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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* $(\bar{\mathbf{q}}^A, \bar{\mathbf{q}}^B, \bar{\mathbf{Q}})$ *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*

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

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 **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 **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 SR*1.

(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 SR*1.

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 $(\mu_1 \dots \mu_k)$ 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 ξ_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, $\xi_y = \mathbf{0}$) 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, ξ_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*: $\xi_{y_i} = \theta_i \xi_{y_1}$ *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

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

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

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

and

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

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

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

[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

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

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," $\mathbf{z}$, or "distribution factors" $\mathbf{y}$. We include the preference factors in the conventional way by allowing them to modify the parameters of the indices $a(\mathbf{p})$ and $b(\mathbf{p})$:

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

and

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

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

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

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

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

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:

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

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

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

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, $l_{\boldsymbol{\alpha}}$ 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
Overidentification	1.9 (6) [92.6%]	6.69 (6) [35.1%]	41.8 (21) [0.54%]
Symmetry	11.1 (15) [74.7%]	17.4 (15) [29.7%]	49.4 (21) [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 than High School	0.09	0.22	0.79	0.77	0.23	0.11	−1.09
	(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 Collar	−0.59	0.18	0.34	0.93	0.23	0.24	−0.34
	(0.39)	(0.21)	(0.39)	(0.31)	(0.16)	(0.23)	(0.30)
Wife White Collar	−0.29	0.57	0.09	−0.36	0.34	0.21	−0.73
	(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 Log Earnings	−0.53	−0.26	0.17	0.29	−0.18	0.38	−0.26
	(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 → Restriction →	Unitary Unrestricted	Collective Unrestricted	Collective 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 $\Gamma = (\mathbf{f}_{\mathbf{p}} + \mathbf{f}_x\mathbf{f}')$ 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 $S = \Sigma + \mathbf{u}\mathbf{v}'$ (where Σ is symmetric) is not symmetric, then $\mathbf{u}$ and $\mathbf{v}$ are linearly independent; otherwise $S = \Sigma + \mathbf{u}\mathbf{v}' = \Sigma + \lambda\mathbf{v}\mathbf{v}'$ for some λ and hence S is symmetric. Thus $M = S - S' = \mathbf{u}\mathbf{v}' - \mathbf{v}\mathbf{u}'$, 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 $\mathbf{w} = M\mathbf{z} = (\mathbf{u}\mathbf{v}' - \mathbf{v}\mathbf{u}')\mathbf{z} = (\mathbf{v}'\mathbf{z})\mathbf{u} - (\mathbf{u}'\mathbf{z})\mathbf{v}$ 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 $M = \mathbf{a}\mathbf{b}' + \mathbf{c}\mathbf{d}'$ for some vectors $\mathbf{a}, \mathbf{b}, \mathbf{c}, \mathbf{d}$; then anti-symmetry requires that $M = \mathbf{a}\mathbf{b}' - \mathbf{b}\mathbf{a}'$ 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

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

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 $M = \mathbf{a}\mathbf{b}' - \mathbf{b}\mathbf{a}' = \lambda(\bar{\mathbf{u}}\bar{\mathbf{v}}' - \bar{\mathbf{v}}\bar{\mathbf{u}}')$. *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 $S = \Sigma + \mathbf{f}\mu(\mu_{\mathbf{p}} + \mu_x \mathbf{q})'$. From $\xi(\mathbf{p}, x, y) = \mathbf{f}(\mathbf{p}, x, \mu(\mathbf{p}, x, y))$ we have $\xi_y(\mathbf{p}, x, y) = \mathbf{f}_\mu \mu_y$. Thus $S = \Sigma + \xi_y(\mu_{\mathbf{p}} + \mu_x \mathbf{q})'(1/\mu_y) = \Sigma + \xi_y \mathbf{v}'$.

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

PROOF OF PROPOSITION 8: From $\xi(\mathbf{p}, x, y_1, y_2 \cdots y_m) = \mathbf{f}(\mathbf{p}, x, \mu(\mathbf{p}, x, y_1, y_2 \cdots y_m))$ we have $\xi_{y_i} = \mathbf{f}_\mu \mu_{y_i} = (\mu_{y_i}/\mu_{y_1})\xi_{y_1}$. *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 ξ. *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 $\mathbf{R} = \frac{1}{2}(\beta + 2\lambda(\tilde{x}/b(\mathbf{p})))\mathbf{p}'$ 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 $\Gamma = \Sigma^* + \mathbf{u}\mathbf{v}'$ where Σ^* is symmetric. Then:

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

Since $\mathbf{R}$ has at most rank 1, $(\mathbf{u}\mathbf{v}' - \mathbf{v}\mathbf{u}')\mathbf{R}'$ 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).

REFERENCES

BANKS, JAMES, RICHARD BLUNDELL, AND ARTHUR LEWBEL (1992): "Quadratic Engel Curves, Welfare Measurement and Consumer Demand," Institute for Fiscal Studies (IFS) Working Paper: W92/14.

BECKER, GARY S. (1991): *A Treatise on the Family*. Cambridge and London: Harvard University Press.

BERGSTROM, THEODORE C. (1989): "A Fresh Look at the Rotten Kid Theorem—and Other Household Mysteries," *Journal of Political Economy*, 97, 1138–1159.

BLACKORBY, CHARLES, AND DAVID DONALDSON (1993): "Adult Equivalence Scales and the Economic Implementation of Interpersonal Comparisons of Well Being," *Social Choice and Welfare*, 10, 335–361.

BLUNDELL, RICHARD, PIERRE-ANDŔE CHIAPPORI, THIERRY MAGNAC, AND COSTAS MEGHIR (1998): "Collective Labor Supply: Heterogeneity and Nonparticipation," Mimeo, UCL.

BLUNDELL, RICHARD, PANOS PASHARDES, AND GUGLIELMO WEBER (1993): "What Do We Learn About Consumer Demand Patterns from Micro Data?" *American Economic Review*, 83, 570–597.

BLUNDELL, RICHARD, AND JEAN-MARC ROBIN (1993): "An Iterated Moment Estimator for Conditionally Linear Equation Systems," Unite de Recherche Document de Travail ENSAE/INSEE: 9342.

BOURGUIGNON, FRANÇOIS (1984): "Rationalité Individuelle ou Rationalité Strategique: Le Cas de l'Offre Familiale de Travail," *Revue Economique*, 35, 147–162.

BOURGUIGNON, FRANÇOIS, MARTIN BROWNING, AND PIERRE-ANDRÉ CHIAPPORI (1995): "The Collective Approach to Household Behaviour," Mimeo, DELTA, Paris.

BOURGUIGNON, FRANÇOIS, MARTIN BROWNING, PIERRE-ANDRÉ CHIAPPORI, AND VALÉRIE LECHENE (1993): "Intra Household Allocation of Consumption: A Model and Some Evidence from French Data," *Annales d'Economie et de Statistique*, 137–156.

BOURGUIGNON, FRANÇOIS, AND PIERRE-ANDRÉ CHIAPPORI (1993): "Collective Models of Household Behavior: An Introduction," *European Economic Review*, 36, 355–364.

BROWN, DONALD, AND ROSA MATZKIN (1995): "Estimation of Nonparametric Functions in Simultaneous Equations Models, with an Application to Consumer Demand," Mimeo, Northwestern University.

BROWNING, MARTIN, FRANÇOIS BOURGUIGNON, PIERRE-ANDRÉ CHIAPPORI, AND VALÉRIE LECHENE (1994): "Income and Outcomes: A Structural Model of Intrahousehold Allocation," *Journal of Political Economy*, 102, 1067–1096.

BROWNING, MARTIN, AND COSTAS MEGHIR (1991): "The Effects of Male and Female Labor Supply on Commodity Demands," *Econometrica*, 59, 925–951.

CHIAPPORI, PIERRE-ANDRÉ (1988a): "Rational Household Labor Supply," *Econometrica*, 56, 63–90.

——— (1988b): "Nash Bargained Household Decisions: A Comment," *International Economic Review*, 29, 791–796.

——— (1990): "La Fonction de Demande Agrégée en Biens Collectifs: Théorie et Application," *Annales d'Economie et de Statistiques*, 19, 27–42.

——— (1991): "Nash Bargained Household Decisions: A Rejoinder," *International Economic Review*, 32, 761–762.

——— (1992): "Collective Labor Supply and Welfare," *Journal of Political Economy*, 100, 437–467.

CHIAPPORI, PIERRE-ANDRÉ, BERNARD FORTIN, AND GUY LACROIX (1998): "Household Labor Supply, Sharing Rule and the Marriage Market," Mimeo, University of Chicago.

FORTIN, BERNARD, AND GUY LACROIX (1997): "A Test of the Neo-Classical and Collective Models of Labour Supply," *Economic Journal*, forthcoming.

FRY, VANESSA, AND PANOS PASHARDES (1992): "An Almost Ideal Quadratic Logarithmic Demand System for the Analysis of Micro Data," Oxford Applied Economics Discussion Paper Series: 145.

LEWBEL, ARTHUR (1991): "The Rank of Demand Systems: Theory and Non-parametric Estimation," *Econometrica*, 59, 711–730.

