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EFFICIENT INTRA-HOUSEHOLD ALLOCATIONS: A GENERAL CHARACTERIZATION AND EMPIRICAL TESTS

BY M. BROWNING AND P. A. CHIAPPORI[1]

The neoclassical theory of demand applies to individuals, yet in empirical work it is usually taken as valid for households with many members. This paper explores what the theory of individuals implies for households that have more than one member. We make minimal assumptions about how the individual members of the household resolve conflicts. All we assume is that however decisions are made, outcomes are efficient. We refer to this as the collective setting. We show that in the collective setting household demands must satisfy a symmetry and rank condition on the Slutsky matrix. We also present some further results on the effects on demands of variables that do not modify preferences but that do affect how decisions are made.

We apply our theory to a series of surveys of household expenditures from Canada. The tests of the usual symmetry conditions are rejected for two-person households but not for one-person households. We also show that income pooling is rejected for two-person households. We then test for our collective setting conditions on the couples data. None of the collective setting restrictions are rejected. We conclude that the collective setting is a plausible and tractable next step to take in the analysis of household behavior.

KEYWORDS: Intra-household allocation, household bargaining, collective model, Slutsky matrix.

1. INTRODUCTION

WHEN CONSIDERING HOUSEHOLD BEHAVIOR and welfare it is almost universally assumed that the many-person household can be treated as though it has a single set of goals. The adoption of this "unitary" model is very convenient, if only because standard tools of consumer analysis can then be applied at the household level. Methodologically, however, it stands on weak grounds. Neoclassical utility theory applies to individuals and not to households.[2] There is also mounting empirical evidence that the unitary model does not hold. In particular the fundamental observable implication of utility theory—symmetry of the Slutsky matrix—is regularly rejected on household data (see, for example, Blundell, Pashardes, and Weber (1993) and Browning and Meghir (1991)). Further disquiet is given by the universal rejection of the "income pooling"

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[2]Two major contributions have tried to reconcile the unitary model with the fact that households may consist of more than one decision maker. However, Samuelson's (1956) idea of a household welfare function relies upon the ad-hoc idea that the latter (and in particular the respective weights given to each member's utility) is independent of prices and incomes. While Becker's 'rotten kid' theorem (see Bergstrom (1989) for a statement) appears sounder, it still requires transferable preferences and a specific decision process to hold true.

property of the unitary model, that is, the implication that the source of household income should not have any effect on allocations once we condition on total expenditure (see, for instance, Thomas (1990), Schultz (1990), Bourguignon, Browning, Chiappori, and Lechene (1993), Phipps and Burton (1992), and Lundberg, Pollak, and Wales (1997)). These rejections have either been seen as a rejection of utility theory or have been attributed to specification problems (inadequate functional forms, inappropriate separability assumptions, misspecification of the stochastic structure, and so on). Thus it has been concluded either that utility theory is false or that it is untestable.

Our answer to these "problems" with neoclassical utility theory is completely different. We claim that the theory has not been taken seriously enough. We start from the premise that utility theory does apply, but only to individuals and not to households. In this paper we present a general characterization of an alternative model of household behavior to the unitary model, namely the "collective" model suggested in Chiappori (1988a and 1992). The two assumptions of the collective model are that each person in the household has his or her own preferences and that collective decisions are Pareto efficient. Under these assumptions, we exhibit a set of theoretical properties that have to be fulfilled by household demands, and can thus be seen as a generalization to the multi-person setting of Slutsky symmetry in the unitary framework. We then test the conditions on a sample of Canadian households.

The idea of explicitly modelling household behavior as a collective process can be traced back at least to Becker's seminal work (see Becker (1991) for a recent exposition). Also, it has been clear for some time that a multi-person approach might well (and actually should) lead to violations of the predictions from the unitary model. For instance, this point is emphasized by Bourguignon (1984) within a noncooperative setting and Pollak (1985) using a "transaction approach."

Several models have explicitly modelled intra-household decision making as a cooperative process. The Nash bargaining representation of family decisions, as initiated by Manser and Brown (1980) and McElroy and Horney (1981), is of particular interest for our present purpose. At the core of this approach are two interesting ideas. One is that, within a collective framework, household demands should be sensitive to the intra-household distribution of resources, and more generally to any environmental variable that may influence the decision process —say, through a shift in threat points ("EEP's" in McElroy (1990) terminology, or "distribution factors" in Browning et al. (1994)). This has given rise to the literature on testing for "income pooling" that was referenced above. In previous papers with other co-authors (Bourguignon et al. (1993), Browning et al. (1994), and Bourguignon, Browning, and Chiappori (1995)) we contributed to this line of research by investigating what could be learned from conventional family expenditure data about what goes on inside the household. In the third paper, in particular, we showed that the collective setting imposes testable restrictions upon the way in which distribution factors can enter demand equations; moreover, we investigate the conditions under which the observation of household demands enables us to identify individual Engel curves and the form of the decision process. The key point, however, is that this analysis requires only cross-section variation in the data; that is, we did not exploit any price variation.

More relevant for the present paper is the second intuition put forth in the Nash-bargaining literature—namely, that the repeated rejections of Slutsky symmetry in empirical work may occur because household decisions cannot be crammed into an overly restrictive unitary framework. This suggests that the case where price variations can be observed deserves careful investigation. In this framework, a very natural question arises: can one derive restrictive, testable implications of the Nash-bargaining framework upon demand functions, that could be seen as the counterpart (or, more precisely, the generalization) of Slutsky symmetry and negativeness in the unitary case? This is precisely the topic of the present paper.

Important as it is, it is fair to say that this question has not received a convincing answer so far (see Chiappori (1988b, 1991) and McElroy and Horney (1990)). One contribution of the present paper is to fill this gap. In what follows, we actually solve a more general problem—namely, what does the efficiency assumption alone imply for household demands, and specifically for the form of the Slutsky matrix?

Though we do not formally justify the efficiency assumption, we do believe that it has a good deal of intuitive appeal. For one thing, the household is one of the preeminent examples of a repeated "game" so that we feel justified in assuming that each person knows the preferences of the other people in the household. Given this symmetry of information and the fact that the game is repeated, it is plausible that agents find mechanisms to support efficient outcomes; as it is well known, cooperation often emerges as a long-term equilibrium of repeated noncooperative frameworks.[3] A second point is that efficiency is probably the most natural generalization to the multi-person setting of utility maximization in standard models. In particular, the collective model we consider includes the unitary representation as a (very) special case; hence, the conditions we derive generalize in a straightforward way Slutsky symmetry—a fact that leads directly to nested tests. Finally, axiomatic models of bargaining with symmetric information generally assume efficient outcomes. This is the case, for instance, of all models developed so far in the Nash-bargaining approach. In other words, the "collective" framework we consider in this paper encompasses all cooperative models existing in this literature. As a consequence, the condi-

[3]This is not to say, however, that we cannot envision circumstances that would lead to inefficient outcomes. Clearly, if there is asymmetric information (for example, one partner can consume some goods without the other partner knowing), then the case for efficiency is weakened. In the end this is an empirical matter: what does the collective setting imply for household behavior and are these predictions rejected by the data? This paper is directed to these issues.

tions we shall derive from the efficiency assumption alone apply, a fortiori, to all these models as well.[4]

Our main purpose is the derivation of testable implications of the collective framework. An immediate implication is that we must adopt the least restrictive set of assumptions possible. Ideally, the conditions we are seeking should result from the efficiency axiom only, with no additional ("auxiliary") assumption required. In this spirit, we do not suppose that the econometrician can determine which goods are private and which public within the household; any commodity may be either public, or private, or both. Moreover, we do not assume that the individual consumption of private goods is observable. Similarly, we do not introduce any particular assumption on individual preferences, except that they can be represented by conventional utility functions. That is, we allow for intra-household consumption externalities, altruism, etc.

Despite this explicitly minimalist set of assumptions, we show that one can make very specific predictions about household behavior. The principal theoretical result of the paper is that although Slutsky symmetry need not hold in the collective setting, it can be generalized in a straightforward way; namely, the Slutsky matrix has to be equal to the sum of a symmetric matrix and a rank one matrix. This strong theoretical property is a consequence of the efficiency hypothesis alone.

This basic result is presented in Section 2. In Section 3 we extend the analysis in three different directions. The most important of these extensions is to allow for distribution factors (as alluded to above), formally defined as variables which do not enter individual utilities directly but that do affect distribution within the household. It turns out that the collective model implies that there is a close relationship between the influence of such variables on demand and price responses.

The second part of the paper is empirical, and is aimed at testing our predictions on household data. From a general viewpoint, the case of price variations that we consider here has implications for two areas: demand analysis on time series of family expenditure surveys (for example, the U.K. FES or the U.S. CEX) and the analysis of labor supply on cross-sections (or panel data) where the prices that vary across individuals are wages. Although the latter is the more important application, we have chosen initially to concentrate on the former since the analysis of labor supply for individuals raises many problems that are less pressing in the demand case (for example, wages may be nonlinear, endogenous, and unobserved for some individuals).

In Section 4 we present a flexible parametric demand system and derive the implications of the predictions of the previous sections for the parameters of this system. This includes a novel analysis of testing for the rank of a matrix in our context. In Section 5 we present empirical results using the Canadian Family

[4]The specific concept of Nash-bargaining can actually be viewed as a way of determining the location of the final outcome in the Pareto set. Whether this particular assumption implies additional restrictions upon observed behavior is still an open question.

Expenditure Survey (FAMEX) data on single person households and households containing just a married couple. We first show that Slutsky symmetry is not rejected for singles but it is for couples. To the best of our knowledge this is the first time that anyone has shown that symmetry is not rejected for singles. We then go on to test the predictions of the collective setting derived in Sections 2 and 3 on the couples data. We do not reject any of these restrictions. This provides strong, though preliminary, support for our view that the collective model is a viable alternative to the unitary model. In the concluding section we discuss some possible areas of future research.

2. THEORY—THE GENERAL CASE

2.1. *The Collective Setting*

2.1.1. *Preferences*

We consider a two person (A and B) household. Household purchases[5] are denoted by the n-vector $\mathbf{q}$ with associated market price vector $\mathbf{p}$. Household demands are divided between three uses: private consumption by each person, $\mathbf{q}^A$ and $\mathbf{q}^B$, and public consumption $\mathbf{Q}$. Each good may serve several uses simultaneously;[6] public and private consumption vectors are only linked by

$$\mathbf{q}^A + \mathbf{q}^B + \mathbf{Q} = \mathbf{q}. \tag{2.1}$$

The household budget constraint is

$$\mathbf{p}'(\mathbf{q}^A + \mathbf{q}^B + \mathbf{Q}) = \mathbf{p}'\mathbf{q} = x \tag{2.2}$$

where x denotes total expenditure.

As said before, we adopt a Beckerian framework in which each member has her or his own preferences over the goods consumed in the household. Whether consumption of a particular good by a particular person is, by nature, private, public, or both is irrelevant for our results. Also, each member's preferences can depend on both members' private and public consumption (the "altruistic" case in Bourguignon and Chiappori (1992)); this allows for altruism, but also for externalities or any other preference interaction. Our results are consistent with all possible interactions. We only assume that preferences, defined on $(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q})$, are "well-behaved" in the usual sense:

AXIOM 1: *Member I's preferences* $(I = A, B)$ *can be represented by a utility function of the form* $u^I(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q})$ *that is strongly concave and twice differentiable in* $(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q})$, *and strictly increasing in* $(\mathbf{q}^I, \mathbf{Q})$.

[5] Formally purchases could include leisure (so that the price vector includes the wages—or virtual wages for nonparticipants—of A and B). As already indicated, we shall not be emphasizing the implications of our results for labor supply. Also, we only consider a static model, and assume that all goods are nondurables.

[6] For instance, expenditures on "telephone services" includes a public element (the rental) and a private element (the actual use of telephone).

Note that we do not impose that $u^I(\cdot)$ is increasing in $\mathbf{q}^J$ for J not equal to I; that is, we allow for selfishness or even negative consumption externalities between members.

2.1.2. *The Decision Process*

We now consider the mechanism that the household uses to decide on what to buy. Note, first, that if the functions u^A and u^B represent the same preferences, then we are back in the conventional "unitary" model; then the common utility is maximized under the budget constraint. Alternatively, we could assume that one of the partners can impose her (or his) preferences and use the corresponding utility function in the traditional way; this also yields a unitary model. But these are highly specific assumptions. In general, the "process" that takes place within the household is more complex.

