1 first columns of A_m and B_m, and A_v and B_v corresponds to the next K_2 columns. The testable constraints are summarized in Table 1. These conditions does not impose unrealistic restrictions on household behavior. Furthermore, we set $\alpha_0 = \beta_0 = 1$ as a normalization in order to identify the unconstrained model.

4.2 Econometric Issues

Before presenting data and estimates of the parameters, we have to address some econometric issues. The equations are estimated using conventional iterated GMM techniques. We must indeed allow for the possible endogeneity of some right-hand-side variables. The estimation method is also consistent with heteroscedasticity of unknown form in the errors.

The GMM implementation is based on the conditional moments given by (13). In particular, the natural instruments to correct for the endogeneity of X_A and X_B are Y_A, Y_B and S. The critical point here is that Y_A, Y_B and S should not affect the demands (or prices) for goods once we condition on X_A and X_B. The exclusion of these variables in the CMM demands is actually a theoretical prediction which can be tested by the J-test of overidentifying restrictions. Furthermore, the fact that Y_A, Y_B and S affect the household behavior only through X_A and X_B can be seen as a transposition of the distribution property, previously defined, in the CMM context. Finally, other specific tests (homogeneity, symmetry and separability) can be made with LR-type tests. The corresponding statistics is computed as the difference between the J-statistics computed for the constraint model and the one computed for the unconstraint model; see Newey and West (1987).

One last point must be adressed. In the estimation procedure, we use unconditional moments defined by the orthogonality conditions between errors and functions of the exogenous variables:

$$E(\varepsilon \diagdown w(R_A, R_B, Y_A, Y_B, P, Q, S)) = 0,$$

where $w(\cdot)$ is a vector of convenient functions. Of course, the choice of f is of great importance. The most usual approach consists in using a set of polynomials of the exogenous variables: $R_A, R_A^2, \ldots, R_B, R_B^2, \ldots, R_A R_B, \ldots$ In this case, the number of instruments may become very large and dramatically colinear. In what follows, we use a more parcimonious approach. First, a set of second-order polynomials of the exogenous variables is computed as usual. However, this set

Table 1: Set of testable constraints

I.	Homogeneity:	$A_p\iota + A_r + A_r^* = B_p\iota + B_r + B_r^* = 0$
		$\alpha_p'\iota + \alpha_r + \alpha_r^* = \beta_p'\iota + \beta_r + \beta_r^* = 0$
II.	C-Separability:	$A_x^* = A_r^* = B_x^* = B_r^* = 0$
		$\alpha_x^* = \alpha_r^* = \beta_x^* = \beta_r^* = 0$
III.	Symmetry:	1. General Case
		$A_m = A_m'$ and $B_m = B_m'$
		$A_x = A_r + \alpha_m$ and $B_x = B_r + \beta_m$
		$A_r\alpha_x = A_x\alpha_r$ and $B_r\beta_x = B_x\beta_r$
		$A_r^*\alpha_x^* = A_x^*\alpha_r^*$ and $B_r^*\beta_x^* = B_x^*\beta_r^*$
		2. $\alpha = \beta = 0$
		$A_r = A_x$ and $B_r = B_x$
		$A_r^* = k_A \cdot A_x^*$ and $B_r = k_B \cdot B_x^*$
		where k_A and k_B are constants
IV.	P-Separability:	$\vartheta_A = \vartheta_B = 0$

is then replaced by its principal components. The idea is then to use a relatively small set of instruments which capture a large proportion of the variance in the exogenous variables. This permits to avoid problems associated with the well-known small sample bias. Moreover, the computation is numerically more tractable and more stable.

5 Data and Results [This part is particularly incomplete]

5.1 The Consumer Expenditure Survey

Data are drawn from the 'Consumer Expenditure Survey' which was begun in late 1979; previously this survey had been done periodically. This study uses data from the 'Interview' component of the CES, which contains information on major and recurring expenditure items and also contains global estimates of spending for total food at home and other items for the three-month period immediately preceding the interview. The unit of observation is the consumer unit, which is defined as all members of a housing unit who are related by blood or legal arrangement and a person living alon or with others who is financially independent. Consumer units are interviewed five times, but the first quarter of expenditure data are used only for bounding purposes. Several studies have exploited this survey over the last 10 years (e.g., Manser (1993) or Meghir and Weber (1996)).