LUNDBERG, SHELLY, ROBERT A. POLLAK, AND TERENCE WALES (1997): "Do Husbands and Wives Pool Their Resources? Evidence From the U.K. Child Benefit," *Journal of Human Resources*, 32, 463–480.

MANSER, MARILYN, AND MURRAY BROWN (1980): "Marriage and Household Decision Making: A Bargaining Analysis," *International Economic Review*, 21, 31–44.

MCELROY, MARJORIE B. (1990): "The Empirical Content of Nash Bargained Household Behavior," *Journal of Human Resources*, 25, 559–583.

MCELROY, MARJORIE B., AND MARY JEAN HORNEY (1981): "Nash Bargained Household Decisions: Toward a Generalization of the Theory of Demand," *International Economic Review*, 22, 333–349.

——— (1990): "Nash Bargained Household Decisions: Reply," *International Economic Review*, 31, 237–242.

PHIPPS, SHELLEY, AND PETER BURTON (1992): "What's Mine is Yours? The Influence of Male and Female Incomes on Patterns of Household Expenditure," Working Paper 92-12, Department of Economics, Dalhousie University.

POLLAK, ROBERT A. (1985): "A Transaction Cost Approach to Families and Households," *Journal of Economic Literature*, 23, 581–608.

SAMUELSON, PAUL (1956): "Community Indifference Curves," *Quarterly Journal of Economics*, 70, 1–22.

SCHULTZ, T. PAUL (1990): "Testing the Neoclassical Model of Family Labor Supply and Fertility," *Journal of Human Resources*, 25, 599–634.

SHAFER, WAYNE, AND HUGO SONNENSCHEIN (1982): "Market Demand and Excess Demand Functions," Ch. 14 in *Handbook of Mathematical Economics*, Volume 2, ed. by Kenneth Arrow and Michael Intriligator. Amsterdam: North Holland.

THOMAS, DUNCAN (1990): "Intra Household Resource Allocation: An Inferential Approach," *Journal of Human Resources*, 25, 635–664.

New Developments in Aggregation Economics

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Abstract

The goal of this article is to provide a general characterization of the aggregate behavior of a group in a market environment. We allow for public and private consumption, intragroup production, and consumption externalities within a group; we only assume that the group always reaches Pareto-efficient decisions. We show that aggregation problems involve a simple mathematical structure: The aggregate demand of the group, considered as a vector field, can be decomposed into a sum of gradients. We briefly introduce exterior differential calculus as a tool to study this structure. We analyze two main issues. One is testability: What restrictions (if any) on the aggregate demand function characterize the efficient behavior of the group? The second issue relates to identifiability; we investigate the conditions under which it is possible to recover the underlying structure—namely, individual preferences, the decision process, and the resulting intragroup transfers—from the group's aggregate behavior.

1. INTRODUCTION

The notion of aggregation is pervasive in economics.[1] Many (arguably most) economic decisions are made by groups, not individuals, with firms as an obvious example. It has long been recognized that the standard model of a unique, profit-maximizing decision unit often must be extended to take into account the multiperson nature of the decision process. The same remark applies to committees, clubs, villages, and other local organizations, which have also attracted much interest. Even standard micro demand analysis, although it routinely uses the tools of consumer theory, exploits data on households or families, which in general gather several individuals. Partial equilibrium analysis relies on aggregate demand or supply functions. And, quite obviously, macroeconomics concentrates on the aggregate behavior of vast classes of agents (households, firms, etc.), each being routinely identified with a single decision maker.

In all these cases, aggregation issues are raised, at least implicitly. When can a multiperson entity be analyzed as a single decision maker (i.e., when is there a representative consumer)? What data are needed to fully summarize the situation of a group? Are there testable restrictions on aggregate behavior stemming from the utility- (or profit-) maximizing actions of each member? Can one formulate welfare evaluations at the aggregate level, and what are their implications for the individuals under consideration? To what extent is it possible to recover information on individual-level characteristics (e.g., preferences, resources) or the intragroup decision process from the sole observation of aggregate behavior?

Quite often, answers to these questions are taken for granted without much analysis; for instance, macro models typically assume the existence of a representative agent with little discussion of either the prerequisites for the assumption or its implications. Still, theoretical investigations of the aggregation issues just mentioned, and of many others, have been available for several decades. Moreover, the field of aggregation theory has recently attracted renewed interest. Old, open problems have been solved; existing questions have been reconsidered from a different perspective; and more generally, a new subfield has emerged, with original emphasis, techniques, and results. In this review, we survey some of these recent developments.

The structure of the review is as follows. We first describe the notations we use throughout the article. Section 3 then briefly summarizes the main features of traditional aggregation theory, as it has developed up to the late 1970s and early 1980s. Section 4 describes how some of the traditional questions have recently been solved or reinterpreted. The recent literature on the aggregate behavior of small groups (i.e., aggregation in the small) is covered in Section 5.

Finally, one caveat is in order. The goal of this article is simply to provide a quick overview of some recent results. For the sake of brevity, we omit the proofs of some of the most important (and most complex) results, as well as many interesting but specific developments. The interested reader is referred to our recent book (Chiappori & Ekeland 2009a) for a more complete exposition.

[1]Throughout the article, we consider issues related to aggregation over individuals. The word aggregation is sometimes used in a totally different context—namely, the aggregation of several commodities into some composite good (e.g., the aggregation of various types of meat, vegetables, and dairy into the general category of food). The aggregation of commodities is not considered in this article.

2. NOTATION

We first define the notation used throughout the article. In what follows, the transpose of vector x is denoted x^T, and the scalar product of vectors x and y is denoted $x^T y$.

2.1. Commodities

We consider a group consisting of H members. Agents may consume M commodities, I of which are privately consumed by each member, while the remaining $J = M - I$ are public within the group; formally, the list of commodities may include leisure. Moreover, a given, physical commodity may be further indexed by the period or the state of the world (or both) at which it is available. Therefore, our setting extends to intertemporal behavior (savings, investment, human capital accumulation) as well as risk sharing and group decision under uncertainty.

Let x_h^i denote the private consumption of commodity i by group member h, and X^j the group's consumption of public good j. An allocation is a $J + HI$ vector $(X, x_1, \ldots, x_H)$, where

$$X = \left(X^1, \ldots, X^J\right) \in \mathbb{R}^J$$

and

$$x_h = \left(x_h^1, \ldots, x_h^I\right) \in \mathbb{R}^I \text{ for } h = 1, \ldots, H,$$

and the group's aggregate demand is the vector $(X, x) \in \mathbb{R}^M$, where $x = \sum_h x_h$. For brevity, the vector (X, x) is often denoted ξ.

2.2. Utility Functions

We assume that each person has a utility function over allocations. We denote h's utility function by $U^h(X, x_1, \ldots, x_H)$. This formulation is fully general; it allows the utility of h to depend on the private consumption of other members in a nonrestricted way. This interaction may be the result of altruism (i.e., h cares about other members' well-being) or paternalism (h is concerned with her partners' consumptions); it may also reflect other external impacts between consumptions (e.g., a member's smoking bothers the other members by reducing their utility, an intragroup externality in the usual sense). In particular, other members' consumption of private goods may impact h's marginal rate of substitution between her own private and public goods; in other words, we do not impose separability restrictions so far.

The utility functions $U^h, h = 1, \ldots, N$, are assumed continuously differentiable and strictly concave. In some cases, one will require stronger restrictions (e.g., infinite differentiability; strong concavity, requiring that the matrix of second derivatives is negative definite everywhere; or strong quasi-concavity, requiring that the restriction of this matrix to the subspace orthogonal to the gradient is negative definite).

Although quite reasonable, the form just described is sometimes too general—if only because it is difficult to incorporate such preferences into a model in which agents live alone for some part of their life cycle. Consequently, in many models preferences are egoistic, of the form $U^h(X, x_h)$. Finally, a fraction of the literature deals with market economies. In this context, preferences are strictly egoistic, and all commodities are

privately consumed. In particular, interactions between group members (if any) are restricted to commodity trading. Then the general form just defined boils down to

$$U^h(X, x_1, \ldots, x_H) = u^h(x_h). \tag{1}$$

2.3. Aggregate Budget Constraint

Let p denote the price vector of private goods, P the price vector of public goods, and y the group's total income. Again, for brevity, the vector (P, p) is often denoted π, so the aggregate demand (as a function of prices and income) becomes $\xi(\pi, y)$.

The group has limited resources. Specifically, its purchase vector $\xi = (X, x)$ must satisfy a standard market budget constraint of the form

$$\pi^T \xi = P^T X + p^T \left(\sum_h x_h \right) \leq y.$$

Throughout, we assume that behavior is zero homogeneous in prices and income. For some computations, we therefore may normalize the group's total income to be one. Also, we sometimes consider the group's budget shares, defined by

$$\Psi = (\Psi_1, \ldots, \Psi_M) \text{ where } \Psi^i = \frac{\pi_i \xi^i}{y}.$$

3. STANDARD AGGREGATION THEORY: A BRIEF OVERVIEW

As a first step, it is useful to briefly reconsider some crucial aspects of aggregation theory as it has developed up until the early 1980s. Our goal here is not to provide a survey; the interested reader is referred to, for instance, Deaton & Muelbauer (1980) and Shafer & Sonnenschein (1982) for that purpose. Instead, we want to briefly recall the main features of this literature, and in particular the questions it asked and the answers it provided. The general notion of aggregation theory gathers a host of different and more or less related approaches. To provide an overview, we find it convenient to distinguish between two core approaches: one in which the group is considered as a (mostly exchange) economy and a more general perspective that allows for richer interactions such as public consumptions or intragroup production.