As stated in the introduction, our approach at this point is axiomatic; we postulate efficiency, as expressed in the following axiom:

AXIOM 2: *The outcome of the household decision process is Pareto efficient; that is, for any price-income bundle* $(\mathbf{p}, x)$, *the consumption vector* $(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q})$ *chosen by the household is such that no other vector* $(\bar{\mathbf{q}}^A, \bar{\mathbf{q}}^B, \overline{\mathbf{Q}})$ *in the budget set could make both members better off.*

Following Chiappori (1992), we refer to models that allow for different preferences with efficiency as the "collective" setting. Finally, we add some structure by assuming the following:

AXIOM 3: *There exists a differentiable, zero-homogeneous function* $\mu(\mathbf{p}, x)$ *such that, for any* $(\mathbf{p}, x)$, *the vectors* $(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q})$ *are solutions to the program:*

$$\max_{\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}} \mu(\mathbf{p}, x) \cdot u^A(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}) + [1 - \mu(\mathbf{p}, x)] \cdot u^B(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}) \tag{2.3}$$
$$\textit{subject to} \quad \mathbf{p} \cdot (\mathbf{q}^A + \mathbf{q}^B + \mathbf{Q}) = x.$$

As it is well-known, any point on the Pareto frontier can be obtained as a solution to a program of this type (for some well-chosen μ). Axiom 3 essentially postulates that the decision process always has a *unique*, *well-defined outcome*, or, in other terms, that there exists a *demand function* (and that, in addition, the latter is continuous and zero-homogeneous). Homogeneity is uncontroversial; it essentially means that expressing prices and incomes in cents instead of dollars does not change actual behavior. The smoothness assumption is standard, and made for analytical convenience.[7] Uniqueness, on the other hand, is a real

[7]The key point that drives the results is that the set of efficient outcomes is one-dimensional—a property that could be derived without a smoothness (or even uniqueness) assumption. However, its more natural (and more tractable) development is in terms of $(n-1)$ dimensional manifolds, which requires smoothness.

assumption, albeit not an extremely restrictive one. Two points should in particular be emphasized:

(i) The assumption is consistent with our general framework, which postulates efficiency. Indeed, a natural (although not exclusive) justification is that the members play some *cooperative* game under symmetric information. In most cases, this should lead to a unique outcome.[8] Note, in particular, that all bargaining models developed in the literature exhibit the same property, since they are based upon a specific bargaining equilibrium concept (Nash, Kalai-Smorodinsky,...).

(ii) From an applied viewpoint, assuming the existence of a demand function does not seem unduly restrictive. To the best of our knowledge, most (if not all) existing empirical work on demand relies upon a similar assumption.

The "distribution" function μ summarizes the decision process. Take some given utility functions u^A and u^B. Then the budget constraint defines, for any price-income bundle, a Pareto frontier. From Axiom 2, the final outcome will be located on this frontier. Then μ determines the final location of the demand vector on this frontier.

The parameter μ has an obvious interpretation as a "distribution of power" function. If $\mu = 1$ then the household behaves as though A always get their way, whereas if $\mu = 0$ it is as though B is the effective dictator. For intermediate values, the household behaves as though each person has some decision power. Note that μ will generally depend on prices and total expenditures, since these environmental variables influence the distribution of "power" within the household.

Two additional points may be noted at this stage. One is that, in general, μ may also depend on other factors, such as the individual incomes of the two partners, or any factor of the household environment that may affect the decision process ("distribution factors" in Browning et al. (1994)). This idea is explored in the next section; for the moment, let us first investigate the properties of the basic model. Also, assume preferences are identical. Then we are back in the unitary setting and μ is not defined. However, we can then use the convention that $\mu = 0$ (or, as a matter of fact, any other convention).

Any given (demand) function $\mathbf{q}(\mathbf{p}, x)$ is said to be *compatible with collective rationality* if and only if there exist functions $\mathbf{q}^A(\mathbf{p}, x), \mathbf{q}^B(\mathbf{p}, x), \mathbf{Q}(\mathbf{p}, x)$, solution of a program of the type (2.3), such that $\mathbf{q}(\mathbf{p}, x) = \mathbf{q}^A(\mathbf{p}, x) + \mathbf{q}^B(\mathbf{p}, x) + \mathbf{Q}(\mathbf{p}, x)$. A first property of such functions is given by the following result:

PROPOSITION 1: *Assume that* $\mathbf{q}(\mathbf{p}, x)$ *is compatible with collective rationality. Then it is zero-homogeneous, continuously differentiable, and satisfies* $\mathbf{p}'\mathbf{q}(\mathbf{p}, x) = x$.

[8]This is in sharp contrast with noncooperative games, or with models of bargaining under asymmetric information—where multiplicity of equilibria is more difficult to rule out. Of course, such models are in general incompatible not only with the uniqueness assumption, but with Axiom 2 as well, since the outcome will typically violate efficiency.

In the following, our goal is to derive additional properties of these functions.

2.1.3. *Household Utility*

The next step is to define what we shall call the household utility function. The latter will be reminiscent of the unitary setting, but with the difference that it will depend on μ. Formally, we have the following definition.

DEFINITION 1: In the collective setting, the *household utility function* is defined as

$$u^H(\mathbf{q}, \mu) = \max_{\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}} \mu \cdot u^A(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}) + (1-\mu) \cdot u^B(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}) \tag{2.4}$$

subject to

$$\mathbf{q}^A + \mathbf{q}^B + \mathbf{Q} = \mathbf{q}.$$

Clearly, the maximization of the household utility under the budget constraint will lead to the same demand function as program (2.3) above. Two points must be stressed here:

(i) The household utility function u^H will depend on prices and income as soon as μ is a function of these variables. So we are in a case of price-dependent preferences, which explains why the usual results of consumer theory (Slutsky symmetry, etc.) will no longer hold true in the collective context.

(ii) However, *prices and income enter only through the scalar function* μ. The same will also be true of any other variable that affects the decision process but not preferences. This remark will be crucial in the derivation of the results below.

2.2. *Dual Representations of the Collective Program*

Given utility functions for the two people we can define a dual representation of "household" preferences. This can be done in two equivalent ways. First, for any μ, define the household indirect utility function $V(\mathbf{p}, x, \mu)$ as the maximand of the initial optimization problem above:

$$V(\mathbf{p}, x, \mu) = \max_{\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}} \mu u^A(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}) + (1-\mu) u^B(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}) \tag{2.5}$$
$$\text{subject to} \quad \mathbf{p} \cdot (\mathbf{q}^A + \mathbf{q}^B + \mathbf{Q}) = x,$$

which can also be written as

$$V(\mathbf{p}, x, \mu) = \max_{\mathbf{q}} u^H(\mathbf{q}, \mu) \qquad \text{subject to} \tag{2.6}$$
$$\mathbf{p}'\mathbf{q} = x.$$

In what follows, let $\mathbf{q} = \mathbf{f}(\mathbf{p}, x, \mu)$ denote the solution of this program—that is, the collective counterpart of Marshallian demands; note that $\mathbf{f}(\cdot)$ is a function of μ as well.

Now, we know, from the envelope theorem, that

$$\frac{\partial V(\mathbf{p}, x, \mu)/\partial p_i}{\partial V(\mathbf{p}, x, \mu)/\partial x} = -f_i,$$

which is the equivalent, in the collective setting, of Roy's identity in the unitary case. This means that, *for any constant* μ, an infinitesimal change in one price, say dp_i, can be "compensated" (in the sense that the household utility will not change) by a change in income exactly equal to $dx = q_i \cdot dp_i$. Of course, each member's utility will, in general, change.

The corresponding expenditure function will be defined as

$$E(\mathbf{p}, u, \mu) = \min_{\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}} \mathbf{p}'(\mathbf{q}^A + \mathbf{q}^B + \mathbf{Q}) \qquad \text{subject to} \tag{2.7}$$

$$\mu \cdot u^A(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}) + (1-\mu) \cdot u^B(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}) \geq u.$$

The analogy with traditional duality theory can in fact be pushed somewhat further. First, the expenditure function $E(\cdot)$ is linear homogeneous and concave in $\mathbf{p}$. Also, let $\mathbf{h}(\mathbf{p}, u, \mu)$ denote the solution of program (2.7). Note that $\mathbf{h}(\mathbf{p}, u, \mu)$ can be interpreted as a compensated demand function (since it is the demand that obtains holding household utility constant). It is important to stress, however, that $\mathbf{h}(\cdot)$ is defined as a function of the "distribution of power" index $\mu(\cdot)$—that is, μ must also be kept constant.

Again from the envelope theorem, we have

$$\frac{\partial E(\mathbf{p}, u, \mu)}{\partial p_i} = h_i.$$

Duality between programs implies that

$$\mathbf{f}(\mathbf{p}, E(\mathbf{p}, u, \mu), \mu) = \mathbf{h}(\mathbf{p}, u, \mu).$$

It follows that

$$\frac{\partial f_i}{\partial p_j} + \frac{\partial f_i}{\partial x} \cdot f_j = \frac{\partial h_i}{\partial p_j}.$$

This is equivalent to Slutsky conditions in the unitary case. In particular, the matrix Σ with general term

$$\sigma_{ij} = \left(\frac{\partial f_i}{\partial p_j} + \frac{\partial f_i}{\partial x} \cdot q_j \right)$$

can be interpreted as the partial derivatives of demands with respect to prices, *holding both household utility and the "distribution of power" index* μ *constant.*

2.3. *Restrictions on Demands*

We now derive our main result, which characterizes the properties of observed demand functions. What has to be emphasized here is that *we never observe the function* $\mathbf{f}(\mathbf{p}, x, \mu)$. Indeed, by definition, $\mathbf{f}(\mathbf{p}, x, \mu)$ describes how demands respond to independent variations of $\mathbf{p}$, x, and μ. But we do not observe such independent variation. For any given price-income bundle $(\mathbf{p}, x)$, the behavior we observe corresponds to *one* specific value of μ—namely, the value $\mu(\mathbf{p}, x)$ taken at this point by the specific distribution function that characterizes the household at stake. In other words, what we actually observe is the demand function $\boldsymbol{\xi}$ defined by

$$\boldsymbol{\xi}(\mathbf{p}, x) = \mathbf{f}(\mathbf{p}, x, \mu(\mathbf{p}, x)).$$

The question, now, is which predictions does the collective setting imply for observed demand functions $\boldsymbol{\xi}(\mathbf{p}, x)$? A first, elementary property was given in Proposition 1 above: demands $\boldsymbol{\xi}(\mathbf{p}, x)$ are zero-homogeneous and continuously differentiable in $(\mathbf{p}, x)$ and satisfy adding-up:

$$\mathbf{p}'\boldsymbol{\xi}(\mathbf{p}, x) = x.$$

Of course, we are interested in deeper and more structural properties. To derive these, we first define the pseudo-Slutsky matrix associated with $\boldsymbol{\xi}(\mathbf{p}, x)$ as

$$S = \boldsymbol{\xi}_{\mathbf{p}} + \boldsymbol{\xi}_x \boldsymbol{\xi}'$$

where $\boldsymbol{\xi}_{\mathbf{p}}$ is the $(n \times n)$ Jacobian matrix of partials of $\boldsymbol{\xi}$ with respect to $\mathbf{p}$, and $\boldsymbol{\xi}_x$ the vector of partials of $\boldsymbol{\xi}$ with respect to x. In the unitary setting, S would be symmetric and negative semi-definite. In the collective model, this property generalizes as follows:

PROPOSITION 2: *In the collective setting, the Pseudo-Slutsky matrix S is the sum of a symmetric and negative semi-definite matrix Σ and an outer product*:

$$S = \Sigma + \mathbf{u}\mathbf{v}'$$

where $\mathbf{u}$ *and* $\mathbf{v}$ *are n-vectors with*

$$u_i = \frac{\partial f_i}{\partial \mu} \quad \text{and} \quad v_j = \frac{\partial \mu}{\partial p_j} + \frac{\partial \mu}{\partial x}\xi_j.$$

The interpretation of this formula goes as follows. Assume that the price of good j is changed by an infinitesimal amount dp_j, the change being compensated by an increase in income $dx = q_j \cdot dp_j$. What will be the effect of this on the demand for good i? The formula says that this effect can be decomposed into two components. One corresponds to a substitution effect: holding both household utility V and power index μ constant, the change in price will induce a reallocation of consumption, as defined by the corresponding term in matrix Σ. But, on the top of this, such a change will also modify μ; precisely,

$$d\mu = \frac{\partial \mu}{\partial p_j} \cdot dp_j + \frac{\partial \mu}{\partial x} \cdot dx = \left(\frac{\partial \mu}{\partial p_j} + q_j \frac{\partial \mu}{\partial x} \right) \cdot dp_j,$$

and hence the $\mathbf{v}$ vector. This, in turn, will change consumption of good i by an amount

$$dq_i = \frac{\partial f_i}{\partial \mu} \cdot d\mu,$$

as indicated by the $\mathbf{u}$ vector.