Because of the rotating panel nature of the survey, the data used in this study refer to each of the overlapping 12-month periods January 1980–December 1980, February 1980–January 1981, and so on through the 12 month period October April 1998–March 1999. The complete sample includes about 100,000 households from 1980 to 1999. From the complete sample, we select a subsample of married couples without children. We also restrict the sample to couples where the husband and the wife are both full-time working (whose yearly labor supply is higher than 1700 hours) and less than 65 years old. These selection rules and the exclusion of missing data leaves us with a total of 1,865 cases for the empirical analysis. The description of the sample is precisely given in Appendix.

Following Browning et al. (1994), we suppose that there are typically two exclusive goods: man's clothing and woman's clothing. Furthermore, this study also consider four other private expenditure categories: food at home (FDAH), food away from home (REST), alcohol and tobacco (VICE) and water and fuel (FUEL). We assume that these six goods are separable from the other categories. The fact that expenditures for the whole year are taken means that these data have less of an infrequency of purchase problem than other data sets. Of course, there is still some lumpiness in these expenditures even when we take annual expenditures.

Finally, the price indexes are taken from the Bureau of Labor Statistics and the sex-ratio — which is a distribution factor according to Chiappori et al. (2001) — from the Census survey.

5.2 Empirical Results: A Preliminary Investigation

In this preliminary inverstigation, we use a simple version of the previous functional form where $\alpha = \beta = 0$. This form is linear and consequently easier to estimate. The estimation of the most flexible functional form is still in progress. Furthermore, the classification between public and private goods is exogenously given. We assume a priori that FDAH, REST and VICE are private and FUEL is public. This classification is of course debatable. A more convincing approach would consist in determining the convenient classification from the data but the theoretical basis of this approach must still be developed.

In what follows, we use 40 instruments per equations (or 160 instruments for the whole model) and consider four types of models. These are described in Table 2. We note that, for all these models, Hansen's test does not reject the validity of the instruments and the over-identifying restrictions. In addition, the various sets of restrictions (homogeneity, C-separability, symmetry and P-separability) are never rejected. We may conclude that the data are overall consistent with the collective setting.

TABLE 2: MODEL SELECTION

Private goods:	FDAH, REST, VICE		
Public goods:	FUEL		
Models	Set of constraints	J-stat.	Degrees of freedom
MODEL 1	IV	46.54	56
MODEL 2	I, IV	50.15	64
MODEL 3	I, II, IV	87.94	90
MODEL 4	I, II, III, IV	97.20	100

The parameters estimates of the unrestricted model are given in Table 3. Unfortunately, almost all the parameters are unsignicant. Moreover, the rare significant parameters are in the demographic variables. This may explain the validity of the different tests. Note however that the parameters relative to the quantity of public goods (FUEL) have a small standard deviation by comparison with the parameters of the prices for the private goods. This may be explained by the fact that these variables have a small variability in the sample.[13]

The parameters estimates of the restricted model are given in Table 4. We may note that, when the set of all the restrictions is imposed, almost all the parameters are significant.

6 Conclusion

In this paper, we present a simple collective model with public and private goods. We show that the household demands have to satisfy a set of constraints

[13] An increase in the number of instruments improves, as expected, the significancy of most parameters. These investigations are still in progress.

Table 3a: estimates for the unrestricted model

A) Husbands demands				
	FDAH	REST	VICE	FUEL
Prices				
$P-$ FDAH	12.40	-33.08	-0.06	-32.05
	(57.13)	(52.34)	(32.75)	(21.85)
$P-$ REST	-85.45	117.26	-23.69	39.99
	(103.11)	(71.61)	(52.44)	(35.44)
$P-$ VICE	-27.75	-15.78	-23.29	24.42
	(34.67)	(29.98)	(11.65)	(13.02)
$V-$FUEL	2.27	-2.83	1.01	-1.22
	(1.82)	(1.55)	(1.02)	(0.72)
Exclusive goods				
$X-$ CLOM	4.26	-4.45	0.74	1.37
	(6.27)	(6.36)	(3.28)	(2.30)
$P-$ CLOM	297.60	-171.62	132.32	-91.15
	(263.49)	(212.75)	(129.25)	(83.12)
$X-$ CLOF	-7.72	5.38	-2.34	0.67
	(6.42)	(6.52)	(3.35)	(2.22)
$P-$ CLOF	-147.60	102.45	-58.32	30.02
	(131.53)	(107.30)	(65.06)	(40.68)
Demographic variables				
Intercept	-239.77	14.95	91.80	130.44
	(203.20)	(158.99)	(69.66)	(70.55)
black	1.15	1.58	0.25	-0.92
	(2.28)	(1.86)	(0.86)	(0.92)
spanish	0.27	-1.55	1.38	0.32
	(1.77)	(1.73)	(1.01)	(0.60)
education	-0.04	0.04	-0.01	-0.01
	(0.02)	(0.02)	(0.01)	(0.01)
age	0.06	-0.02	-0.01	-0.01
	(0.02)	(0.02)	(0.01)	(0.01)