3.1. Groups as Market Economies

In this first subsection, we assume that all commodities are privately consumed; we thus rule out public goods, as well as externalities of any type, and do not consider intragroup production. A few questions have played a crucial role in the development of the various branches of the field, and we organize our presentation around them.

3.1.1. When does a group behave as a single decision maker? A first question relates to the conditions under which the aggregate behavior of a group can validly be described using the tools of standard consumer theory. A first version, which has been known for at least a century [since Antonelli's (1971[1886]) pathbreaking result], is the following. Assume that some total income y is distributed between H agents, who each freely spends his share on several goods. When is it the case that the group's aggregate demand

for each good can be expressed as a function of y alone (i.e., does not depend on how the income has been allocated within the group)? The answer is straightforward: For the property to be satisfied, it must be the case that transferring a dollar from one group member to another does not change total consumption—in other words, the marginal propensity to consume (MPC) each good must be the same for all agents, irrespective of their income. This can only happen under two conditions: (*a*) Each agent's MPC is independent of the agent's income, and (*b*) these constant MPCs are identical across agents. In other words, individual Engel curves must be linear or affine, and the coefficients of income must be common to all agents. When it is the case, one can readily show that the resulting, aggregate demand is compatible with utility maximization.

Clearly, this statement sounds like an impossibility result. Although a group may in theory behave like a single individual, the restrictions required in practice are quite stringent. Cross-section consumer expenditure data provide strong evidence against hypotheses (*a*) and (*b*), at least under the standard assumption that, among consumers with the same observable characteristics, preferences are distributed independently of income.

This negative conclusion has led to a reformulation of the question along a slightly different line, usually called exact nonlinear aggregation. Assume, again, that total income is distributed between the agents, with agent h receiving some amount y_h. Lau (1982) asks, when can one find some (possibly vector-valued) aggregate statistic $\tilde{y}$, dependent on the distribution of income within the group, such that aggregate demands can be expressed as functions of prices and $\tilde{y}$ only? The answer is positive when individual demands have the form

$$x_h^i(p, y_h) = \sum_{k=1}^{K} a_h^{k,i}(p) b_h^{k,i}(y_h). \tag{2}$$

Gorman (1981) proves that for each h and p, the matrix $a_h^{k,i}(p)$ has rank 3 or less. Moreover, the maximum rank can be reached only for specific functions $b_k^h(y_h)$ (see Lewbel 1991 on such rank restrictions). A specification widely used in empirical applications is the PIGLOG form, in which $K = 2$, $b_h^{1,i}(y_h) = y_h$, and

$$b_h^{2,i}(y_h) = y_h \ln(y_h).$$

This yields a so-called Working-Leser functional form (Lau 1982), with individual budget shares of the form

$$\psi_h^i(p, y_h) = p_i a_h^{1,i}(p) + p_i a_h^{2,i}(p) \ln(y_h). \tag{3}$$

If, in addition, $a_h^{1,i}$, $a_h^{2,i}$, and b_h^i are independent of h, then aggregate demand becomes

$$\Psi^i = p_i a^{1,i}(p) + p_i a^{2,i}(p) \ln(\tilde{y}),$$

where $\tilde{y}$ is defined by

$$\ln \tilde{y} = \frac{\sum_h y_h \ln(y_h)}{\sum_h y_h},$$

which is closely related to Theil's inequality index.[2]

[2]Specifically, Theil's index is defined by $T_1 = \frac{\sum_h y_h \ln(y_h)}{\sum_h y_h} - \ln(\bar{y}) = \ln(\tilde{y}/\bar{y})$, where $\bar{y}$ denotes average income.

In that case, aggregate market shares Ψ_i only depend on individual incomes through the aggregate indicator $\tilde{y}$. Moreover, they have exactly the same form as the individual market shares in Equation 3; therefore, they can be derived from the maximization of a utility of the same form, using the aggregate indicator $\tilde{y}$ as the group's pseudo-income. It follows that, in terms of budget shares, the group behaves like a single agent, endowed with the same utility as each individual in the group and a pseudo-income equal to $\tilde{y}$. Moreover, as the same functional form can be used at both the individual and the aggregate levels, this specification may be useful when individual data do not display enough price variation. Indeed, a strong motivation for earlier research was the design of a demand function that would allow the estimation of Engel curves from cross-sectional data and of price effects from aggregate time series.

One can see from this example that one drawback of Antonelli's restrictions—the lack of realism of individual demands—is largely alleviated by the nonlinear aggregation approach. In fact, state-of-the-art estimations of individual demands routinely use functional forms such as the quadratic almost ideal demand system (Banks et al. 1997) with budget shares of the rank-3 Gorman form:

$$\psi_h^i(p, y_h) = p_i a_h^{1,i}(p) + p_i a_h^{2,i}(p) \ln(y_h) + p_i a_h^{3,i}(p) \ln^2(y_h).$$

However, the second problem remains: Aggregation is possible only under very strong restrictions regarding heterogeneity of preferences (in our example, all agents must have identical preferences, although this can be slightly relaxed). In short, a representative consumer may exist for acceptably general individual demands—but only when agents have similar preferences.[3]

A last remark is that one should be cautious with welfare judgments suggested by the representative consumer's utility. Indeed, several authors have provided examples showing that a given reform may increase the utility of the representative consumer while decreasing the welfare of all individuals in the economy (see, for instance, Jerison 1984b, Dow & da Costa Werlang 1988).

3.1.2. Is some structure preserved by (large-scale) aggregation? A second line of research adopts the opposite viewpoint. Instead of imposing a priori some desired structural properties of aggregate demand (e.g., the existence of a representative consumer) and trying to find sufficient conditions on individual preferences for these properties to be satisfied, these approaches consider general preferences and ask which structure (if any) aggregate demand must have, given that each individual in the economy maximizes a well-behaved utility under a budget constraint. We have known for a long time that utility maximization generates a lot of structure for individual demands (namely, the symmetry and negativeness of the Slutsky matrix); the question is whether (some of) this structure is preserved by aggregation.

The problem was initially raised by Sonnenschein (1973) in a seminal article. Technically, Sonnenschein states two versions of the problem. In both cases, individuals each maximize utility under a budget constraint, but in the first version each individual

[3]More heterogeneity of individual preferences can be allowed if the distribution of income is restricted, for example, if the consumers get fixed shares of aggregate income, as in the case of workers with different skill levels and no other capital (see Jerison 1984a,b; Mas-Colell et al. 1994, chapter 4).

h receives some nominal income y_h, whereas in the second each receives a fixed endowment ω_h. Technically, individual maximization programs are therefore of the form

$$\begin{aligned} &\max_{x_h} U^h(x_h) \text{ subject to} \\ &p^T x_h = y_h \end{aligned} \tag{4}$$

in the first case and

$$\begin{aligned} &\max_{x_h} U^h(x_h) \text{ subject to} \\ &p^T x_h = p^T \omega_h \end{aligned} \tag{5}$$

in the second. The first case corresponds to the market demand problem; the second determines the agent's excess demand, defined as the difference between the agent's desired consumption bundle and her initial endowment.

In both cases, aggregate demand depends on prices and initial endowments. The main question, however, is the characterization of aggregate demand as a function of prices. It can therefore be stated as follows: Consider a given function $x(p)$. When is it possible find H smooth, increasing, strongly concave utility functions U^h and (*a*) (market demand) H scalars $(y_1, \ldots, y_H)$ such that

$$x(p) = \sum_h x_h(p),$$

where $x_h(p)$ solves Equation 4 and (*b*) (excess demand) H vectors $(\omega_1, \ldots, \omega_H)$ in $\mathbb{R}^N$ such that

$$x(p) = \sum_h x_h(p),$$

where $x_h(p)$ solves Equation 5.

The statement of the excess demand case can actually be slightly simplified. For any given set of direct utilities $\{U^1, \ldots, U^H\}$ and initial endowments $\{\omega_1, \ldots, \omega_H\}$, one can define the utilities $\{\tilde{U}^1, \ldots, \tilde{U}^H\}$ by $\tilde{U}^h(z) = U^h(z + \omega_h)$, $h = 1, \ldots, H$. With this notation, and defining $z_h = x_h - \omega_h$, the program in Equation 5 can be rewritten as

$$\begin{aligned} &\max_{z_h} \tilde{U}^h(z_h) \text{ subject to} \\ &p^T z_h \leq 0. \end{aligned} \tag{6}$$

There are obvious restrictions that the aggregate market or excess demand will satisfy. One is continuity (or differentiability in our context). Another is adding up (sometimes called the Walras law); namely, it must be the case that $p^T x(p) = \sum_h y^h$ for market demand, and $p^T z(p) = \sum_h p^T [x_h(p) - \omega_h] = 0$ for excess demand. Finally, excess demand functions are zero homogeneous in prices. The question is whether these properties are sufficient or whether the underlying structure generates stronger properties at the aggregate level.