The following corollary states a consequence that will be useful in the following.

COROLLARY 1 (SR1 Property): *In the collective setting, the pseudo-Slutsky matrix S is the sum of a symmetric, negative semi-definite matrix Σ and a matrix R that has at most rank one.*

This SR1 ("symmetric plus rank one") condition obviously generalizes the unitary model (since $R = 0$ in the latter). This property is somewhat reminiscent of the Diewert-Mantel aggregation restrictions for economies with more goods than agents; see Shafer and Sonnenschein (1982) for an overview.

A geometric interpretation of SR1 is the following. Remember, first, that for any given pair of utilities, the budget constraint defines the Pareto frontier as a function of the price-income bundle; then μ determines the location of the final outcome on the frontier. Assume, now, that prices and income are changed. This has two consequences. For one thing, the Pareto frontier will move. Keeping μ constant, this would change demand in a way described by the Σ matrix. Note, however, that this change will *not* violate Slutsky symmetry; that is, its nature is not different from the traditional, unitary effect. The second effect is that μ will also change; this will introduce an additional move of demand *along* the (new) frontier. This change (as summarized by the R matrix) *does* violate Slutsky symmetry (in general). But moves along a one-dimensional manifold are quite restricted. For instance, the set of price-income bundles that lead to the *same* μ is likely to be quite large in general; indeed, under our smoothness assumption, it is an $(n-1)$-dimensional manifold. Considering the linear tangent spaces, this means that there is a whole hyperplane such that, if the (infinitesimal) change in prices and income belongs to that hyperplane, then no deviation from Slutsky symmetry can be observed. In other words, *the SR1 condition is a direct consequence of the fact that, in a 2-person household, the Pareto frontier is of dimension 1, whatever the number of commodities*.

2.4. *Testing for SR1*

How can a property like SR1 be tested? The result we exploit is that a matrix S is SR1 if and only if the antisymmetric matrix $M = S - S'$ is of rank at most 2 (remember that a matrix M is antisymmetric if $M' = -M$). A more precise statement is the following:

LEMMA 1: (i) *Let S be some SR1 matrix*:

$$S = \Sigma + \mathbf{u}\mathbf{v}'$$

and assume that S is not symmetric. Then vectors $\mathbf{u}$ *and* $\mathbf{v}$ *are linearly independent; the matrix $M = S - S'$ is of rank 2, and* $\mathrm{Im}(M)$ *(the subspace spanned by the columns of M) is spanned by* $\mathbf{u}$ *and* $\mathbf{v}$.

(ii) *Conversely, let M be an antisymmetric matrix of rank 2, and let* $\bar{\mathbf{u}}$ *and* $\bar{\mathbf{v}}$ *be arbitrary independent vectors of* $\mathrm{Im}(M)$. *There exists a scalar $\lambda \neq 0$ that* $M = \lambda(\bar{\mathbf{u}}\bar{\mathbf{v}}' - \bar{\mathbf{v}}\bar{\mathbf{u}}') = \mathbf{u}\mathbf{v}' - \mathbf{v}\mathbf{u}'$ *where* $\mathbf{u} = \lambda\bar{\mathbf{u}}$, $\mathbf{v} = \bar{\mathbf{v}}$. *In particular, for any symmetric matrix Σ, the matrix $S = \Sigma + \mathbf{u}\mathbf{v}'$ is such that $M = S - S'$.*

What is important for our purpose is that, according to this result, testing for the collective model amounts to testing for the rank of matrix $M = (S - S')$. The collective model (with two decision makers) predicts this rank should be at most two, while it would be zero in the unitary case. This will be crucial in the empirical sections below.

A final remark is that antisymmetry has specific implications for the rank of M. These are given by the following Lemmas:

LEMMA 2: *All the nonzero eigenvalues of a real antisymmetric matrix are imaginary. In particular, a real antisymmetric matrix has even rank.*

LEMMA 3: *Let $M = (m_{ik})$ be any nonzero, real antisymmetric matrix, and assume, without loss of generality, that m_{12} is not equal to 0. Then M has rank 2 if and only if, for all (i, k) such that $k > i > 2$,*

$$m_{ik} = \frac{m_{1i}m_{2k} - m_{1k}m_{2i}}{m_{12}}.$$

Thus the elements of rows 3 to n in M are functions of the elements of the first two rows (the same is true for columns). Since this characterization only involves parametric restrictions of the familiar sort it is easy to test. Note that for an $(n \times n)$ matrix this involves $(n-2)(n-3)/2$ restrictions. As a benchmark, testing for Slutsky symmetry involves $n(n-1)/2$ restrictions. So, though Slutsky symmetry is of course more restrictive, the number of restrictions is of the same order when n is large.

Our findings can be summarized in the following proposition, that underlies the empirical analysis of the next sections:

PROPOSITION 3: *Let S denote the pseudo-Slutsky matrix, and let $M = S - S'$. Then, in the collective setting:*

(i) *M has rank zero or two.*

(ii) *If M has rank zero, the unitary case cannot be ruled out.*

(iii) *If M has rank 2, then $M = \mathbf{u}\mathbf{v}' - \mathbf{v}\mathbf{u}'$ for two vectors* $\mathbf{u}$ *and* $\mathbf{v}$ *that span* $\mathrm{Im}(M)$. *Moreover, for any vector* $\mathbf{w}$ *orthogonal to* $\mathrm{Im}(M)$ *(that is, such that* $\mathbf{w}'\mathbf{v} = \mathbf{w}'\mathbf{u} = 0$), *then* $\mathbf{w}'S\mathbf{w} \leq 0$.

Note that these tests have a nested structure. Namely, one can first test whether the rank of M is more than two, which would reject the collective model altogether. If it is not rejected, then one can test whether the rank is zero, which would correspond to the unitary model. The collective model predicts that the rank should be zero for singles, but may be two for couples.

2.5. *How Many Goods Are Needed?*

We have just proved that a given household demand function cannot be compatible with the collective model unless it satisfies the SR1 condition—that is, unless its Slutsky matrix S is such that $M = S - S'$ is of rank at most two. Suppose we observe the household demand for n commodities; what is the minimum value of n for which this property does in fact imply testable restrictions upon demand functions? In other words, how many commodities do we need to test the SR1 property?

The answer is given by the following Proposition:

PROPOSITION 4: *Take any n functions $f^i(\mathbf{p}, x)$, $i = 1, \ldots, n$.*

(i) *If $n \leq 3$, then the corresponding Slutsky matrix S always satisfies $SR1$.*

(ii) *If $n \leq 4$ and if the f^i's are zero homogeneous in $(\mathbf{p}, x)$ and satisfy adding-up, then the corresponding Slutsky matrix S always satisfies $SR1$.*

The conclusion is that, given the homogeneity assumption above, *one needs at least 5 commodities to test the SR1 property*. This has important implications for modelling labor supply; we discuss this further in the conclusion.

3. THEORY—EXTENSIONS

In this section we present three extensions to the basic theory of the last section. The first of these extends the theory to households with more than two members. The second extension allows for distribution factors; that is, variables that affect the distribution function μ but not preferences directly. The final extension puts some restrictions on the way prices enter μ.

3.1. *Many-Person Households*

If there are more than two people in the household, then the class of demands admitted in the collective setting will generally be wider. The exact conditions are given in the next Proposition (the proof follows that of Proposition 2):

PROPOSITION 5: *Assume that the household has $k+1$ members where $k < (n-1)$. In the collective setting the Pseudo-Slutsky matrix S is the sum of a symmetric matrix and a matrix of rank no greater than k (SRk).*

Fairly obviously all of the previous analysis goes through with $(\mu_1 \ldots \mu_k)$ replacing μ everywhere. This rank condition includes the unitary case and also the two-person collective setting.

One possible field of application is to households with children present. To illustrate, suppose the child is named C and let $u^C(\cdot)$ be her utility function. Formally, we can test whether the household behaves as a one-, two-, or three-person decision unit by testing for symmetry, SR1 and SR2 respectively. If we reject symmetry but not SR1, then it is as though the household is composed of two decision makers. One obvious choice would be mother and father; this is not to say, of course, that neither parent cares about the child but simply that the child does not have a direct influence on the decision making process. They may, however, have an indirect effect since each parents' preferences over $(\mathbf{q}^A, \mathbf{q}^B, \mathbf{q}^C, \mathbf{Q})$ may take into account the child's preferences. Other interpretations are also possible: for example, mother and daughter have the same preferences and father differs.

Identifying intra-household interactions requires more structure than we have so far imposed (see Bourguignon, Browning, and Chiappori (1995) for a discussion in the cross-section case) but even the possibility of determining the effective number of decision makers in a household leads to interesting issues. For example, in the adult equivalence scale literature, statements are often made about the amount of income needed to make one household as well off as another. Since it is people and not households that have welfare this equating of household welfare is sometimes somewhat murky (but not in all formulations; see, as an exemplary counterexample, Blackorby and Donaldson (1993)). Within the collective framework we can, of course, define household welfare as being the weighted sums of particular utilities. Whether or not we actually want to make this identification between weights that rationalize demands and weights in a social (family) welfare index is another matter. Knowing that father acts as a dictator and discounts the welfare of mother and daughter may not lead us to do the same.

In the multi-person household above we restricted the number of members to be at least two less than the number of goods. The necessary condition in Proposition 5 is no longer restrictive for $k \geq n-1$, since any $n \times n$ matrix can be written as the sum of a symmetric matrix and a matrix of rank $(n-1)$. Though the condition in Proposition 5 is only necessary, it is indeed the case that if we have as many people as goods minus one, then the collective setting does not impose any restrictions on demand, as stated in the following result.

PROPOSITION 6 (Chiappori (1990)): *Assume that the household has at least $(n-1)$ members. For any finite set of prices and demands, one can find preferences for which observed behavior is compatible with the collective setting.*

The proof relies on known results on aggregate demands for private goods.

3.2. *Including Distribution Factors*

The next extension to the basic model that we discuss in this section is the inclusion of variables that affect the distribution function $\mu(\mathbf{p}, x)$. The obvious examples here are the incomes of the two partners but these variables could also include a host of Extra-Environmental Parameters (EEP's) to use the terminology of McElroy (1990). For example, it might be that changes in divorce law or discrimination against women in the work place have an impact on intra-household decision making (as they shift power within the household). In defining such variables it is most important to identify variables that may affect the μ function but that do not affect preferences directly (that is, that do not enter each person's utility function). We term such variables *distribution factors*. We distinguish such variables from *preference factors* which are variables that affect preferences directly.[9]

To take an example, suppose that it is the case that there are fixed costs of going to work that are independent of the wage. Then participation in the labor force could be considered a preference factor and earnings would be a candidate for a distribution factor since demand should not depend on earnings, once we condition on total expenditure and labor force participation. Of course, if the costs of going to work do depend on the wage (for example, high wage jobs require more expensive clothing or higher travel costs), then we cannot take earnings as a distribution factor.[10]

We begin with the case of a single distribution factor y, so that $\mu = \mu(\mathbf{p}, x, y)$. As already discussed this means that y only enters the household utility function through the same index as prices and total expenditure: $u = u(\mathbf{q}, \mu(\mathbf{p}, x, y))$. Household demands take the form $\xi(\mathbf{p}, x, y) = f(\mathbf{p}, x, \mu(\mathbf{p}, x, y))$. Denoting the gradient of demands to changes in y by ξ_y, we have the following conditions on the way this factor can affect demands:

PROPOSITION 7 (Distribution Factor Linearity): *In the collective setting, we have the following equivalent conditions*:

(i) *The Pseudo-Slutsky matrix takes the form* $S = \Gamma + \xi_y \mathbf{v}'$ *where* Γ *is symmetric.*

(ii) ξ_y *can be written as a linear combination of the columns of* $(S - S')$.

Since S and the vector $\boldsymbol{\xi}_y$ are observable we can use condition (ii) to test for this restriction. Of course, we can only test for condition (ii) conditional on imposing SR1 on S; without this $(S - S')$ can have full rank and condition (ii) would be satisfied trivially.

Proposition 7 is an unusual result since it relates the response to a change in the distribution factor to price effects "purged" of the usual Slutsky symmetry. Outside the collective setting there is no particular reason why responses to, say,

[9] For convenience we assume that there is no overlap between preference and distribution factors. Thus all variables that affect demands (other than prices and total expenditure) are partitioned between these two groups.

[10] Another example of a distribution factor is the sex ratio, taken as an indicator of the situation on the market for marriage. See Chiappori, Fortin, and Lacroix (1998).

changes in the relative earnings of the two partners should be related to price responses. Thus this proposition offers a potentially powerful test of the collective setting.