Table 3b: estimates for the unrestricted model

B) Wives demands				
	FDAH	REST	VICE	FUEL
Prices				
$P-$ FDAH	3.06	21.00	4.25	19.83
	(38.00)	(34.85)	(21.74)	(14.27)
$P-$ REST	46.24	-71.97	12.85	-26.26
	(67.49)	(35.96)	(34.17)	(22.84)
$P-$ VICE	16.39	9.33	14.98	-16.11
	(23.25)	(20.17)	(8.64)	(8.59)
$V-$ FUEL	-2.39	2.83	-0.03	-0.62
	(1.38)	(1.30)	(0.71)	(0.52)
Exclusive goods				
$X-$ CLOM	5.56	-1.57	1.99	-0.33
	(5.09)	(4.79)	(2.51)	(1.64)
$P-$ CLOM	-170.84	104.14	-77.30	57.05
	(167.22)	(134.59)	81.75	(52.94)
$X-$ CLOF	-5.57	0.39	-1.69	0.61
	(4.89)	(4.58)	(2.43)	(1.62)
$P-$ CLOF	76.46	-61.99	26.11	-14.61
	(79.36)	(63.79)	(38.89)	(24.77)
Demographic variables				
Intercept	153.63	-10.53	91.80	-91.74
	(135.15)	(106.95)	(69.66)	(45.79)
black	-1.05	-1.83	0.25	0.52
	(1.68)	(1.32)	(0.86)	(0.64)
spanish	-0.28	0.94	1.38	-0.04
	(1.77)	(1.22)	(1.01)	(0.45)
education	-0.01	-0.01	-0.01	0.01
	(0.02)	(0.02)	(0.01)	(0.01)
age	0.01	0.01	-0.01	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)

Table 4a: estimates for restricted model

A) Husbands demands				
	FDAH	REST	VICE	FUEL
Prices				
$P-$ FDAH	68.75	-64.43	-0.46	3.06
	(20.72)	(20.52)	(4.97)	(0.96)
$P-$ REST	-64.43	49.48	10.38	-8.27
	(20.52)	(22.20)	(7.32)	(1.77)
$P-$ VICE	-0.46	10.38	-6.99	2.41
	(4.97)	(7.32)	(4.16)	(0.94)
$V-$ FUEL	3.06	-8.27	2.41	-1.42
	(0.96)	(1.77)	(0.94)	(0.49)
Exclusive goods				
$X-$ CLOM	6.92	-12.84	-17.88	-4.22
	(3.12)	(3.67)	(7.02)	(2.85)
$P-$ CLOM	6.92	-12.84	-17.88	-4.22
	(3.12)	(3.67)	(7.02)	(2.85)
$X-$ CLOF	0.00	0.00	0.00	0.00
	—	—	—	—
$P-$ CLOF	0.00	0.00	0.00	0.00
	—	—	—	—
Demographic variables				
Intercept	3.74	6.68	3.59	-4.15
	(3.78)	(5.39)	(3.28)	(1.33)
black	-2.90	12.46	-8.66	2.94
	(3.26)	(6.11)	(3.17)	(1.69)
spanish	-1.16	5.06	-2.13	0.87
	(1.85)	(2.71)	(1.25)	(0.55)
education	-0.01	-0.01	-0.01	-0.1
	(0.01)	(0.02)	(0.01)	(0.00)
age	0.03	0.03	0.01	-0.01
	(0.01)	(0.02)	(0.01)	(0.01)