In practice, a large fraction of the subsequent literature has been devoted to the case of a large economy, i.e., one in which the number of agents exceeds the number of commodities. Sonnenschein's conjecture was that in large economies, the obvious properties just listed fully characterize aggregate demands: Individual structure is therefore lost by aggregation, at least if the latter takes place on a sufficiently large scale.

Within months after Sonnenschein's initial statement, the excess demand case was independently solved by Mantel and Debreu [this literature is actually often referred to as Debreu-Mantel-Sonnenschein (DMS)]. Specifically, Mantel (1974) establishes that any smooth function satisfying homogeneity and adding up could be decomposed on any compact set of prices as the aggregate excess demand of an economy with at least $H=2M$ agents. Debreu (1974) shows that the result is valid for $H=M$, and Mantel (1976) proves that, in addition, one could assume that all utilities were homothetic.

Chiappori & Ekeland (2004) provide a short proof of a slightly stronger result. Their approach is based on the properties of individual excess demand functions. Surprisingly enough, given their theoretical importance, individual excess demands had not been studied in detail until recently. Their key result is the following. Suppose that $V(p)$ is a smooth function defined on some neighborhood $\mathcal{O}$ of $\bar{p}$, with $D_p V(\bar{p}) \neq 0$. Assume that it is quasi-convex, positively homogeneous of degree zero [which implies that $p^T \cdot D_p V(p) = 0$], that $D^2_{pp} V(p)$ has rank $(N-1)$, and that the restriction of $D^2_{pp} V(p)$ to $\mathrm{Span}\{p, D_p V(p)\}^{\perp}$ is positive definite. Take any C^2 function $\lambda(p) > 0$, homogeneous of degree (–1) on $\mathcal{O}$, and set

$$z(p) = -\frac{1}{\lambda(p)} D_p V(p) \tag{7}$$

so that $p^T z(p) = 0$. Then $z(p)$ is the excess demand function of some consumer; i.e., there exists a strictly quasi-concave function $U(z)$ defined and C^2 in a neighborhood $\mathcal{N}$ of $z(\bar{p})$, such that V is the indirect utility associated with U. It follows, in particular, that if $z(p)$ is an individual excess demand, then for any positive, zero-homogeneous scalar function $\zeta(p)$, $\zeta(p)z(p)$ is also an individual excess demand.

Consider now some compact subset K of the positive orthant. For $H \geq M$, take some family $V^h(p)$, $1 \leq h \leq H$, such that at every $p \in K$, the set of linear combinations of $DV^h(p)$ with nonnegative coefficients spans $T_p S^{N-1}$ (the tangent space $T_p S^{N-1}$ at p to the N-dimensional simplex, to which the price vector can be normalized to belong). Then for any C^2 map $x(p)$ defined on K, homogeneous of degree zero and satisfying the Walras law $p^T x(p) = 0$, one can find excess demand functions $z_h(p)$, $1 \leq h \leq H$, such that the decomposition $x(p) = \sum_h z_h(p)$ holds on K and the indirect utility associated with z_h is V^h. This version of the result is slightly stronger than Debreu's because the indirect utilities can be defined independently of the excess demand at stake; i.e., the same $V^1(p), \ldots, V^H(p)$ can be used in the decomposition of any given function.[4]

The DMS result was quite influential in the profession. Its theoretical implications are far from trivial; for instance, it immediately implies that for any compact subset of the positive orthant, one can always find economies with exactly one equilibrium within the compact subset, such that this equilibrium is not stable by the Walrasian tatonnement. From a more epistemological perspective, it has also been widely interpreted as a negative result: If aggregate demand can be anything, it was argued, then general equilibrium theory has no testable implication (except maybe the existence of an equilibrium), at least when applied to a large-enough economy. As shown below, this somewhat excessive claim, however, has been drastically reconsidered by the recent literature on the topic.

[4]This property may sound surprising. In sharp contrast with market demands, it reflects the existence of a continuum of individual excess demands that correspond to the same indirect utility (of course, they involve different initial endowments in general).

Finally, the case of a small economy (i.e., one with fewer agents than goods) has been considered by Diewert (1977) and Geanakoplos & Polemarchakis (1980). These authors show that, in such a setting, additional conditions (beyond the obvious ones) have to be fulfilled for a given function to be the aggregate excess demand of such an economy. Their approach relies on a local linearization of the problem; in particular, although the conditions they provide are indeed necessary, neither article provides sufficiency results. We come back to these results below.

3.1.3. Can aggregation create structure? The main conclusion of the Sonnenschein program is that assembling a sufficiently large number of sufficiently diverse utility maximizers may result in a collective demand with bizarre (in fact arbitrary) properties; in short, aggregation in the large tends to destroy any structure that may exist at the individual level (and in small groups; see below). An interesting question, however, relies on the opposite perspective: Is it the case that the aggregation of sufficiently diverse individual demands results in an object that is more regular than its component? In other words, can aggregation create structure?

This line of research has been pioneered by Hildenbrand. In a series of papers, Hildenbrand (1983, 1994) investigates the law of demand (LD) (see Hicks 1956). Denoting by $X(p)$ a demand function, it is said to satisfy the LD if the inequality

$$[X(p) - X(q)]^T (p - q) \leq 0$$

holds for all price systems p and q. If $X(p)$ is differentiable, it is equivalent to the Jacobian matrix

$$D_p X = \left(\frac{\partial X^i}{\partial p_j}\right)_{1 \leq i, j \leq I}$$

being negative semidefinite at every p. Roughly speaking, the LD means that consumption and prices move in opposite directions. It implies that the demand curve for every good is downward sloping, but it is of course much more. For instance, if aggregate demand satisfies the LD, then the equilibrium is unique.

It is well known (e.g., Giffen goods) that individual demand functions need not satisfy the LD. For an individual having nominal income y, Marshallian demand is a function $x(p, y)$, and we have

$$D_p x = S(p, y) - (D_y x)x',$$

where D_p and D_y denote partial derivatives. The first term on the right-hand side, $S(p, y)$, is the Slutsky matrix, which is negative definite. The second term on the right-hand side, $(D_y x)x'$, describes the income effect, that is, the change in wealth due to the change in prices. If preferences are homothetic, it is positive semidefinite, so the LD is satisfied. Apart from this special case, the income effect bites, and the LD needs not be satisfied at the individual level.

Hildenbrand's idea is that the LD can nevertheless be satisfied at the macroeconomic level because of special properties of the income distribution. This idea is best explained from the example in Hildenbrand (1983). Suppose all individuals have identical preferences, and the income distribution has a differentiable density $\mu(y)$ on $[0, \bar{y}]$ with $\mu(\bar{y}) = 0$. The aggregate demand is

$$X(p) = \int_0^{\bar{y}} x(p, y)\mu(y)dy.$$

The aggregate Slutsky matrix is obviously negative definite, and the aggregate income effect is

$$\sum \int_0^{\bar{y}} \frac{\partial x^i}{\partial y} x^i \mu(y)dy = \sum \int_0^{\bar{y}} \frac{\partial}{\partial y} \left(x^i\right)^2 \mu(y)dy$$
$$= -\sum \int \left(x^i\right)^2 \frac{d\mu}{dy} dy,$$

where we have integrated by parts. The two boundary terms vanish, the first one because $x^i(0) = 0$ and the second one because $\mu(\bar{y}) = 0$, and we are left with the integral term. Now a striking result emerges: If $\frac{d\mu}{\partial y} \leq 0$, that is, if the density is decreasing, then the aggregate income effect is positive definite, and the collective demand $X(p)$ satisfies the LD, even though the individual demands do not. Of course, it is unrealistic to assume that individuals have identical preferences, but this example vindicates the idea that particular properties of the wealth distribution can result in the LD. As shown in Chiappori (1985), one can also obtain the LD by putting conditions on the form of both individual demand and the wealth distribution, the Hildenbrand result, in which all preferences are identical, being just a polar case. The question is then to find characteristics of consumption and wealth distributions that (*a*) are empirically verifiable and (*b*) will generate the LD.

Jerison (1982, 1999) shows that aggregate demand satisfies the weak axiom of revealed preference (RP), a weak version of the LD, if there is increasing demand dispersion, that is, if the cloud of consumption vectors for individuals of a given income level is increasingly dispersed as the level rises (in other words, the Engel curves spread out at higher income levels). Grandmont (1992) decomposes a population into subclasses that are rescaled replicas of each other and shows that sufficient heterogeneity, as measured by the flatness of the density of the scale factors, leads to the LD. Kneip (1999) introduces a nonparametric notion of demand heterogeneity with the same result. Hildenbrand (1994) takes a different approach and checks directly, using British and French family expenditure data, that the aggregate income effect is positive definite (Härdle et al. 1991). There are a number of econometric problems to overcome. For instance, as such surveys do not follow an individual through time, one cannot infer from the data how a small change in income would affect the average consumption of individuals at a given income level. However, the surveys give the average consumption of individuals with slightly higher or slightly smaller incomes, and this should be a reasonable stand-in, provided the other characteristics of the population do not change dramatically across income classes. This being said, the econometric conclusions do seem to provide empirical support for the LD.