Proposition 7 also has an interesting converse. Suppose that we have some variable y that we are sure would affect demands if the collective model holds but the unitary model does not hold. If we find that this variable does not affect demands (that is, $\boldsymbol{\xi}_y = \mathbf{0}$) then we cannot reject the unitary model. To illustrate, if there is no effect of relative incomes on demand, then it must be that households behave as though they are maximizing a single utility function (since Γ is symmetric). Of course, this test relies on our maintaining that if anything is going to affect intra-household allocation but not preferences, then it is relative incomes; if we do not maintain this, then this is not a test of the unitary model (that is, $\boldsymbol{\xi}_y$ being zero is only necessary for the unitary model, it is not sufficient). This parallels the tests of the unitary model which test for "income pooling" (that is, the absence of any effect of incomes on allocation) that have now been performed by many people (see, for example, Thomas (1990), Bourguignon et al. (1993), Phipps and Burton (1992), and Lundberg et al. (1997)).

If we do not observe price variation, then the presence of a single distribution factor does not impose any restrictions on demands (strictly, Engel curves). Intuitively, this can be seen by noting that the condition in Proposition 7 (ii) requires an estimate of S that is only identified if we have price variation. Thus Proposition 7 adds to the conditions that are present if we observe price variation. If we add more distribution factors so that $\mathbf{y}$ is now a vector, then the collective setting imposes further restrictions. In Bourguignon et al. (1993) the following is proved:

PROPOSITION 8 (Distribution Factor Proportionality): *In the collective setting we have*: $\boldsymbol{\xi}_{y_i} = \theta_i \boldsymbol{\xi}_{y_1}$ *for all* $i \geq 2$, *where* $\theta_i \in \mathbb{R}$.

Thus the responses to different distribution factors are co-linear; this is very simple to test (see Bourguignon et al. (1993)). The extra distribution factors do not, however, impose any more restrictions on the Pseudo-Slutsky matrix S. The testing of restrictions in Proposition 8 constitute an independent series of tests of the collective model (which can be applied in the nonprice context) to those developed in the previous section. Thus we can test for distribution factor proportionality (Proposition 8) and for SR1 (Proposition 3) independently. If neither is rejected, then we can test for distribution factor linearity (Proposition 7) with both SR1 and distribution factor proportionality imposed. This is the route we shall follow in our empirical work below.

3.3. *Restricting the Dependence of Distribution on Prices*

We can also impose alternative structure on the distribution function μ. For example, suppose that we restrict prices to enter μ only through a known linear homogeneous price index $\pi(\mathbf{p})$. This assumption smacks of ad hocery but it does cut down on the way price variation can affect demands a great deal. This case is particularly interesting if all of the distribution factors are money variables, since in this case we can normalize and make all monetary values real. In addition, we can normalize prices and income in the same way. Formally, let P_i, X, Y denote real variables; i.e.,

$$P_i = \frac{p_i}{\pi(\mathbf{p})}, \qquad X = \frac{x}{\pi(\mathbf{p})}, \qquad Y = \frac{y}{\pi(\mathbf{p})}.$$

We then have $\mu = \mu(X,Y)$; moreover, demands can be expressed as functions of real variables:

$$\xi_i(\mathbf{p}, x, y) = \xi_i\left(\frac{\mathbf{p}}{\pi(\mathbf{p})}, \frac{x}{\pi(\mathbf{p})}, \frac{y}{\pi(\mathbf{p})}\right) = \xi_i(\mathbf{P}, X, Y).$$

Then we have the following proposition.

PROPOSITION 9: *If there is only a single distribution factor and* $\mu = \mu(X,Y)$ (*with the above notations*), *then the Pseudo-Slutsky matrix takes the form*: $S = \Gamma + k\xi_y \boldsymbol{\xi}'$ *where k is a constant.*

Since the two components of the outer product on the right-hand side are observable, this gives an immediate test of the collective model with a known linear homogeneous price index and a single distribution factor. Note that we need to know the price index a priori to deflate x and y. The condition given in Proposition 9 is a special case of the condition given in Proposition 8 above (the vector $\mathbf{v}$ is replaced by $k\xi$).

4. A PARAMETRIC DEMAND SYSTEM

4.1. *A Quadratic Log Demand System*

In this section we take a parameterization for the demand system and derive the implications of the restrictions implied by the collective setting. Our attention will focus on tests of symmetry and "symmetry plus rank one" (SR1) and the restrictions imposed for distribution factors (Propositions 7 and 8). 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 parameterization is too restrictive a priori. Thus we start with the Quadratic Almost Ideal Demand System (QUAIDS) of Banks, Blundell, and Lewbel (1992).[11] This system takes the AI demand system, which includes a term in log deflated total expenditure, and adds a quadratic term in log deflated total expenditure to it. Although it might be preferable to use nonparametric methods, these are not yet sufficiently developed to allow us to estimate multi-equation systems with endogenous

[11] The QUAIDS of Banks et al. is not the only generalization of the AI model that has this property (see, for example, the quadratic AI model of Fry and Pashardes (1992)) but in the absence of any evidence that any one of these is better than any other we choose to work with it.

right-hand side variables and cross-equation restrictions.[12] The parameterization chosen is, however, very flexible and admits of different shaped Engel curves even when the integrability conditions are imposed (formally, it is rank three in the sense of Lewbel (1991)). The nonparametric analysis presented in Banks et al. (1992) suggests that this quadratic log system captures all of the significant curvature in Engel curves.

We model the budget share n-vector $\boldsymbol{\omega}$ as a function of log prices and log total expenditure. To save on notation we now take $\mathbf{p}$ to be the n-vector of log prices (rather than the vector of levels of prices); as before, we denote total expenditure as x. The QUAIDS demand system takes the vector form

$$(4.1) \qquad \boldsymbol{\omega} = \boldsymbol{\alpha} + \boldsymbol{\Gamma}\mathbf{p} + \boldsymbol{\beta}(\ln(x) - a(\mathbf{p})) + \boldsymbol{\lambda}\frac{(\ln(x) - a(\mathbf{p}))^2}{b(\mathbf{p})}$$

where $\boldsymbol{\alpha}$, $\boldsymbol{\beta}$, and $\boldsymbol{\lambda}$ are n-vectors of parameters and Γ is an $n \times n$ matrix of parameters. In our empirical work below we shall allow these parameters to depend on demographics but for now we work with just prices and total expenditure. The price indices $a(\mathbf{p})$ and $b(\mathbf{p})$ are defined as

$$(4.2) \qquad a(\mathbf{p}) = \alpha_0 + \boldsymbol{\alpha}'\mathbf{p} + \frac{1}{2}\mathbf{p}'\Gamma\mathbf{p}$$

and

$$(4.3) \qquad b(\mathbf{p}) = \exp(\boldsymbol{\beta}'\mathbf{p}).$$

Note that (4.1) reduces to the AI model if the $\boldsymbol{\lambda}$ vector is zero. Adding up implies that $\boldsymbol{\alpha}'\mathbf{e} = \mathbf{1}$ and $\boldsymbol{\beta}'\mathbf{e} = \boldsymbol{\lambda}'\mathbf{e} = \boldsymbol{\Gamma}\mathbf{e} = 0$ where $\mathbf{e}$ is an n-vector of ones. Homogeneity implies that $\boldsymbol{\Gamma}'\mathbf{e} = 0$. We shall derive the symmetry restrictions in the next subsection.

In all that follows we shall always impose homogeneity.[13] Adding up is automatically implied by the data construction. Thus we drop the last equation to accommodate adding up and work with homogeneous prices (that is, prices divided by the price of the good that is dropped from the system). Then we estimate the parameters of the $(n-1)$-vectors $(\boldsymbol{\alpha}, \boldsymbol{\beta}, \boldsymbol{\lambda})$ without their last elements and the parameters of the $(n-1) \times (n-1)$ Γ matrix without its last row and column. To cut down on notation, we now take n to be the number of goods minus one and $(\boldsymbol{\alpha}, \boldsymbol{\beta}, \boldsymbol{\lambda})$ and Γ to be these reduced vectors and matrices.

We derive the Pseudo-Slutsky matrix for the parameterization in equation (4.1) using the budget share form

$$S = \boldsymbol{\omega}_{\mathbf{p}} + \boldsymbol{\omega}_{\mathbf{x}}\boldsymbol{\omega}'$$

[12] See Brown and Matzkin (1995) for a recent contribution along these lines.

[13] One of the more encouraging results of moving from testing on aggregate data to micro data is that homogeneity is not usually rejected. Tests for homogeneity on the data used below (not reported) also fail to reject.

where $\boldsymbol{\omega}_{\mathbf{p}}$ is the $n \times n$ Jacobian matrix of partial derivatives of the budget shares with respect to log prices and $\boldsymbol{\omega}_{\mathbf{x}}$ is the gradient of $\boldsymbol{\omega}$ with respect to $\ln x$. Applying this to (4.1)–(4.3) we have

$$(4.4) \qquad S = \Gamma - \frac{1}{2}\left(\boldsymbol{\beta} + 2\boldsymbol{\lambda}\frac{\tilde{x}}{b(\mathbf{p})}\right)\mathbf{p}'(\Gamma - \Gamma') + \tilde{x}\left(\boldsymbol{\beta}\boldsymbol{\beta}' + \frac{\tilde{x}}{b(\mathbf{p})}(\boldsymbol{\lambda}\boldsymbol{\beta}' + \boldsymbol{\beta}\boldsymbol{\lambda}') + \left(\frac{\tilde{x}}{b(\mathbf{p})}\right)^2 \boldsymbol{\lambda}\boldsymbol{\lambda}'\right)$$

where $\tilde{x} = \ln(x) - a(\mathbf{p})$. Since all of the parameters in (4.4) are identified from the system (4.1), we can use this for testing.

4.2. *Testing for Symmetry and SR1*

We are now in a position to give the necessary and sufficient conditions for symmetry and "symmetry plus rank one" (SR1) for our parameterization.

PROPOSITION 10: *S is SR1 for all $(\mathbf{p}, x)$ if and only if Γ is SR1.*

Thus the matrix of parameters inherits the symmetry and SR1 properties of S. This makes testing relatively easy; all we need to do is test for parametric restrictions on the estimated Γ, using the conditions in Lemma 3.

4.3. *Testing for Other Implications of the Collective Model*

In the demand system given in (4.1) we conditioned only on prices and total expenditure but other observable factors also have an important influence on demand patterns. Following the distinction made in Section 3 we designate these other variables as either "preference factors," **z**, or "distribution factors" **y**. We include the preference factors in the conventional way by allowing them to modify the parameters of the indices $a(\mathbf{p})$ and $b(\mathbf{p})$:

$$(4.5) \qquad a(\mathbf{p}, \mathbf{z}) = \alpha_0 + \boldsymbol{\alpha}(\mathbf{z})'\mathbf{p} + \frac{1}{2}\mathbf{p}'\Gamma\mathbf{p}$$

and

$$(4.6) \qquad b(\mathbf{p}, \mathbf{z}) = \exp(\boldsymbol{\beta}(\mathbf{z})'\mathbf{p}).$$

In our parameterization we take $\boldsymbol{\alpha}(\mathbf{z})$ and $\boldsymbol{\beta}(\mathbf{z})$ to be linear; that is

$$(4.7) \qquad \boldsymbol{\alpha}(\mathbf{z}) = \boldsymbol{\alpha}^0 + \boldsymbol{\alpha}^1 z_1 + \cdots \boldsymbol{\alpha}^{l_\alpha} z_{l_\alpha}$$

where l_α is the number of preference factors included in the $\alpha(\cdot)$ term and the α^k's are n-vectors. Similarly we have

$$(4.8) \qquad \boldsymbol{\beta}(\mathbf{z}) = \boldsymbol{\beta}^0 + \boldsymbol{\beta}^1 z_1 + \cdots \boldsymbol{\beta}^{l_\beta} z_{l_\beta}$$

where l_β is not necessarily equal to l_α.

Note that in (4.5) we follow most other investigators and assume that the price response terms are the same for all households within any given strata. It is important to emphasize, however, that in our empirical work below we stratify fairly finely and estimate separate demand systems for different strata. Thus we only impose that price responses are the same within strata and not across the whole population. In particular, we shall allow the matrix Γ to vary across households of different sizes. In the present context, imposing that Γ is the same across single people and couples would be particularly inappropriate since the former should have a symmetric Γ, whereas the latter may not (unless the unitary model holds for couples).