Table 4b: estimates for restricted model

B) Wives demands				
	FDAH	REST	VICE	FUEL
Prices				
$P-$ FDAH	-40.07	38.27	1.39	-2.88
	(13.22)	(13.17)	(3.27)	(0.68)
$P-$ REST	38.27	-28.46	-6.95	4.04
	(13.17)	(14.38)	(4.78)	(1.13)
$P-$ VICE	1.39	-6.95	4.29	-0.98
	(3.27)	(4.78)	(2.71)	(0.60)
$V-$ FUEL	-2.88	4.04	-0.98	-0.68
	(0.68)	(1.13)	(0.60)	(0.31)
Exclusive goods				
$X-$ CLOM	0.00	0.00	0.00	0.00
	—	—	—	—
$P-$ CLOM	0.00	0.00	0.00	0.00
	—	—	—	—
$X-$ CLOF	-3.29	6.90	-2.25	-0.05
	(1.55)	(3.11)	(1.55)	(1.33)
$P-$ CLOF	-3.29	6.90	-2.25	-0.05
	(1.55)	(3.11)	(1.55)	(1.33)
Demographic variables				
Intercept	5.24	0.53	-2.11	2.33
	(2.86)	(4.06)	(2.40)	(0.99)
black	1.81	-11.04	6.45	-2.48
	(2.52)	(4.62)	(2.53)	(1.27)
spanish	0.54	-3.80	1.42	-0.43
	(1.32)	(1.81)	(0.89)	(0.40)
education	-0.01	0.03	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.00)
age	0.02	0.01	-0.01	0.01
	(0.01)	(0.02)	(0.01)	(0.01)

and the Lindahl prices for the public goods can be partially retrieved. These empirical results are followed by euand empirical application with US data.

The basic concept in this analysis is the exclusive goods. In fact, an exclusive goods is good whose individual consumption and individual price aez observed. The main limitation of the present analysis is the role of composite goods: we assume that each good is either private or public and exclude the possibility of composite goods.

The present framework can be used in principle to evaluate the cost of children. Moreover, since most public goods have a durable component, the direction for future researches is to incorporate durable goods (including lodging) in the present framwork.

Appendix

A.1 Proof of Proposition 2

We consider the following conditions:

$$\frac{\partial u_i}{\partial X_i} = \lambda_i \cdot R_i, \qquad \frac{\partial u_i}{\partial Z_i} = \lambda_i \cdot P, \qquad \frac{\partial u_i}{\partial V} = \lambda_i \cdot Q_i$$

where $\lambda_i = \lambda/\phi_i$. We solve these equations for X_i, Z_i and Q_i as functions of R_i, P, V and λ_i and obtain the following relations:

$$X_i = \hat{X}_i(\lambda_i, R_i, M), \qquad Z_i = \hat{Z}_i(\lambda_i, R_i, M), \qquad Q_i = \hat{Q}_i(\lambda_i, R_i, M).$$

The remainder of the proof follows in stage. In the first step, we show the following lemma.

Lemma 5 *Let us assume that* $\det(\partial \hat{V}/\partial Q_i') \neq 0$. *The functions* $\hat{X}_i, \hat{Z}_i$ *and* $\hat{Q}_i$ *satisfy the following:*

$$\begin{bmatrix} \frac{\partial \hat{X}_i}{\partial R_i} & \frac{\partial \hat{X}_i}{\partial P'} & \frac{\partial \hat{X}_i}{\partial V'} \\ \frac{\partial \hat{Z}_i}{\partial R_i} & \frac{\partial \hat{Z}_i}{\partial P'} & \frac{\partial \hat{Z}_i}{\partial V'} \\ -\frac{\partial \hat{Q}_i}{\partial R_i} & -\frac{\partial \hat{Q}_i}{\partial P'} & -\frac{\partial \hat{Q}_i}{\partial V'} \end{bmatrix} \text{ is a symmetric matrix.}$$

Proof. To simplify, we introduce the following notation:

$$L_i' = (X_i, Z_i') \qquad \text{and} \qquad N_i' = (R_i, P')$$

and consider the well-known Frisch demands:

$$L_i = \hat{L}_i(\lambda_i, N_i, Q_i), \qquad V = \hat{V}(\lambda_i, N_i, Q_i),$$

which satisfy a symmetry property. We differentiate $(\hat{L}_i, \hat{V}')$ with respect to (N_i, Q_i') and obtain:

$$\begin{aligned} \mathrm{d}L_i &= \frac{\partial \hat{L}_i}{\partial N_i'}\,\mathrm{d}N_i + \frac{\partial \hat{L}_i}{\partial Q_i'}\,\mathrm{d}Q_i, \\ \mathrm{d}V &= \frac{\partial \hat{V}}{\partial N_i'}\,\mathrm{d}N_i + \frac{\partial \hat{V}}{\partial Q_i'}\,\mathrm{d}Q_i. \end{aligned}$$