3.2. Groups as Complex Economies

A second line of research has considered aggregation problems from a totally different perspective. On the one hand, it essentially deals with small groups (typically households or families). On the other hand, instead of focusing on market economies, it considers potentially more complex interactions, involving possibly public consumption and

intragroup production. The initial literature almost exclusively concentrates on one question—namely, which assumptions would guarantee that the group under consideration behaves like a single individual? We briefly describe the two main contributions to this literature: Samuelson's aggregate welfare index and Becker and Bergstrom's transferable utility (TU) setting.

3.2.1. Samuelson's index. Assume that all individuals agree on some global index, the arguments of which are the various individual utilities, that will be maximized by the group. Technically, there exists some strictly increasing W such that the group maximizes

$$W\left[U^1(X, x_1, \ldots, x_H), \ldots, U^H(X, x_1, \ldots, x_H)\right] \tag{8}$$

under the budget constraint

$$P^T X + p^T \left(\sum_h x_h\right) = y. \tag{9}$$

Household production could be introduced at little cost; this task is left to the reader.

It is straightforward to see that this formulation boils down to a standard utility maximization problem. Indeed, define the group utility $\mathcal{U}^G$ by

$$\mathcal{U}^G(X, x) = \max_{\sum_h x_h = x} W\left[U^1(X, x_1, \ldots, x_H), \ldots, U^H(X, x_1, \ldots, x_H)\right].$$

Then $\mathcal{U}^G$ is the utility of a representative consumer for the group: for any consumption vector $(X, x_1, \ldots, x_H)$ that maximizes Equation 8 under Equation 9, the vector (X, x) where $x = \sum_h x_h$ maximizes $\mathcal{U}^G$ under the budget constraint $P^T X + P^T x = y$. Note that this conclusion is just a restatement of an old result by Hicks, sometimes referred to as the composite good theorem: In this setting, for any i the commodities $x_1^i, \ldots, x_H^i$ are always purchased at the same price p_i.

Simple as it may seem, this approach has some interesting properties. First, the relationship between $\mathcal{U}^G$, on the one hand, and $(W, U^1, \ldots, U^H)$, on the other hand, is not one-to-one: There exist many (in fact a continuum of different) structures $(W, U^1, \ldots, U^H)$ that generate the same representative utility U^G. This is exactly the spirit of Hick's theorem: Without variations in the respective prices of $(x_1, \ldots, x_H)$, individual utilities simply cannot be recovered. It follows that in this approach, the group is doomed to be a black box: Its aggregate behavior can certainly be studied (using standard consumer theory), but its inner mechanisms (individual utilities and the index W) are necessarily unrecoverable. Ironically, we see below that Samuelson's index is a particular case of a more general representation (the so-called collective approach), which only postulates that the group decisions are Pareto efficient. In this general family, simple exclusion restrictions are generically sufficient for individual utilities to be identified; the Samuelson index case is among the few exceptions for which individual utilities can never be recovered.

A second remark is that the Samuelson index case satisfies income pooling; that is, the group's behavior depends only on total income, not on its allocation between the group members. Therefore, in this setting, paying a benefit to one member instead of another (e.g., to the husband instead of the wife) cannot possibly have any impact on the outcomes. As shown below, there is strong empirical evidence against this prediction.

Finally, there is a relationship between the Samuelson index and the market economy approach described above, although the link is somewhat subtle. Assume for a moment that agents are egoistic and only consume private goods, and there are no externalities, so we are back in the setting studied in Section 2.1. Now the maximization of $W(U^1,\dots,U^H)$ under a budget constraint generates a consumption plan that is Pareto efficient, for otherwise an alternative allocation would increase some of the U^h without decreasing any, but this would strictly increase W, a contradiction. By the second welfare theorem, this efficient allocation can be decentralized; i.e., there exists an income distribution within the group such that this allocation obtains as an equilibrium; in practice, if each agent h receives a specific income y_h (with $\sum_h y_h = y$) and consumes it at his will, the resulting consumption plan maximizes W under a budget constraint.[5] Clearly, this argument can be applied to any specific value of the price vector $p = (p_1,\dots,p_M)$. The crucial remark, however, is that the income distribution that decentralizes the optimal allocation at prices p may (and generally will) depend on p in an arbitrary way. In particular, there is no reason to expect that it will be either constant, as in the market demand case, or a linear function of p, as in the excess demand case. In other words, in Samuelson's index story, there exists some income allocation $y(p) = [y^1(p),\dots,y^H(p)]$ such that individuals behave as if they were maximizing their own utility under a budget constraint, solving a program of the form

$$\begin{array}{c} \max_{x_h} U^h(x_h) \quad \text{subject to} \\ p^T x_h = y^h(p). \end{array} \tag{10}$$

But the market economy approach imposes an additional restriction on the income allocation, specifically, that it takes one of the following two forms: (*a*) constant nominal income, $y^h(p) = y^h \in \mathbb{R}$ for all p,h, or (*b*) linear income, $y^h(p) = p^T \cdot \omega^h$, where $\omega^h \in \mathbb{R}^N$.

These conditions may be satisfied for special functional forms for individual utilities and the index. For instance, one can readily check that, if utilities are Cobb-Douglas and W is linear,

$$W(U^1,\dots,U^H) = \sum_h \lambda_h U^h,$$

then the optimal consumption plan can be decentralized by allocating to agent h a fixed nominal income equal to $y_h = \lambda_h y$. Most of the time, however, the conditions are not satisfied; the relationship that exists, for given individual utilities $(U^1,\dots,U^H)$, between the index W and the allocation $y(p) = [y^1(p),\dots,y^H(p)]$ is in fact quite complex and in general is highly nonlinear.

3.2.2. The transferable utility case. An alternative situation in which the group's behavior boils down to a single utility maximization is when individual utilities exhibit a TU property (see, for instance, Browning et al. 2011). This happens when one can find, for

[5]The precise, formal argument is as follows. Consider an economy with H customers $U^1,\dots,U^H$ and $(M+1)$ commodities, the M physical commodities plus money. There exists an initial (total) endowment of the $(M+1)$-th commodity (money) equal to y; regarding the other commodities, the initial endowment is nil, but they can be produced from the $(M+1)$-th commodity according to the linear production technology $y = \sum_k p_k x^k$. In this economy, by the second welfare theorem, any Pareto-efficient allocation can be decentralized as an equilibrium. Given the linear technology, equilibrium prices must be proportional to $(p_1,\dots,p_M)$, and we can always normalize them to be equal to that vector. An equilibrium is uniquely characterized by the allocation of initial endowments $(y_1,\dots,y_H)$, which we interpret as an income distribution within the group.

each agent h, a particular cardinalization such that, for all values of prices and income, the Pareto frontier is a hyperplane of the equation

$$\sum_h U^h = K$$

for some K that depends on prices and income. In other words, it must be the case that for some well-chosen cardinalization of individual preferences, agents are able to transfer utility between them at a constant exchange rate (which can be normalized to one).

When all goods are private, the TU obtains only for quasi-linear utilities:

$$U^h(x_h) = x_h^1 + u^h\left(x_h^2, \ldots, x_h^M\right).$$

Here the marginal utility of an additional dollar spent on private consumption of commodity 1 is always constant (and can be normalized to one). This form has strong (and unrealistic) implications; for instance, individual demands for all commodities but the first have a zero-income elasticity. Things become much more interesting when public goods are considered. Bergstrom & Cornes (1983) prove that the TU property obtains if and only if individual utilities can be put into a generalized quasi-linear form (possibly after an increasing transform and a renaming of the private goods):

$$U^h(X, x_h) = u^h\left(x_h^2, \ldots, x_h^M, X\right) + G(X)x_h^1, \tag{11}$$

where $G(X) > 0$ for all X. Note that the G function must be identical for all members, whereas the u functions can be specific to individuals. In words, the TU assumption implies that, for some well-chosen cardinalization of individual preferences, the marginal utility of an additional dollar spent on private consumption of commodity 1 is always the same for all members (although it need not be constant—it may vary with the vector of public goods).

Although this form remains constrained, the restrictions are much less stringent than the quasi-linear case (see Chiappori 2010 for a precise characterization of these restrictions). Interestingly, and similar to the market economy case, the main restriction affects the level of heterogeneity that is allowed between individual preferences: The function G, which determines the marginal utility of private commodity 1, must be the same for all agents in the group.

Under TU, the sole assumption of Pareto efficiency is sufficient to generate a representative consumer, at least when all agents consume a positive quantity of the first private commodity. Indeed, one can readily show that efficiency then requires that the group maximizes the sum of individual utilities. In particular, the level of all public and private consumption (other than of the first private good) is the same for all efficient outcomes. Thus, under TU and assuming efficiency, group members will agree on almost all consumption choices; the only conflict will be in how to divide the private good x^1, which is often referred to as money but may be interpreted more broadly as a medium of exchange. Lastly, if we define

$$U^G(X, x) = \max_{\sum_h x_h = x} \sum_{h=1}^{H} u^h\left(x_h^2, \ldots, x_h^M, X\right) + G(X)x^1,$$

then the group's aggregate demand (X, x) maximizes U^G under a budget constraint, and U^G is therefore the utility of the group's representative consumer.