To incorporate the distribution factors, we note that Propositions 7 and 8 refer to the derivatives of demand with respect to such factors. Thus it is convenient to include these in the constant term in (4.1):

$$\boldsymbol{\omega} = \boldsymbol{\alpha}(\mathbf{z}) + \boldsymbol{\Theta}\mathbf{y} + \Gamma\mathbf{p} + \boldsymbol{\beta}(\mathbf{z})(\ln(x) - a(\mathbf{p},\mathbf{z})) + \boldsymbol{\lambda}\frac{(\ln(x) - a(\mathbf{p},\mathbf{z}))^2}{b(\mathbf{p},\mathbf{z})} \tag{4.9}$$

where $\mathbf{y}$ is an m-vector of distribution factors and Θ is an $n \times m$ matrix of parameters. We denote the kth column of Θ by Θ^k.

The next condition we are interested in testing is the distribution factor proportionality condition given in Proposition 8. For our parameterization this is equivalent to Θ having rank 1. This is most easily tested by testing for the following condition on the columns of Θ:

$$\Theta^k = \tau_k \Theta^1 \quad \text{for} \quad k \geq 2. \tag{4.10}$$

If this condition and SR1 are not rejected, then we can go on to test distribution factor linearity (see Proposition 7). This states that the (observable) vector of the derivatives of demand with respect to the factor $\mathbf{y}$ be a linear combination of the first two columns of the matrix M. Denoting the ith column of M as M^i, we have the following joint test for distribution factor proportionality and linearity:

$$\Theta = (M^1 \quad M^2) * \begin{pmatrix} \lambda_1 \boldsymbol{\tau} \\ \lambda_2 \boldsymbol{\tau} \end{pmatrix} \quad \text{where} \quad \boldsymbol{\tau} = (1 \quad \tau_2 \quad \cdots \quad \tau_m). \tag{4.11}$$

This restriction has $m(n-2) - 1$ degrees of freedom.

In this section we have presented a flexible demand system (4.9) and a series of tests of conditions implied by the unitary and collective model. These are tests for "symmetry" and "symmetry plus rank 1"; "distribution factor proportionality" and "distribution factor linearity and proportionality." We turn now to testing these conditions on individual household data.

5. EVIDENCE FROM THE CANADIAN FAMEX

5.1. *A Description of the Data*

To test and estimate the collective model we need several features in the data. First, we of course need information on (household) demands; thus we have to use household data. We also need enough price variation to allow us to estimate the price responses reliably. This already rules out many data sets since this requires either a long time series of cross sections or a shorter time series with some observable cross-section price dispersion within the period. Finally we need reliable information on the individual incomes of the members of the household since these will be our prime candidates for distribution factors. We use the Canadian Family Expenditure Survey (FAMEX) which is a survey of annual purchases by households (see the Data Appendix for details). The FAMEX is not run every year; here we use the surveys for the years 1974, 1978, 1982, 1984, 1986, 1990, and 1992.[14] If intertemporal variation was the only source of relative price variation, then this would not be enough years to estimate price effects; fortunately, however, there is also significant price variation within Canada (due to different provincial tax rates and transport costs) so that we can estimate reliable price responses even when we allow for cross-country taste differences.

We consider only single males, single females, and couples with no one else in the household. Our primary interest is in many person households but the singles are an important control for at least two reasons. First, the demands for singles should satisfy the usual Slutsky conditions. If they do not, then it is plausible that the usual rejections of the integrability conditions is due to something other than inappropriate aggregation across household members. Second, for singles we can test for the presence of different variables in demands and use this analysis in the framing of the specification for couples. For example, we find that we can exclude income from the demands for singles; this justifies taking household income and individual incomes as instruments for the unitary model for couples.[15]

For couples we model the demand for eight nondurables: food at home, food outside the home, household operations (sometimes referred to as services), men's clothing, women's clothing, transport (excluding the purchase of vehicles), recreation and vices (tobacco and alcohol). For singles we model one less good since purchases of women's (men's) clothing by single men (respectively, women) are not recorded. Precise details of sample selection and variable construction and description are given in the Data Appendix. One notable feature of these data is that since the FAMEX is a survey of annual purchases there are far fewer zeros for goods such as clothing, vices and eating out than one finds in surveys based on short diaries.

We assume that the preferences for these goods are separable from all other goods except labor force status, car ownership, and home ownership. We allow for nonseparabilities between goods and leisure by conditioning on labor force

[14] These are all publicly available. The only other public use tape available is for 1969. We do not use the 1969 data since the price data associated with them are unreliable.

[15] A referee has suggested that this may not be valid if, for example, one person responds to the survey in the two-person household and he or she systematically misreports the other person's expenditures and income and these reporting errors are correlated. Although the income information in our data is unusually reliable (see the Data Appendix) this remains a possibility for which it is difficult to control without information on who responds to the survey.

status (see Browning and Meghir (1991)); specifically, we select on all agents being in full time employment (defined as at least 48 weeks of full time work in the survey year). We allow for the dependence of demands on car and home ownership by including dummy variables for these in our set of preference factors. Two issues arise here. First, demands may not be exogenous to these choices (or even to the selection on being single or married with no one else in the household). We shall simply assume that they are (primarily for want of decent instruments), but this is an important area for future work. The second issue is that home ownership and labor force status may be distribution factors. As discussed above we partition demographics and income variables between preference factors and distribution factors. We do this since, as can be seen from the specification in equation (4.9), we cannot separately identify the parameters for a variable that enters one or another of the utility functions and the distribution function. Thus we choose to treat all variables that enter the demands for singles (in particular, car and home ownership and labor force status) as preference factors for couples. The issue of which demographics enter the distribution function assumes a larger importance when we come to identifying "who gets what" in the household; once again this is left for future work.

5.2. *Econometric Issues*

Before presenting estimates of the parameters of equation (4.9) we have to address some econometric issues. First, we must allow for unobservable heterogeneity. Although it would be desirable to derive the stochastic formulation by allowing for heterogeneity in each partner's preferences and the distribution function (as it is done in Blundell et al. (1998)), we follow usual practice and simply add a (heteroskedastic) error term to each equation.

We also allow for the possible endogeneity of total expenditure. Since the tests of the validity of these instruments play an important role in what follows, we present a preliminary discussion here; the precise details of included and excluded variables is given below. The usual reason for assuming that total expenditure might be endogenous in a demand system is that unusually high (or low) expenditure on one good by a particular household will affect both the error for that household and total expenditure; thus infrequency (or lumpiness of purchases) will induce a correlation between total expenditure and the errors in the system. Measurement error for individual expenditures also induces such a correlation. The usual instrument suggested to correct for this is net income. This is correlated with total expenditure but is usually assumed to be uncorrelated with any infrequency of purchase or measurement error. The critical point here is that within the unitary model, income should not affect demand once we condition on total expenditure. Thus it should be excluded from the right-hand side of the system and is available as an instrument. The same applies to the individual incomes of the two members in the couples households. We shall return to this issue in the next subsection in which we present a detailed account of our empirical specification.

The final difficulty in estimating equation (4.9) is that it is nonlinear. Note, however, that if we have estimates of the indices $a(\mathbf{p}, z)$ and $b(\mathbf{p}, z)$ in (4.5) and (4.6), then we can estimate (4.9) as a system of linear equations. The obvious estimates of $a(\cdot)$ and $b(\cdot)$ to use are the values constructed using estimates of the $\boldsymbol{\alpha}$, Γ, and $\boldsymbol{\beta}$ in the definitions of these indices. These in turn can be derived from estimates of the system. Thus we only need starting estimates of the $a(\cdot)$ and $b(\cdot)$ indices; we use a Stone price index for the linear homogeneous $a(\cdot)$ and unity for the zero homogeneous $b(\cdot)$.[16] This "iterated moment" estimator is discussed more fully in Browning and Meghir (1991) and Blundell and Robin (1993). In practice, it works well and usually converges after three or four iterations. The only parameter that cannot be estimated in this way is α_0 in the $a(\cdot)$ index; although it is formally identified, it is not well-determined and the final results are insensitive to the value of this parameter so we simply hold it constant in all that follows.

The tests of the conditions given in the last section are all performed using minimum chi-squared methods (see Browning and Meghir (1991) for an account of min-χ^2 tests in this context). Thus we first estimate the parameters and covariance matrix of the parameters of the system (4.9) with no restrictions using conventional GMM methods; denote these by φ and C respectively. Then we impose the restrictions by solving

$$\text{(5.1)} \qquad \min_{\eta} (\varphi - f(\eta))' C^{-1} (\varphi - f(\eta))$$

where $f(\eta)$ is the mapping from the restricted parameters η to the unrestricted parameters φ. The value of this minimand gives the χ^2 statistic for the restriction. The covariance matrix for the restricted parameter estimates is given by $(F'CF)^{-1}$ where F is the Jacobian of $f(\cdot)$ evaluated at $\hat{\eta}$, the vector that minimizes (5.1).

5.3. *The Unitary Model*

We first present a conventional demand analysis for the three strata (couples, single females, single males). That is, an analysis assuming that the unitary model holds for all households. The purpose of this is to illustrate some of the problems that motivated the analysis presented in this paper. To do this we estimate the parameters of the system given in (4.9) without the Θ matrix.

For the singles we include thirteen preference variables in the $a(\cdot)$ index (that is, l_α in (4.7) equals thirteen). These are dummies for four regions of residence (Atlantic region, Quebec, Prairies, and British Columbia, with Ontario as the excluded region), car ownership, home ownership, living in a city, having more than high school education, white collar occupation, the respondent's mother tongue being French, the respondent's mother tongue being something other

[16] We tried very many other starting values; in all cases the system converged to the same estimates.

than French or English, as well as age and age squared. We also allow for two variables in the $b(\cdot)$ index: car ownership and home ownership (this choice is the result of a preliminary investigation which is not reported here). This gives twenty-four parameters per equation (the intercepts and variables in the $a(\cdot)$ and $b(\cdot)$ indices, the six homogeneous prices, and the λ parameter).

The instruments for the singles are the intercept, the thirteen preference factors included in the $a(\cdot)$ index, the six log homogeneous prices, the log (absolute) price of the numeraire good, and log net income, log net income squared, and log net income crossed with the car and home ownership dummies. The absolute price of the numeraire good can be excluded from the demand system if homogeneity is maintained and it should also be correlated with total expenditure if agents are at all sensitive to real interest rates. As to the income variables, as discussed above, in a unitary model income should not affect demands once we condition on total expenditure but it is obviously correlated with total expenditure. One objection to this is that preferences may be correlated with demand if, for example, higher paid jobs require more expensive clothing. In this case we would expect to see that higher paid individuals have a higher budget share for clothing than lower paid individuals with the same total expenditure. This is entirely plausible, but it is also testable since we have one over-identifying restriction per equation for a total of six degrees of freedom for the system.[17]

For couples we include fifteen preference factors in the $a(\cdot)$ index; this is the end result of some preliminary analysis which excluded some variables (such as the wife's language) which were found to be wholly "insignificant" everywhere. We include twelve dummy variables and three continuous variables. The dummies are for region of residence (four dummies, as for the singles), home ownership, living in a city, car ownership, the husband having more than high school education, the husband having a white collar job, the wife having a white collar job, and the husband's two language options. The three continuous variables are the age and age squared of the husband and the age of the wife. For the preference factors in the $b(\cdot)$ index, we include the same variables as for singles, that is, dummy variables for car and home ownership. Thus we have twenty-seven parameters per equation (recall that we have one more (clothing) good for couples and hence one extra price).

The instrument set for total expenditure for the couples sample includes the fifteen variables included in the $a(\cdot)$ index, the seven log homogeneous prices, the log absolute price of the numeraire good, and a set of income variables. The specific income variables we use in the instrument set are also the result of a preliminary investigation which is not reported here. The main criterion for inclusion in the instrument set is that we do not want to include variables that have little explanatory power in the auxiliary equation since this simply reduces the power of the over-identifying test. In all we use six income variables: log

[17]On the other hand, if the excluded absolute price of the numeraire does not have much explanatory power, then this test is not very powerful.

TABLE I

TESTS OF THE UNITARY MODEL RESTRICTIONS

Test for:	Single Females # = 2173	Single Males # = 2044	Couples # = 2428
	1.9	6.69	41.8
Overidentification	(6)	(6)	(21)
	[92.6%]	[35.1%]	[0.54%]
	11.1	17.4	49.4
Symmetry	(15)	(15)	(21)
	[74.7%]	[29.7%]	[0.05%]

Note: χ^2 test statistic; (degrees of freedom); [probability under the null].

(real) net household income, the square of log net income, log net income crossed with dummies for car ownership and home ownership, the log of the wife's gross earnings, and the log of the husband's earnings. In all we have thirty instruments per equation (the intercept, fifteen preference factors, seven log homogeneous prices, the log price of the numeraire good, and the six income variables). This gives four over-identifying restrictions per equation and a total of twenty-four degrees of freedom for the six good system.

To save on space we do not present the full set of parameter estimates here;[18] rather, in Table I we present the tests for symmetry and for the validity of the over-identifying restrictions for our three strata.