We solve this system with respect to $\mathrm{d}L_i$ and $-\,\mathrm{d}Q_i$ and obtain:

$$\begin{aligned} \mathrm{d}L_i &= \left(\frac{\partial \hat{L}_i}{\partial N_i'} - \frac{\partial \hat{L}_i}{\partial Q_i'}\left(\frac{\partial \hat{V}}{\partial Q_i'}\right)^{-1}\frac{\partial \hat{V}}{\partial N_i'}\right)\cdot \mathrm{d}N_i + \frac{\partial \hat{L}_i}{\partial Q_i'}\left(\frac{\partial \hat{V}}{\partial Q_i'}\right)^{-1}\cdot \mathrm{d}V \\ -\mathrm{d}Q_i &= \left(\frac{\partial \hat{V}}{\partial Q_i'}\right)^{-1}\frac{\partial \hat{V}}{\partial N_i'}\cdot \mathrm{d}N_i - \left(\frac{\partial \hat{V}}{\partial Q_i'}\right)^{-1}\cdot \mathrm{d}V. \end{aligned}$$

Since Frisch symmetry establishes that

$$\frac{\partial \hat{L}_i}{\partial N'} = \left(\frac{\partial \hat{L}_i}{\partial N'}\right)', \qquad \frac{\partial \hat{V}}{\partial Q_i'} = \left(\frac{\partial \hat{V}}{\partial Q_i'}\right)', \qquad \frac{\partial \hat{V}}{\partial N'} = \left(\frac{\partial \hat{L}_i}{\partial Q_i'}\right)',$$

we have:

$$\frac{\partial \hat{Q}_i}{\partial V} = \left(\frac{\partial \hat{Q}_i}{\partial V}\right)', \qquad \frac{\partial \hat{L}_i}{\partial N_i} = \left(\frac{\partial \hat{L}_i}{\partial N_i}\right)', \qquad -\frac{\partial \hat{Q}_i}{\partial N_i'} = \left(\frac{\partial \hat{L}_i}{\partial V'}\right)'.$$

This completes the proof. ■

In the second step, we show the connection between individual collective Frisch mixte-demands and individual CMM demands. To begin with, we denote $D_i' = (Z_i', -Q_i')$. Then, $\bar{D}_i$ and $\hat{D}_i$ are related as follows:

$$\hat{D}_i(\lambda_i, R_i, M) = \bar{D}_i(\hat{X}_i(\lambda_i, R_i, M), R_i, M). \tag{14}$$

We differentiate this expression with respect to M and obtain:

$$\frac{\partial \hat{D}_i}{\partial M'} = \frac{\partial \bar{D}_i}{\partial M'} + \frac{\partial \bar{D}_i}{\partial X_i}\frac{\partial \hat{X}_i}{\partial M'}, \tag{15}$$

where the left-hand side of this expression is symmetric from Lemma 1. Moreover, Lemma 1 also implies that

$$\frac{\partial \hat{X}_i}{\partial M'} = \frac{\partial \hat{D}_i'}{\partial R_i} = \frac{\partial \bar{D}_i'}{\partial R_i} + \frac{\partial \bar{D}_i'}{\partial X_i}\frac{\partial \hat{X}_i}{\partial R_i}, \tag{16}$$

where the second equality follows from (14). We introduce (16) in (15) and obtain:

$$\frac{\partial \hat{D}_i}{\partial M'} = \frac{\partial \bar{D}_i}{\partial M'} + \frac{\partial \bar{D}_i}{\partial X_i}\frac{\partial \bar{D}_i'}{\partial R_i} + \frac{\partial \bar{D}_i}{\partial X_i}\frac{\partial \bar{D}_i'}{\partial X_i}\frac{\partial \hat{X}_i}{\partial R_i}$$

The last term in the right-hand side of this expression is clearly symmetric. Therefore, we establish that

$$\frac{\partial \bar{D}_i}{\partial M'} + \frac{\partial \bar{D}_i}{\partial X_i}\frac{\partial \bar{D}_i'}{\partial R_i} \text{ is symmetric.}$$

Since $\sum_i D_i = D$, the second statement in Proposition 2 is proved. ■

A.2 The construction of Data

The order in which the selection criteria were applied and their effects in terms of the number of observations deleted using each criteria is given in the following table.

Table A1: Selection Criteria

Total number of candidate observations		96,949
Attrition in the family interview	–	35,258
Single headed households	–	29,345
Households with members > 65	–	6,396
Households with children	–	18,361
Households with part-time working members	–	4,485
Missing data	–	1,239
Remaining sample		1,865

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