The TU framework is extremely convenient for many economic problems and is therefore widely used.[6] Still, it comes at a cost. Because TU is compatible with the existence of a representative customer, the resulting behavior satisfies income pooling. As mentioned above, empirical evidence does not support this property. Moreover, the representation of group behavior it provides is highly peculiar: This is a world in which, under efficiency, group members do not disagree about anything except the allocation of one private good. Applied to household economics, this implies that parents must always agree on all public expenditures, from housing to health care and from the brand of a new car to the level of education to be provided to each child. Such a representation may sometimes be convenient; in many contexts, however, it conflicts with evidence and omits some of the most interesting issues of group behavior—namely how shifts in the members' respective powers affect the group's decisions and aggregate behavior. These are issues on which new approaches—and especially the collective model that we describe below—put a lot of emphasis, thus requiring a more general framework.

4. AGGREGATION IN MARKET ECONOMIES: NEW RESULTS, NEW PERSPECTIVES

The market economy approach was actively pursued in the 1970s and the 1980s. Since then, there have been new advances. First, the market aggregate demand problem, which had been open since Sonnenschein's (1973) formulation, was solved; several extensions, dealing primarily with the case of small groups, have subsequently been developed. Second, the standard interpretation of the DMS results—that general equilibrium theory has no empirical content—has been challenged, and a more subtle interpretation has emerged.

4.1. Aggregate Market Demand

Although Sonnenschein's first problem, the excess demand case, was solved within months, the second remained open for 25 years and was solved only in 1997.[7] The existence of a decomposition has so far only been proved locally (i.e., in some open neighborhood of a regular point), and only for analytic functions; moreover, the proof relies on one of the most impressive results of twentieth-century mathematics, the Cartan-Kähler theorem (see Kähler 1934, Cartan 1945, and Bryant et al. 1991 for a modern presentation).

We do not provide the entire proof here; the interested reader is referred to Chiappori & Ekeland (1997, 1999a,b, 2000, 2006, 2009a). Instead, we briefly present the mathematical nature of the problem and try to explain why the market demand problem turned out to be much more difficult than its apparently similar counterpart, the excess demand one.

We start by assuming that $y^h = 1$ for all h. This simplifies the notations without reducing the generality of the proof, which can readily be extended to any vector $y=(y^1,\ldots,y^H)$.

[6]According to Bergstrom (1989), it lies at the core of Becker's celebrated rotten kid theorem (see Browning et al. 2011 for a precise discussion).

[7]However, Andreu (1982) provides a solution for finite data sets, and Sonnenschein (1973) includes perceptive intuitions.

Also we assume that $H \geq N$. We consider some mapping $x(p)$ from $\mathbb{R}^N$ to itself, which has to be decomposed into the sum of H individual market demand functions,

$$x(p) = x_1(p) + \ldots + x_H(p), \tag{12}$$

such that for all h, $x_h(p)$ solves

$$\begin{aligned} &\max U^h(x) \text{ subject to} \\ &p^T x = 1, \end{aligned} \tag{13}$$

where U^h is smooth (in a sense that is discussed below), strongly convex, and strictly increasing.

As usual, the indirect utility of agent h is defined as the value of the program in Equation 13. By the envelope theorem,

$$D_p V^h = -\lambda^h x_h(p), \tag{14}$$

where λ^h is the Lagrange multiplier of the budget constraint in Equation 13. The problem thus becomes the following: Finding H smooth, decreasing, quasi-convex functions $V^1, \ldots, V^H$ such that the function $x(p)$ can be written as (the negative of) a convex combination of the gradients of the V^h,

$$x(p) = -\sum_h \frac{1}{\lambda^h} D_p V^h, \tag{15}$$

where the V^h satisfy the additional restriction

$$p^T D_p V^h = -\lambda_h. \tag{16}$$

Note that the market demand problem is similar to the excess demand one except for one feature—namely, the individual budget constraint is $p^T x = 1$ instead of $p^T z = 0$, so the condition on indirect utilities is Equation 16 instead of $p^T D_p V^h = 0$. This apparently minor variation results in a considerably more difficult problem. As mentioned above, an obvious but crucial property of a constraint like $p^T z = 0$ is that if it is satisfied by some function z, then it is also satisfied by $k \cdot z$ for any scalar function k—and the proof of the result heavily exploits this fact. No such property exists in the market demand context.

Decomposing a given function into a linear or convex combination of gradients is a standard problem in mathematics (often referred to as the Darboux problem; see, for instance, Ekeland & Nirenberg 2002). Here, however, two additional complexities appear. One is that the V functions must be quasi-convex; the other is that they must satisfy Equation 16. Unlike the excess demand case, these complexities cannot be overcome by simple manipulations; they require the full strength of the Cartan-Kähler approach. The same tools can actually be applied to the case of small economies, in which necessary and sufficient conditions can be derived (see, for instance, Ekeland & Djitte 2006).

Finally, it should be stressed that the class of mathematical problems just described—decomposing a given function into a convex combination of gradients, possibly under additional constraints—lies at the core of most, if not all, modern aggregation theory. It appears not only in the market problem, but also in the much more general approach presented in the next section below.

4.2. Is General Equilibrium Theory Testable?

A widely accepted interpretation of the DMS results is that they shed light on a severe weakness of general equilibrium theory, namely its inability to generate empirically falsifiable predictions. A prominent illustration of this stand is provided, for instance, by Arrow (1991, p. 201), who listed among the main developments of utility theory the result that "in the aggregate, the hypothesis of rational behavior has in general no implications," concluding that "if agents are different in unspecifiable ways, then ... very few, if any, inferences can be made."

This view, however, has been recently challenged as overly pessimistic. New results show that general equilibrium theory can actually generate strong testable predictions, even for large economies. The main idea, initially introduced by Brown & Matzkin (1996), Snyder (1999), Brown & Shannon (2000), and Kubler (2003) and reformulated from a differential perspective by Chiappori et al. (2002a, 2004), can be summarized as follows. The DMS approach concentrates on the properties of aggregate excess (or market) demand as a function of prices. However, this viewpoint is not the most adequate to assess the testability of general equilibrium theory. As far as testable predictions are concerned, the structure of aggregate excess demand is not the relevant issue, if only because excess demand is, in principle, not observable, except at equilibrium prices, where, by definition, it vanishes. However, prices are not the only variables that can be observed to vary. Price movements reflect fluctuations of fundamentals, and the relationship between these fundamentals and the resulting equilibrium prices is the natural object for empirical observation. One of the goals of general equilibrium theory is to precisely characterize the properties of this relationship. As it turns out, this characterization generates strong testable restrictions.

To illustrate this view, Brown & Matzkin (1996) consider the simplest possible structure, namely an exchange economy. Here, for given preferences, the economy is fully described by the initial endowments, which are observable, in principle, and general equilibrium theory precisely describes the link between endowments and equilibrium prices by characterizing the structure of the equilibrium manifold. Brown & Matzkin derive a set of necessary and sufficient conditions in the form of linear equalities and inequalities that have to be satisfied by any finite data set consisting of endowments and equilibrium prices. They show that these relationships are indeed restrictive. Dealing with the same problem, Chiappori et al. (2002a, 2004) adopt a differentiable viewpoint; their necessary and sufficient conditions take the somewhat more familiar form of a system of partial differential equations, reminiscent of Slutsky conditions. In particular, these conditions can readily be imposed on a parametric estimation of the equilibrium manifold and therefore can be tested using standard econometric tools. They also show that these restrictions, if fulfilled, are sufficient to generically recover the underlying economy—including individual preferences. These results, however, require that individual endowments be observable; indeed, when only aggregate endowments are observable, a nontestability result can be proved.

The conclusion that emerges from this literature is that, in contrast to prior views, general equilibrium theory does generate strong, empirically testable predictions. The subtlety, however, is that tests can only be performed if data are available at the micro (here individual) level. One of the most interesting insights of new aggregation theory may be there—in the general sense that testability generally requires micro data and does not

seem to survive (except maybe under stringent auxiliary assumptions) in a macro context, when only aggregates can be observed.

5. AGGREGATION IN THE SMALL: THE MICROECONOMICS OF EFFICIENT GROUP BEHAVIOR

A major development in aggregation theory has been the emergence of the so-called collective models of group behavior. Unlike the market economy literature developed in the 1970s and 1980s, these models mostly concentrate on small groups (formally defined as groups in which the number of agents is small relative to the number of commodities); therefore, some structure is preserved by aggregation. And unlike Samuelson's or Becker's approach, they do not try to force aggregate behavior into the unitary structure of consumer theory; on the contrary, they explicitly acknowledge that groups cannot be expected to behave as a single individual. The emphasis is actually put on what precisely distinguishes groups from individuals—that is, the existence of a (possibly complex) decision process, and more specifically the notion of power. Central to the collective approach is the view that power matters—that any variation in the allocation of power between members will systematically result in changes in the aggregate behavior of the group and that these changes constitute an extremely interesting object for economic analysis. In collective models, paying a benefit to the wife instead of the husband makes a difference, and this difference is a major topic of interest.