The results for the two single strata do not display any signs of misspecification; it seems that *the singles data are consistent with the unitary model* (or at least the implications of symmetry and the exclusion of income). The results for couples are representative of the results usually presented in the literature on demand analysis on micro data: the symmetry and the over-identifying restrictions are both rejected at conventional sizes. One reaction to this is to adjust significance levels so that we do not interpret these test statistics as indicating rejection. For example, if we use a "Schwarz" critical level of (degrees of freedom $*$ ln (sample size)) = 163.7 for both the tests given here, then we would conclude that the unitary model is, a posteriori, the more likely. Under this interpretation there are no problems with the application of the unitary model to household data. The converse view (which is the one we take) is that the restrictions are suspect and that we cannot necessarily apply the unitary model to two-person households. We now turn to testing the implications of our proposed alternative for couples, the collective model.

5.4. *The Collective Model*

The results presented in Table I suggest that there are some problems with imposing the unitary model on the couples data that do not appear for singles.

[18] In the Appendix we present estimates for the collective model for the couples sample; all detailed results are available on request to the authors.

Thus we now estimate the collective model for couples. To do this we include two extra variables on the right-hand side of the demand equations: the log of the wife's earnings minus the log of the husband's income ("the income difference") and the wife's gross income; see (4.9). We present the parameter estimates for the unrestricted demand system in Table II; the tests of particular interest are presented in Table III.

As can be seen, the test for the over-identifying restrictions is much improved; thus it seems that the individual incomes should be included in the demand system. The next row of Table III presents direct evidence on this: this is a test for excluding the two income measures from the system (see Table II for the individual estimates). We conclude that individual incomes are important in the demands of couples. Referring back to Table I we see that this is not the case for singles since income is one of the excluded variables used to identify the model and the over-identification restrictions are not rejected for singles.

The next two rows in Table III test for symmetry and "symmetry plus rank one." Comparing the test statistics for symmetry in Tables I and III we see that adding the individual income variables decreases the test statistic a little but not to the point where we would not reject symmetry at conventional levels of significance. The SR1 condition, however, is not rejected. Thus the price responses are consistent with the collective model.

The next row presents the test for distribution factor proportionality. As already discussed this restriction is independent of the test for SR1. The proportionality test does not reject. Finally, then, we can go on to testing for SR1, distribution factor proportionality, and distribution factor linearity together; see the final row of Table III. As can be seen, these restrictions are not rejected. We conclude that the data are consistent with the collective setting.

5.5. *Substantive Implications of the Parameter Estimates*

Although the foregoing analysis indicates that we do need to weaken the unitary model for two person households, it is not so clear that this has any strong implications for the values that we are usually concerned with in demand models. Specifically, what happens to total expenditure and own price elasticities if we impose the various restrictions given by the unitary and collective models? In our investigation of this, we shall impose one further restriction on our estimates of the collective model. This restriction is that it is only the difference in log earnings that enters the sharing function. This is a very natural assumption to test in this context. The $\chi^2(1)$ value that the proportionality factor in the collective-restricted model (the last row of Table III) is zero is 1.03; thus we can reject the hypothesis that the wife's income has a role to play over and above its effect on the differences in (log) incomes. In all that follows we shall compare the unrestricted unitary model with the unrestricted collective model with two sharing factors (see Table II) and the restricted collective model with only the difference in log income (see Table IV).

TABLE II

PARAMETER ESTIMATES FOR UNRESTRICTED COLLECTIVE MODEL

	F	H	R	E	M	W	V
Intercept	173.22	117.33	−77.75	−31.54	−0.14	−28.06	105.81
	(79.38)	(59.46)	(59.66)	(46.15)	(27.05)	(31.43)	(53.93)
Atlantic	−0.19	0.55	−1.30	0.37	−0.93	0.24	0.85
	(0.88)	(0.48)	(0.79)	(0.65)	(0.33)	(0.47)	(0.71)
Quebec	1.59	−0.50	−0.78	0.34	−0.42	0.07	−0.40
	(0.91)	(0.55)	(0.82)	(0.69)	(0.36)	(0.50)	(0.73)
Prairies	−0.78	0.67	0.12	0.97	−0.66	0.40	−2.71
	(0.89)	(0.56)	(0.85)	(0.72)	(0.41)	(0.55)	(0.72)
B.C.	−1.41	−0.32	1.09	2.31	−0.72	0.56	−2.22
	(0.94)	(0.51)	(0.88)	(0.71)	(0.36)	(0.54)	(0.75)
Car-Owner	−26.29	11.39	−18.21	19.55	15.16	10.27	−25.39
	(31.45)	(16.36)	(18.00)	(18.38)	(11.42)	(12.37)	(21.01)
Home-Owner	28.93	0.55	−29.03	17.77	0.23	−3.09	−0.28
	(12.54)	(6.79)	(9.66)	(8.86)	(4.62)	(5.86)	(9.53)
City-Dweller	0.27	−0.70	−1.04	1.70	−0.26	−0.32	0.06
	(0.49)	(0.26)	(0.46)	(0.34)	(0.18)	(0.25)	(0.37)
Husband's Age	4.02	0.87	−8.82	−3.32	1.21	0.71	2.81
(decades)	(4.44)	(3.03)	(4.06)	(3.27)	(2.12)	(2.55)	(3.76)
Age-Squared	−40.93	−9.10	62.56	−24.22	8.14	1.83	−26.82
	(21.30)	(12.91)	(20.15)	(14.69)	(8.83)	(11.10)	(16.58)
Husband has More	−0.20	0.30	0.91	0.91	0.25	0.07	−0.65
than High School	(0.48)	(0.29)	(0.50)	(0.41)	(0.23)	(0.30)	(0.38)
Francophone	0.39	−0.65	−1.13	0.71	0.55	1.03	−0.13
	(0.71)	(0.42)	(0.62)	(0.55)	(0.26)	(0.42)	(0.53)
Allophone	1.46	0.11	−0.63	−0.51	0.09	0.56	−1.58
	(0.66)	(0.33)	(0.57)	(0.45)	(0.24)	(0.36)	(0.46)
Husband White	−0.71	0.15	0.44	0.94	0.27	0.20	−0.29
Collar	(0.39)	(0.22)	(0.39)	(0.31)	(0.16)	(0.24)	(0.30)
Wife White	−0.23	0.52	0.20	−0.47	0.33	0.23	−0.80
Collar	(0.42)	(0.24)	(0.40)	(0.32)	(0.18)	(0.24)	(0.32)
Wife's Age	13.63	5.01	−2.74	−2.06	−4.13	−0.53	−0.41
(decades)	(4.54)	(3.07)	(4.28)	(3.39)	(2.13)	(2.72)	(4.02)
Difference	−3.50	0.03	1.72	0.34	−0.02	0.01	2.94
in Log Earnings	(1.57)	(0.91)	(1.41)	(1.23)	(0.77)	(0.77)	(1.24)
Wife's Log	5.31	−0.09	−3.43	0.27	−0.31	0.53	−6.03
Earnings	(2.70)	(1.54)	(2.49)	(2.06)	(1.20)	(1.34)	(2.12)
Price (F)	−79.78	−66.79	80.64	−2.25	0.82	15.84	−22.66
	(51.52)	(41.71)	(42.70)	(32.55)	(18.15)	(22.84)	(39.57)
Price (H)	−88.87	−54.63	62.02	−5.16	−9.49	12.94	−12.92
	(44.77)	(37.55)	(38.15)	(28.38)	(16.17)	(19.95)	(34.90)
Price (R)	99.61	63.39	−79.30	12.02	0.87	−14.52	0.42
	(50.68)	(41.12)	(42.26)	(32.55)	(17.70)	(22.41)	(39.37)
Price (E)	13.76	−0.59	6.18	−8.82	−5.43	−13.97	9.02
	(5.97)	(3.11)	(5.56)	(4.36)	(2.21)	(3.18)	(4.87)
Price (M)	−2.34	−9.43	11.91	−20.77	6.22	0.72	−12.49
	(12.25)	(8.19)	(10.98)	(8.67)	(4.80)	(6.33)	(9.82)

TABLE II—*Continued*

	F	H	R	E	M	W	V
Price (W)	−0.63	2.89	−11.59	16.47	−3.04	2.56	16.71
	(10.39)	(6.66)	(9.79)	(7.57)	(4.22)	(5.65)	(8.28)
Price (V)	−28.52	−18.02	23.23	−3.48	−0.96	4.08	−8.75
	(15.50)	(12.95)	(13.10)	(9.86)	(5.69)	(6.92)	(11.94)
β Intercept	−56.37	−42.35	45.05	4.37	−2.01	6.70	−19.37
	(33.86)	(26.88)	(27.42)	(20.66)	(11.68)	(14.42)	(24.95)
β Car Owner	4.28	−3.46	3.67	−4.64	−3.71	−2.50	4.32
	(6.63)	(3.62)	(3.94)	(3.95)	(2.49)	(2.68)	(4.50)
β Home Owner	−6.30	−0.18	6.24	−3.63	−0.09	0.56	0.03
	(2.66)	(1.46)	(2.06)	(1.88)	(0.97)	(1.24)	(2.02)
λ	3.13	4.60	−4.05	0.76	0.86	−0.06	2.69
	(3.39)	(2.90)	(2.87)	(2.12)	(1.29)	(1.52)	(2.61)

Notes: All parameter estimates and standard errors multiplied by 100. All price variables are log (price relative to price of transport).

Before comparing the predictions from the different models we examine how demands change as the income share of the wife changes. Referring to Table IV, we see that an increase in the wife's share of income (holding everything else constant) significantly increases the demand for women's clothing and significantly decreases the demand for men's clothing and food at home. If we increase the wife's share of income from 10% to 90% (both values are within the range of our data), then the share for food at home falls from 19.5% to

TABLE III

TESTS OF THE COLLECTIVE MODEL RESTRICTIONS

Test for:	
Over-identification	12.2 (7) [9.3%]
Exclusion of the individual income variables	25.9 (14) [2.7%]
Symmetry	42.0 (21) [0.41%]
SR1	10.0 (10) [44.3%]
Distribution factor proportionality	7.7 (6) [26.0]
SR1, distribution factor proportionality and linearity	27.4 (21) [15.7%]

TABLE IV
PARAMETER ESTIMATES FOR RESTRICTED COLLECTIVE MODEL

	F	H	R	E	M	W	V
Intercept	92.40	51.93	5.31	−8.10	10.73	−28.43	131.69
	(37.60)	(20.29)	(20.42)	(26.64)	(11.92)	(19.82)	(35.52)
Atlantic	−0.19	0.43	−0.56	0.11	−0.79	0.35	0.99
	(0.78)	(0.41)	(0.67)	(0.61)	(0.31)	(0.45)	(0.64)
Quebec	0.96	−0.68	0.32	−0.06	−0.36	0.22	−0.27
	(0.82)	(0.49)	(0.71)	(0.64)	(0.32)	(0.47)	(0.62)
Prairies	−1.27	1.06	0.06	0.66	−0.58	0.19	−1.06
	(0.73)	(0.41)	(0.72)	(0.61)	(0.29)	(0.43)	(0.54)
B.C.	−1.55	−0.28	0.61	1.96	−0.73	0.43	−1.60
	(0.87)	(0.46)	(0.83)	(0.69)	(0.33)	(0.48)	(0.65)
Car Owner	−29.84	0.62	−4.53	17.23	17.31	8.51	−14.28
	(27.61)	(12.00)	(14.16)	(15.96)	(9.50)	(10.20)	(18.05)
Home Owner	19.93	−0.33	−21.84	19.44	1.16	−4.44	10.50
	(11.39)	(6.03)	(9.12)	(8.41)	(4.54)	(5.79)	(8.89)
City Dweller	0.15	−0.74	−0.87	1.82	−0.26	−0.30	0.08
	(0.48)	(0.26)	(0.46)	(0.33)	(0.18)	(0.25)	(0.37)
Husband's Age	2.96	−1.60	−6.59	−3.84	1.47	1.03	2.43
	(4.37)	(2.62)	(3.94)	(3.22)	(1.99)	(2.49)	(3.74)
Age Squared	−20.86	−16.29	49.29	−24.20	5.87	6.91	−60.45
	(16.69)	(9.80)	(14.60)	(11.83)	(6.17)	(8.86)	(13.05)
Husband has More	0.09	0.22	0.79	0.77	0.23	0.11	−1.09
than High School	(0.43)	(0.26)	(0.47)	(0.38)	(0.21)	(0.28)	(0.34)
Francophone	0.16	−0.70	−1.03	0.81	0.62	1.06	−0.01
	(0.71)	(0.42)	(0.61)	(0.54)	(0.26)	(0.42)	(0.53)
Allophone	1.71	−0.17	−0.89	−0.49	0.10	0.61	−1.94
	(0.64)	(0.31)	(0.52)	(0.43)	(0.22)	(0.34)	(0.42)
Husband White	−0.59	0.18	0.34	0.93	0.23	0.24	−0.34
Collar	(0.39)	(0.21)	(0.39)	(0.31)	(0.16)	(0.23)	(0.30)
Wife White	−0.29	0.57	0.09	−0.36	0.34	0.21	−0.73
Collar	(0.39)	(0.23)	(0.39)	(0.31)	(0.16)	(0.23)	(0.30)
Wife's Age	15.09	7.25	−4.88	−1.73	−4.43	−0.76	−1.09
	(4.48)	(2.75)	(4.17)	(3.35)	(2.05)	(2.67)	(3.98)
Difference in	−0.53	−0.26	0.17	0.29	−0.18	0.38	−0.26
Log Earnings	(0.22)	(0.16)	(0.17)	(0.22)	(0.08)	(0.15)	(0.18)
Price (F)	−3.07	−12.26	2.63	−6.62	0.36	12.21	−29.50
	(9.38)	(6.24)	(6.64)	(8.35)	(3.41)	(6.28)	(11.02)
Price (H)	−22.97	−6.05	4.56	−6.86	−9.92	13.10	−30.07
	(10.30)	(7.73)	(7.00)	(8.89)	(3.69)	(6.68)	(11.94)
Price (R)	15.02	7.18	−5.73	10.10	0.41	−12.07	16.81
	(8.55)	(5.98)	(7.20)	(8.16)	(3.21)	(5.70)	(9.64)
Price (E)	16.63	−1.23	9.26	−10.48	−6.66	−12.06	−1.89
	(5.86)	(3.09)	(5.18)	(4.52)	(2.18)	(3.13)	(4.88)
Price (M)	7.00	−2.94	−6.05	−18.32	3.03	−0.76	−16.76
	(8.43)	(4.88)	(5.27)	(6.82)	(3.69)	(5.23)	(7.27)