This perspective opens a host of new questions: How, and under which assumptions, should the decision process be modeled? How can we formally represent the abstract notion of power? Should the group remain a black box, or is there something one can say about its structure (utilities, decision process) from the sole observation of its aggregate behavior? Are empirical predictions possible, and of what kind? In what follows, we describe the answers provided by the main line of research in this direction. We first present the formal model. We then provide a full characterization of the aggregate demand functions stemming from this framework. Finally, we discuss issues related to identification; we show that, generically, a set of simple exclusion restrictions (one per group member) is sufficient to fully recover welfare allocation between members.

5.1. Efficiency and Power

The collective approach essentially relies on one basic assumption, namely efficiency. Whatever the decision process may be, it is assumed that it leads to efficient outcomes, in the usual (Pareto) sense that no alternative would have been preferred by all group members. Innocuous as it may seem, this assumption still excludes several existing models of group (often household) behavior based on noncooperative game theory, for instance. It also rules out asymmetric information or agency problems. As such, it is particularly relevant for modeling long-term interactions between members that know each other well (families being a typical example). More generally, it can be seen as a benchmark formulation that will be extended in the future. Also, it encompasses and generalizes both the market economy approach (as, in the latter setting, equilibria are Pareto efficient) and the unitary perspective à la Becker/Samuelson.

Formally, we thus assume the following.

> **Axiom 1 (efficiency):** The outcome of the group decision process is Pareto efficient; the consumption $(x_1, \dots x_H, X)$ chosen by the group is such that no other vector $(\bar{x}_1, \dots \bar{x}_H, \bar{X})$ feasible at the same prices and incomes could make all members better off, one of them strictly so.

The set of Pareto-efficient allocations can be characterized in a number of equivalent ways. First, for any vector (π, y) of prices and income in $\mathbb{R}^{M+1}$, there must exist numbers $\bar{u}_2, \dots, \bar{u}_H$ and vectors $X, x_1, \dots, x_H$, which may depend on (π, y), such that $(X, x_1, \dots, x_H)$ solves

$$\begin{gathered} \max_{X, x_1, \dots, x_H} U^1(X, x_1, \dots, x_H) \text{ subject to} \\ U^h(X, x_1, \dots, x_H) \geq \bar{u}_h, \quad h = 2, \dots, H, \\ \pi^T \xi = y, \end{gathered} \tag{17}$$

where, again, $\pi = (P, p)$ and $\xi = \left(X, \sum_h x_h\right)$.

Second, if μ^h denotes the Lagrange multiplier of the h-th constraint, the axiom can be restated as follows: There exist $H-1$ scalar functions $\mu^h(\pi, y) \geq 0$, $2 \leq h \leq H$, such that $(X, x_1, \dots, x_H)$ solves

$$\begin{gathered} \max_{X, x_1, \dots, x_H} \sum_h \mu^h U^h(X, x_1, \dots, x_H) \quad \text{subject to} \\ \pi^T \xi = y, \end{gathered} \tag{18}$$

where $\mu^1 = 1$. The equivalence between efficiency and the maximization of a weighted sum of utilities is well known; the μ^h are the Pareto weights of the program. Clearly, Pareto weights are defined only up to some normalization. In the program given in Equation 18, the first weight is normalized to be one. Clearly, other normalizations are possible.

A more geometric interpretation is the following. For any given utility functions $U^1, \dots, U^H$ and any price-income bundle, the budget constraint defines a Pareto set for the group (defined as the set of vectors $U^1, \dots, U^H$ that are reachable); under the assumptions stated (concave utilities, convex production set), the Pareto set is moreover convex. From Axiom 1, the final outcome will be located on the frontier of the Pareto set. Under standard smoothness assumptions, this frontier is an $(H-1)$-dimensional manifold, indexed by the vector $\mu = (1, \mu^2, \dots, \mu^H)$.

An important remark is that the vector μ, renormalized, for instance, by $\sum \mu_h = 1$, summarizes the decision process because it determines the final location of the demand vector on this frontier. In that sense, it describes the distribution of power within the group. If one of the weights, μ^h, is equal to one for every (π, y), then the group behaves as though h is the effective dictator. For intermediate values, the group behaves as though each person h has some decision power, and the person's weight μ^h can be seen as an indicator of this power. This power interpretation must be used with some care, as the Pareto coefficient μ^h depends on the particular cardinalization adopted for individual preferences; if U^h is replaced with $G(U^h)$ for some increasing mapping G, the set of Pareto-efficient allocations does not change, but the parameterization through the vector μ has to be modified accordingly. It follows that interpersonal comparisons of Pareto weights are meaningless; for instance, $\mu^h > \mu^r$ does not imply that h has more power

than r. However, the variations of μ^h are significant, in the sense that for any fixed cardinalization, a policy change that increases μ^h while leaving μ^r constant unambiguously ameliorates the position of h relative to r.

If the μ^h are constant, then the program (P) boils down to the maximization of a unique utility under production and a budget constraint. We then get a variant of the Samuelson index model, and the group behaves as if it were a single decision maker. In general, however, the weights μ^h depend on prices and income because these variables in principle may influence the distribution of power within the group, hence the location of the final choice over the Pareto frontier. The maximand in P is therefore price dependent; the standard properties of unitary models do not apply in this context. However, the dependence on prices and income has a specific form, which is exploited in what follows.

Three additional remarks can be made. First, because we postulate throughout the absence of monetary illusion, the μ^h are taken to be zero homogeneous in (π, y). Second, following Browning & Chiappori (1998), we often add some structure by assuming that the μ^h are continuously differentiable. Third, if we assume that all commodities are privately consumed and there are no externalities, then by the second welfare theorem any Pareto-efficient allocation can be decentralized as an equilibrium—and we are back to the framework studied in Section 2. Indeed, the market economy approach is a special case of the collective model.[8]

5.2. Aggregate Demand of an Efficient Group: A Characterization

The characterization problem can be stated as follows. Take a group that satisfies the assumptions made above and that makes Pareto-efficient decisions under the constraints defined by its production technology and its budget. What restrictions (if any) on the aggregate demand function characterize the efficient behavior of the group, and how do these restrictions vary with the size of the group? In other words, is it possible to derive conditions that are sufficient for some demand function to stem from a Pareto-efficient decision process within a well-behaved group? Technically, consider a demand function $\xi = (X, x)$ of $(\pi, y) = (P, p, y)$ that satisfies two standard conditions, namely homogeneity and adding up (i.e., $\pi^T \xi = y$ for all π, y), and that is sufficiently smooth in a sense that is defined below. Are there necessary and sufficient conditions on ξ that stem from the theoretical structure under consideration, i.e., from the fact that it is the Pareto-efficient demand of an H-person group?

5.2.1. The SNR($H-1$) condition. We start with a set of necessary conditions that characterize group demand in the most general framework. In what follows, utilities are of the unrestricted form $U^h(X, x_1, \ldots, x_H)$—we simply assume that U^h is increasing and strongly concave; moreover, intragroup production could be introduced at no cost. We maintain the homogeneity assumption; therefore, we normalize y to be one. The budget constraint is

$$\pi^T \xi = 1,$$

and aggregate demand is now a function $\xi(\pi)$ of prices only.

[8]The collective approach also encompasses several models of household behavior that have been developed in the literature, including models based on cooperative bargaining (Manser & Brown 1980, McElroy & Horney 1981) or on equilibrium (Grossbard-Schechtman & Neuman 2003).

Household utility. As discussed above, Pareto efficiency requires that the group demand solves the program given in Equation 18 above. We define the function $\mathbb{U}^H$, from $\mathbb{R}^M \times \mathbb{S}$ to $\mathbb{R}$, where $\mathbb{S}$ denotes the H-dimensional simplex, by

$$\begin{aligned}\mathbb{U}^H(\xi,\mu) = \mathbb{U}^H\big(X,x,\mu^1,\ldots,\mu^H\big) = \max_{X,\,x_1,\ldots,\,x_H} \textstyle\sum_b \mu^b U^b(X,x_1,\ldots,x_H)\\ \text{subject to } x = x_1 + \ldots + x_H.\end{aligned} \tag{19}$$

In words, $\mathbb{U}^H$ denotes the maximum value of the weighted sum $\sum_b \mu^b U^b$ when aggregate group demand is ξ. In that sense, $\mathbb{U}^H$ can be interpreted as the group's utility function, and Equation 18 is equivalent to maximizing U^H under the budget constraint

$$\begin{aligned}\max \mathbb{U}^H(\xi,\mu)\\ \text{subject to } \pi^T\xi = 1.\end{aligned} \tag{20}$$

In what follows, let $\tilde{\xi}(\pi,\mu)$ denote the solution to Equation 20.