TABLE IV—*Continued*

	F	H	R	E	M	W	V
Price (W)	−5.07	−3.00	2.35	13.81	−2.05	4.66	11.17
	(7.17)	(4.11)	(5.28)	(5.66)	(3.22)	(4.43)	(5.66)
Price (V)	−20.77	−20.62	8.00	−17.83	−16.93	13.31	−73.42
	(19.73)	(14.33)	(12.51)	(17.76)	(7.15)	(13.58)	(25.80)
β Intercept	−10.32	−14.99	1.12	−5.94	−9.05	8.76	−50.44
	(13.40)	(8.89)	(8.13)	(11.29)	(4.59)	(8.69)	(16.07)
β Car Owner	4.79	−0.76	0.37	−3.72	−3.74	−1.98	1.91
	(5.15)	(2.29)	(2.71)	(3.03)	(1.83)	(1.96)	(3.40)
β Home Owner	−3.63	0.12	4.04	−3.58	−0.23	0.72	−2.04
	(2.12)	(1.13)	(1.71)	(1.58)	(0.85)	(1.09)	(1.65)
λ	−0.69	1.60	0.17	1.86	1.62	−0.26	5.36
	(1.42)	(1.04)	(0.92)	(1.29)	(0.53)	(0.99)	(1.86)

Notes: All parameter estimates and standard errors multiplied by 100. All price variables are log (price relative to price of transport).

17.2%; women's clothing rises from 6.2% to 7.8% and men's clothing falls from 5.5% to 4.7%. Although not significant, such a change also gives a fall in the vices budget share from 8.65% to 7.5% and a rise in the budget share for food outside the home from 10.7% to 12%.

In Tables V and VI we present estimates of total expenditure elasticities and own price elasticities for three different models: the unrestricted unitary model, the unrestricted collective model with two sharing factors, and the collective model with the full collective restrictions and only one sharing factor. These are

TABLE V

TOTAL EXPENDITURE ELASTICITIES

Model →	Unitary	Collective	
Restriction →	Unrestricted	Unrestricted	Collective
Food at home	0.19	−0.68	0.12
	(0.11)	(0.42)	(0.09)
Household operations	1.11	1.02	1.04
	(0.13)	(0.25)	(0.08)
Recreation	1.53	2.10	1.68
	(0.21)	(0.38)	(0.15)
Food outside	1.39	1.37	1.48
	(0.16)	(0.41)	(0.13)
Men's clothing	1.64	1.56	1.65
	(0.20)	(0.49)	(0.14)
Women's clothing	1.70	1.59	1.70
	(0.19)	(0.37)	(0.17)
Vices	1.38	2.34	1.41
	(0.22)	(0.44)	(0.21)
Transport	0.67	0.61	0.65
	—	—	—

Note: Standard errors given in parentheses.

TABLE VI

OWN PRICE ELASTICITIES

Model → Restriction →	Unitary Unrestricted	Collective Unrestricted	Collective Collective
Food at home	−0.45	+0.78	−0.54
	(0.94)	(3.84)	(0.33)
Household operations	−1.12	−1.11	−1.00
	(1.04)	(2.41)	(0.30)
Recreation	−1.14	−1.01	−1.41
	(1.40)	(3.38)	(0.60)
Food outside	−1.81	−1.83	−1.52
	(0.41)	(0.58)	(0.70)
Men's clothing	+0.72	+0.40	+0.46
	(0.95)	(0.71)	(0.62)
Women's clothing	−0.30	−0.53	−0.10
	(0.78)	(0.74)	(0.65)
Vices	−2.08	−1.06	−2.12
	(2.61)	(0.97)	(2.39)
Transport	−1.85	−0.86	−1.35
	—	—	—

Note: Standard errors given in parentheses.

evaluated for a car and home owning, English speaking couple living in a city in Ontario, both of whom are aged 40 and are in white collar work. We set total expenditure equal to median total expenditure[19] and the differences in earnings to zero.

Table V presents expenditure elasticities for the three different models. The most dramatic difference across columns is that when we include the earnings variables in the demands (column 1 to column 2), the expenditure elasticity for food at home becomes negative. This is a real surprise even though the earnings variables are highly correlated with total expenditure and might be expected to have a sizable impact on expenditure elasticities. On the other hand, once we impose the full collective conditions the expenditure elasticity for food at home becomes positive (albeit "insignificant"). This pattern, that the full collective elasticities are closer to the unrestricted unitary estimates than they are to the unrestricted collective estimates is also seen in other goods, notably recreation and vices.[20] Referring to Table II, we see that the wife's earnings are most "significant" for food at home, recreation and vices—it is this that gives the variations across the three columns.

The estimates of own price elasticities given in Table VI also have the pattern that the estimates (and standard errors) from the restricted collective model are close to those for the unrestricted unitary model. Once again, imposing the

[19] Much the same qualitative results emerge at other points of the total expenditure distribution.

[20] This is *not* because of the exclusion of one of the earnings variables; similar results hold for the restricted collective model with two sharing factors.

collective restrictions gives somewhat different elasticity estimates for food at home, recreation and vices. Generally, then, we see that estimates of elasticities from the unitary model are not very different from those from the collective-restricted model. The principal differences are in the predictions concerning the effects of the intra-household distribution of earnings on demands.

6. CONCLUSIONS

In the above we presented a general characterization of the collective model. We showed that the collective model can be completely captured by using a household utility function $u(\cdot)$ that depends on household purchases $\mathbf{q}$ and a distribution index μ. If the latter is a constant then we have the usual unitary model. Generally, however, the function $\mu(\cdot)$ depends on prices $\mathbf{p}$, total expenditure x, and distribution factors $\mathbf{y}$. The fact that all nonpreference influences have to act through this index puts strong restrictions on household behavior. In Sections 2 and 3 we presented these restrictions.

In the empirical section we estimated the parameters of a demand system and then tested for some of the predictions of the unitary and collective models. Although we made minimal assumptions in the theory section, we necessarily had to make stronger assumptions in this empirical work. For example, we have assumed that preferences over the nondurables modelled are separable from other goods (except for leisure and the ownership of a house or car). We have also assumed that the labor supply decision is exogenous for the demand system. More fundamentally, we have assumed that the marriage decision is given; that is we do not control for selection into couples or singles. Conditional on these reservations the results are unambiguous: the predictions of the unitary model are not rejected for single people but they are rejected for couples. The predictions of the collective model are not rejected by the data for couples. This encourages us that the collective setting is worth further investigation.

As mentioned in the introduction, one of the other important areas where the results presented here can be applied directly is to the joint labor supply decision of husband and wife. The theoretical results presented in Section 2 and 3 have implications for such work on cross-sectional data. Since there is no cross-section variation in prices for goods, we can only define a single composite commodity, consumption, and then analyze the three "good" system for male and female labor supply and consumption. The cross-section variation in wages gives the (relative) "price" variation that we have exploited in this paper. Referring back to the discussion following Proposition 4, however, we see that without further restrictions, the collective setting does not have any implications for price responses in a three-good model. Any Slutsky responses in a three-good model are consistent with the collective setting. Thus the factor proportionality restrictions (see Proposition 8) are the only restrictions that the collective model imposes in this context (see also Chiappori (1990)). Additional restrictions may be derived, but only under additional assumptions, typically, privateness of leisure and consumption and restrictions on preferences (see, for example, Chiappori (1988a, 1992) and Fortin and Lacroix (1997)).

The power of thinking about the collective model in terms of a distribution function is shown by the ease with which we derived the results in Sections 2 and 3. Just as importantly, this way of looking at things is likely to facilitate future work that undertakes more structural analyses of household behavior. In particular, there are important decisions that individuals make that pre-date the allocation decisions within marriage. This obviously includes the marriage decision itself but also education and human capital decisions. If the collective setting is indeed appropriate for decision making once a union is formed, then the distribution function is a useful "sufficient statistic" for the importance of these earlier decisions in the division of the gains to marriage.

It may also be the case that assuming the collective setting allows a more precise determination of empirical effects. To give an example, suppose that it is posited that changes in law governing the division of assets on divorce leads to shifts in "power" within the household. If we have households that are observed in different policy regimes, then it may be possible to incorporate a variable capturing these differences in environment in the distribution function. The fact that reactions to this variable are closely related to reactions to other distribution factors and to price effects means that we may be able to determine the effects of such changes more precisely. Of course, this gain in precision comes at the expense of maintaining the collective model but we regard this as being acceptable given the foregoing.

Another area that deserves systematic exploration is the use of the distribution function in the analysis of intra-household welfare. Once we accept that households do not have a single welfare index we need to allow for differences in distribution within the household. It is likely that any such extensions that maintain the collective setting will use the distribution function even though at present it is unclear how this will be achieved since the distribution function depends on the normalization of the utility functions used.

As emphasized in the introduction we regard the collective setting as a tractable and plausible next step in the analysis of the behavior and welfare of many-person households. The implications of the collective model are significantly weaker than those of the unitary model but not so weak as to impose no restrictions on observables. In this paper we have restricted attention to demand behavior but it is clear that the collective framework can be extended to the analysis of labor supply, fertility, savings, portfolio choice, and other areas of household behavior.

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APPENDIX A: PROOFS

PROOF OF PROPOSITION 1: Just note that the maximand in (2.3) is differentiable in $(\mathbf{p}, x)$ and differentiable and strongly concave in $(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q})$, while the program itself is zero homogeneous. *Q.E.D.*

PROOF OF PROPOSITION 2: Since $\xi(\mathbf{p}, x) = \mathbf{f}(\mathbf{p}, x, \mu(\mathbf{p}, x))$, we have $S = \xi_{\mathbf{p}} + \xi_x \xi' = \mathbf{f}_{\mathbf{p}} + \mathbf{f}_\mu \mu'_{\mathbf{p}} + (\mathbf{f}_x + \mathbf{f}_\mu \mu_x)\mathbf{f}' = (\mathbf{f}_{\mathbf{p}} + \mathbf{f}_x \mathbf{f}') + \mathbf{f}_\mu(\mu_{\mathbf{p}} + \mu_x \mathbf{f})'$. Since $\mathbf{f}(\mathbf{p}, x, \mu)$ is a conventional uncompensated demand function for fixed μ, this gives $\Gamma = (\mathbf{f}_{\mathbf{p}} + \mathbf{f}_{\mathbf{x}} \mathbf{f}')$ is symmetric and negative semi-definite. Denoting $\mathbf{u} = \mathbf{f}_\mu$ and $\mathbf{v} = (\mu_p + \mu_x \mathbf{f})$ we have the result given in the Proposition. *Q.E.D.*

PROOF OF LEMMA 1: If $S = \Sigma + \mathbf{uv}'$ (where Σ is symmetric) is not symmetric, then $\mathbf{u}$ and $\mathbf{v}$ are linearly independent; otherwise $S = \Sigma + \mathbf{uv}' = \Sigma + \lambda \mathbf{vv}'$ for some λ and hence S is symmetric. Thus $M = S - S' = \mathbf{uv}' - \mathbf{vu}'$, the difference of the outer product of two linearly independent vectors, and hence M has rank 2. Finally let $\mathbf{w}$ be in the image space of M; that is, for some $\mathbf{z}$ we have $\mathbf{w} = M\mathbf{z} = (\mathbf{uv}' - \mathbf{vu}')\mathbf{z} = (\mathbf{v}'\mathbf{z})\mathbf{u} - (\mathbf{u}'\mathbf{z})\mathbf{v}$ and hence $\mathbf{w}$ is a linear combination of $\mathbf{u}$ and $\mathbf{v}$.

Conversely, take any antisymmetric matrix M of rank 2. Rank 2 implies that $M = \mathbf{ab}' + \mathbf{cd}'$ for some vectors $\mathbf{a}, \mathbf{b}, \mathbf{c}, \mathbf{d}$; then anti-symmetry requires that $M = \mathbf{ab}' - \mathbf{ba}'$ where, as above, $\mathbf{a}$ and $\mathbf{b}$ belong to Im M. Since the latter is of dimension 2, any two vectors $\bar{\mathbf{u}}$ and $\bar{\mathbf{v}}$ can be written as

$$\bar{\mathbf{u}} = \alpha \mathbf{a} + \beta \mathbf{b},$$
$$\bar{\mathbf{v}} = \gamma \mathbf{a} + \delta \mathbf{b}.$$

Then

$$\bar{\mathbf{u}}\bar{\mathbf{v}}' - \bar{\mathbf{v}}\bar{\mathbf{u}}' = (\alpha\delta - \beta\gamma)(\mathbf{ab}' - \mathbf{ba}').$$

Here, $\alpha\delta - \beta\gamma \neq 0$, for otherwise $\bar{\mathbf{u}}$ and $\bar{\mathbf{v}}$ would be colinear. For $\lambda = 1/(\alpha\delta - \beta\gamma)$, we have that $M = \mathbf{ab}' - \mathbf{ba}' = \lambda(\bar{\mathbf{u}}\bar{\mathbf{v}}' - \bar{\mathbf{v}}\bar{\mathbf{u}}')$. *Q.E.D.*

PROOF OF LEMMA 2: Let λ be an arbitrary eigenvalue, $\bar{\lambda}$ its conjugate, and z (resp. $\bar{z}$) the corresponding eigenvectors:

$$Mz = \lambda z \Leftrightarrow M\bar{z} = \bar{\lambda}\bar{z}.$$

Then

$$\bar{z}'Mz = \lambda \bar{z}'z = (M'\bar{z})'z = -\bar{\lambda}\bar{z}'z.$$

Since $\bar{z}'z = \|z\|^2 \neq 0$, we have that $\bar{\lambda} = -\lambda$ and λ is imaginary. Since imaginary roots come by conjugate pairs, the number of nonzero eigenvalues must be even. *Q.E.D.*

PROOF OF LEMMA 3: Let M be an antisymmetric matrix with m_{12} not equal to 0. This implies that M has at least rank 2 and the first two rows of M are linearly independent.

If M has rank 2, then the ith row of M can be written $m^i = \pi m^1 + \kappa m^2$. Since M is antisymmetric, we have $m_{13} = -m_{31}$ and $m_{23} = -m_{32}$ so that $\pi = -(m_{2i}/m_{12})$ and $\kappa = -(m_{1i}/m_{12})$. This gives $m_{1k} = \pi m_{1k} + \kappa m_{2k} = (m_{1i}m_{2k} - m_{1k}m_{2i})/m_{12}$ for all (i, k) such that $k > i > 2$.

Conversely, if the relationship given in the lemma holds, then we can write row i for $i > 2$ as $(m_{13}m^2 - m_{23}m^1)/m_{12}$ and hence M has rank 2. *Q.E.D.*

PROOF OF PROPOSITION 3: Only the final statement is new. But for any vector $\mathbf{w}$ orthogonal to Im(M), we have $\mathbf{w}'S\mathbf{w} = \mathbf{w}'\Sigma\mathbf{w} \leq \mathbf{0}$, since Σ is negative semi-definite. *Q.E.D.*

PROOF OF PROPOSITION 4: From Lemma 1, S satisfies SR1 iff $M = S - S'$ is of rank zero or two. But M is antisymmetric; from Lemma 2, its rank must be even. It follows that, if $n \leq 3$, the $(n \times n)$ matrix M cannot be of rank more than two, so that SR1 is fulfilled.

Assume, now, that $n = 4$. Then M can be of rank zero, two, or four. But homogeneity plus adding-up implies that $M \cdot p = 0$, so that M cannot be of full rank. Hence, it can only be of rank zero or two and SR1 is fulfilled. *Q.E.D.*

PROOF OF PROPOSITION 7: (i) From the proof of Proposition 2 we have that $S = \Sigma + \mathbf{f}_{\mu}(\mu_{\mathbf{p}} + \mu_{\mathbf{x}}\mathbf{q})'$. From $\boldsymbol{\xi}(\mathbf{p}, x, y) = \mathbf{f}(\mathbf{p}, x, \mu(\mathbf{p}, x, y))$ we have $\boldsymbol{\xi}_y(\mathbf{p}, x, y) = \mathbf{f}_{\mu}\mu_{\mathbf{y}}$. Thus $S = \Sigma + \boldsymbol{\xi}_y(\mu_{\mathbf{p}} + \mu_{\mathbf{x}}\mathbf{q})'(1/\mu_y) = \Sigma + \boldsymbol{\xi}_y\mathbf{v}'$.

(ii) If $M = S - S'$ has rank 2, then $\boldsymbol{\xi}_y$ and $\mathbf{v}$ in part (i) are linearly independent. Take any vector $\mathbf{w}$ that is orthogonal to $\boldsymbol{\xi}_y$ but not to $\mathbf{v}$. Then $M\mathbf{w} = \boldsymbol{\xi}_y\mathbf{v}'\mathbf{w}$ so that $\boldsymbol{\xi}_y$ is in the column space of M. *Q.E.D.*

PROOF OF PROPOSITION 8: From $\boldsymbol{\xi}(\mathbf{p}, x, y_1, y_2 \cdots y_m) = \mathbf{f}(\mathbf{p}, x, \mu(\mathbf{p}, x, y_1, y_2 \cdots y_m))$ we have $\boldsymbol{\xi}_{y_i} = \mathbf{f}_{\mu}\mu_{y_i} = (\mu_{y_i}/\mu_{y_1})\boldsymbol{\xi}_{y_1}$. *Q.E.D.*

PROOF OF PROPOSITION 9: Consider the vector $\mathbf{v}$ in Proposition 2 as a function of $(\mathbf{P}, X, Y)$. Then since $(\partial\mu/\partial P_j) = 0$, $\mathbf{v}$ is colinear to $\boldsymbol{\xi}$. *Q.E.D.*

PROOF OF PROPOSITION 10: From equation (4.4) we have that S takes the form $S = \Gamma + \mathbf{R}(\Gamma - \Gamma') + \Sigma$ where the matrix $\mathbf{R} = \frac{1}{2}(\beta + 2\boldsymbol{\lambda}(\tilde{x}/b(\mathbf{p})))\mathbf{p}'$ and Σ is symmetric.

If S is SR1 for all $(\mathbf{p}, x)$ then set prices equal to unity so that $\mathbf{p} = \mathbf{0}$ and $\mathbf{R} = \mathbf{0}$. Then $S = \Gamma + \Sigma$, which implies that Γ is SR1.

Conversely, if Γ is SR1 then we can write it as $\Gamma = \Sigma^* + \mathbf{uv}'$ where Σ^* is symmetric. Then:

$$M = S - S' = (I + \mathbf{R})(\mathbf{uv}' - \mathbf{vu}') + (\mathbf{uv}' - \mathbf{vu}')\mathbf{R}'.$$

Since $\mathbf{R}$ has at most rank 1, $(\mathbf{uv}' - \mathbf{vu}')\mathbf{R}'$ has at most rank 1. Thus M is the sum of matrices with at most rank 2 and 1 respectively so that it has at most rank 3. Since it is antisymmetric, by Lemma 2 it has rank 0 or 2, consequently S is SR1, from Lemma 1. *Q.E.D.*

APPENDIX B: DATA APPENDIX

The Canadian FAMEX is a multi-staged stratified clustered survey that collects information on annual expenditures, incomes, labor supply, and demographics for individual households. The survey is run in the Spring after the survey year (that is, the information for 1978 was collected in Spring 1979). All of the information is collected by interview so that the expenditure and income data are subject to recall bias. Although this may give rise to problems, the FAMEX surveying method has the great advantage that information on annual expenditures is collected. Thus the FAMEX has much less problem with infrequency bias than do surveys based on short diaries. For example, the proportion of households reporting zero expenditure on clothing is about 3% in the FAMEX whereas it is over 50% in the U.K. FES. It is also the case that since the survey year coincides with the tax year (January to December) the income information is thought to be unusually reliable since it is collected at about the time that Canadians are filing their (individual) tax returns. These are often explicitly referenced by the enumerators.

Prices are taken from Statistics Canada. When composite commodities are created, the new composite commodity price is the weighted geometric mean of the component prices with budget

TABLE DI

SAMPLE SELECTION

	Single Females	Single Males	Couples
Full sample	7,343	4,653	12,237
In full-time employment	2,229	2,084	2,512
Age < 65	2,179	2,052	2,458
Incomes positive	2,179	2,051	2,449
Education level given	2,173	2,048	2,442
Reasonable expenditures	2,173	2,044	2,440
Reasonable earnings	2,173	2,044	2,428

Sample years: 1974, 1978, 1982, 1984, 1986, 1990, 1992.

shares averaged across the strata (couples, single males, and single females) for weights. Thus, the weights are not the individual household budget shares.

Table DI gives the sample selection path followed; the principal selection is on all agents being in full-time employment and under the age of 65. As well, we select on the education level being observed, net household income being positive, and, for couples, gross earnings being above $2981 (in 1992 terms) (see "reasonable earnings" in the Table). Finally, in 1978 expenditures on recreational vehicles are not given separately from other spending on recreation. This lead to a small number of very high values for the latter in 1978; these have been deleted (see "reasonable expenditures" in the Table).

Experiments were also made with "cleaner" samples than those reported (for example, households with very low net incomes or high budget shares for some goods were excluded). In no case were the qualitative results different.

TABLE DII

DESCRIPTION OF BUDGET SHARES AND INCOMES

	Couples		Single Females		Single Males	
Budget Shares	Mean	# Zeros	Mean	# Zeros	Mean	# Zeros
Food at Home (F)	.202	1	.205	15	.174	37
Food Outside (E)	.104	27	.104	74	.148	58
Men's Clothing (M)	.054	14	0	2,173	.085	23
Women's Clothing (W)	.084	6	.149	6	0	2,044
Hhold Operations (H)	.125	1	.169	0	.101	1
Recreation (R)	.107	10	.098	46	.123	33
Transport (T)	.245	9	.209	11	.247	21
Vices (V)	.078	79	.065	266	.122	121
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Total Expenditure[a]	23,815	8,501	12,162	5,004	15,027	6,357
Hhold Net Income[a]	55,324	19,248	26,039	10,101	31,478	14,192
Gross Earnings (Husb.)[a]	41,262	20,015	—		—	
Gross Earnings (Wife)[a]	29,318	13,201	—		—	
	Mean	Range	Mean	Range	Mean	Range
Price of Vices	0.53	0.175–1.04	0.52	0.175–1.04	0.54	0.175–1.04

[a]All values in 1992 Canadian dollars ($1 Canadian ≈ $0.75 U.S. ≈ £0.50 U.K.).

TABLE DIII

MEANS OF DEMOGRAPHIC VARIABLES

	Couples	Single Females	Single Males
Atlantic	.145	.150	.137
Quebec	.192	.188	.169
Prairies	.294	.320	.312
B.C.	.103	.100	.131
Car Owner	.949	.634	.773
Homeowner	.645	.228	.281
City Dweller	.810	.845	.811
Age[a]	37.3	38.6	36.6
More than High School[a]	.190	.174	.226
Francophone[a]	.196	.187	.172
Allophone[a]	.112	.095	.113
White Collar[a]	.376	.406	.376
Age of Wife	35.0	—	—
Wife White Collar	.345	—	—

[a] Refers to husband for couples.

Tables DII and DIII present sample means and other statistics for all of the variables used in the analysis (except for the homogeneous prices).

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