It is crucial to remark that $\mathbb{U}^H$ also depends on the vector of Pareto weights $\mu = \big(\mu^1,\ldots,\mu^H\big) \in \mathbb{S}$. In particular, $\mathbb{U}^H$ is not a standard utility function: Because the μ^b are generally price and income dependent, so is $\mathbb{U}^H$. In practice, $\tilde{\xi}$, considered as a function of π only (for some fixed μ), is a standard demand function; as such, it satisfies Slutsky symmetry and negativeness. However, $\tilde{\xi}$ is not observable because one cannot vary π while keeping μ constant. What the econometrician observes (or may recover), i.e., the demand function ξ, is related to $\tilde{\xi}$ by

$$\xi(\pi) = \tilde{\xi}[\pi,\mu(\pi)]. \tag{21}$$

Slutsky matrix. We now define the Slutsky matrix associated with ξ by

$$S(\pi) = (D_\pi \xi)\big(I - \pi\xi^T\big).$$

This is the standard definition of a Slutsky matrix, adapted to take into account the normalization $y = 1$.[9] Note, incidentally, that $S(\pi)\nu = 0$ for all vectors $\nu \in \mathrm{Span}\{\pi\}$. Indeed,

$$S(\pi)\pi = (D_\pi\xi)\big(\pi - \pi\xi^T\pi\big) = 0 \text{ because } \xi^T\pi = 1.$$

Now, from Equation 21, we see that

$$\begin{aligned}S(\pi) &= \big(D_\pi\tilde{\xi} + D_\mu\tilde{\xi}\cdot D_\pi\mu^T\big)\big(I - \pi\xi^T\big)\\ &= \big(D_\pi\tilde{\xi}\big)\big(I - \pi\xi^T\big) + D_\mu\tilde{\xi}\cdot D_\pi\mu^T\big(I - \pi\xi^T\big)\\ &= \Sigma(\pi) + R(\pi),\end{aligned}$$

where

$$\Sigma(\pi) = \Big(D_\pi\tilde{\xi}\Big)\Big(I - \pi\xi^T\Big) = \Big(D_\pi\tilde{\xi}\Big)\Big(I - \pi\tilde{\xi}^T\Big)$$

and

$$R(\pi) = D_\mu\tilde{\xi}\cdot D_\pi\mu^T\big(I - \pi\xi^T\big).$$

[9]Homogeneity implies by the Euler relation that $D_\pi\xi\cdot\pi + yD_y\xi = 0$. The Slustky matrix is defined as $S(\pi,y) = D_\pi\xi + D_y\xi\cdot\xi'$. Therefore, $S(\pi,y) = D_\pi\xi + \left(-\frac{1}{y}D_\pi\xi\cdot\pi\right)\cdot\xi'$, and for $y = 1$ the result obtains.

$\Sigma(\pi)$ is the Slustky matrix corresponding to the function $\tilde{\xi}(\cdot, \mu)$, as computed at $\mu(\pi)$. As such, it is symmetric and negative semidefinite and satisfies $v^T \Sigma(\pi) v = 0$ for all vectors $v \in \text{Span}\{\pi\}$. Moreover, the rank of $R(\pi)$ cannot exceed that of $(D_\pi \mu)$, which is at most $H-1$. We therefore can state the basic result from Browning & Chiappori (1998).

Proposition 1 [the SNR($H-1$) condition]: If the C^1 function $\xi(\pi)$ solves problem (P), then the Slutsky matrix $S(\pi) = (D_\pi \xi)\left(I - \pi \xi^T\right)$ can be decomposed as

$$S(\pi) = \Sigma(\pi) + R(\pi), \tag{22}$$

where (a) the matrix $\Sigma(\pi)$ is symmetric and satisfies $v^T \Sigma(\pi) v = 0$ for all vectors $v \in \text{Span}\{\pi\}$, $v^T \Sigma(\pi) v < 0$ for all vectors $v \notin \text{Span}\{\pi\}$, and (b) the matrix $R(\pi)$ is of rank at most $H-1$.

Equivalently, there exists a subspace $\mathcal{E}(\pi)$ of dimension at least $M - H$ such that the restriction of $S(\pi)$ to $\mathcal{E}(\pi)$ is symmetric, negative definite, in the sense that $v^T S(\pi) w = w^T S(\pi) v$ and $v^T S(\pi) v < 0$ for all nonzero vectors $v, w \in \mathcal{E}(\pi)$.

Here, SNR $(H-1)$ stands for symmetric negative plus rank $(H-1)$. As discussed above, an appealing property of these conditions is that they stem from the most general version of the collective model; i.e., they do not require much beyond efficiency and differentiability. Also, the SNR$(H-1)$ property nicely generalizes the standard Slutsky symmetry of the unitary model. Indeed, when $H = 1$ (the unitary setting), then $R(\pi)$ is the null matrix, and $S(\pi) = \Sigma(\pi)$ is symmetric. In the general case in which $H \geq 1$, $S(\pi)$ needs not be symmetric, and $R(\pi)$ represents the deviation from symmetry. Then the rank of this deviation is at most the number of members minus one.

On a more technical side, the $(H \times M)$ matrix $D_\pi \mu^T \left(I - \pi \xi^T\right)$ can be written as

$$D_\pi \mu^T \cdot \left(I - \pi \xi^T\right) = \begin{pmatrix} v_1^T \\ v_2^T \\ \vdots \\ v_H^T \end{pmatrix},$$

where the vectors $v_1, \ldots, v_H \in \mathbb{R}^N$ are linearly dependent.[10] It follows that

$$\begin{aligned} R(\pi) &= D_\mu \tilde{\xi} \cdot \begin{pmatrix} v_1^T \\ v_2^T \\ \vdots \\ v_H^T \end{pmatrix} \\ &= \sum_h D_{\mu^h} \tilde{\xi} \cdot v_h^T = \sum_h u_h \cdot v_h^T, \end{aligned}$$

where

$$u_h = D_{\mu^h} \tilde{\xi}.$$

[10]Obviously, the vectors v_h vary with π and should be written $v_h(\pi)$. To simplify notations, we omit the reference to π whenever it can be done without ambiguity.

Also,

$$R(\pi)\cdot\pi = D_\mu\tilde{\xi}\cdot D_\pi\mu^T\left(I-\pi\xi^T\right)\cdot\pi = 0$$

because $\left(I-\pi\xi^T\right)\cdot\pi = \pi-\pi\left(\xi^T\pi\right) = \pi-\pi = 0$. Therefore, $v_h^T\cdot\pi = 0$ for $h=1,\ldots,H$. By the same token,

$$S(\pi)\cdot\pi = \Sigma(\pi)\cdot\pi = 0.$$

Let $\mathcal{E}(\pi)$ denote the subspace orthogonal to $\{\pi,v_1,\ldots v_H\}$; its dimension is at least $M-H$. Then the space $\mathbb{R}^M$ can be decomposed as

$$\mathbb{R}^M = \text{Span}\{\pi\}\oplus\text{Span}\{v_1,\ldots,v_H\}\oplus\mathcal{E}(\pi),$$

and we know that for any two vectors v and w in $\mathcal{E}(\pi)$,

$$v^TS(\pi)w = v^T\Sigma(\pi)w = w^T\Sigma(\pi)v = w^TS(\pi)v$$

and

$$v^TS(\pi)v = v^T\Sigma(\pi)v < 0,$$

which shows that the restriction of S to $\mathcal{E}(\pi)$ is symmetric, negative definite, as stated in the last part of Proposition 1.

Geometric interpretation. A geometric interpretation of SNR$(H-1)$ is the following. Remember, first, that for any given H-tuple 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. Under smoothness assumptions, the Pareto frontier is actually a manifold of dimension $H-1$. 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. However, this change will not violate Slutsky symmetry; that is, it 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. But moves along an $(H-1)$-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 $(M-H-1)$-dimensional manifold. Considering the linear tangent hyperspace, this means that there is a whole linear manifold of codimension $(H-1)$ such that, if the (infinitesimal) change in prices and income belongs to that hyperplane, no deviation from Slutsky symmetry can be observed. In other words, the SNR$(H-1)$ condition is a direct consequence of the fact that, in an H-person household, the Pareto frontier is of dimension $H-1$, whatever the number of commodities.

Testing for SNR(H − 1). How can a property like SNR$(H-1)$ be tested? The basic idea is that a matrix S is SNR$(H-1)$ if and only if the antisymmetric matrix $\mathcal{M} = S-S^T$ is of rank at most $2(H-1)$ (remember that a matrix $\mathcal{M}$ is antisymmetric if $\mathcal{M}^T = -\mathcal{M}$). A more precise statement is the following.

Lemma 1: Let S be some $SNR(H-1)$ matrix,

$$S = \Sigma + \sum_{h=1}^{H-1} u_h \cdot v_h^T,$$

where the vectors $(u_1, \ldots, u_H)$ are linearly dependent and the vectors $(v_1, \ldots, v_H)$ are linearly dependent. Then the matrix $\mathcal{M} = S - S^T$ is of rank at most $2(H-1)$, and $\mathrm{Im}(\mathcal{M})$ (the subspace spanned by the columns of $\mathcal{M}$) is spanned by the vectors $(u_1, \ldots, u_{H-1}, v_1, \ldots, v_{H-1})$.

Therefore, testing for the collective model amounts to testing for the rank of matrix $\mathcal{M} = \left(S - S^T\right)$. The collective model predicts this rank should be at most $2(H-1)$, while it would be zero in the unitary case (note that antisymmetry implies that the rank of $\mathcal{M}$ must be an even integer).

The tests just described are derived under the crucial assumption of efficiency. Alternative approaches have been developed; the reader is referred to Browning et al. (2011) for a detailed presentation. Lechene & Preston (2011) analyze the demand function of a couple stemming from a noncooperative model (involving private provision of the public goods) similar to that discussed in Section 4. They show that, again, a decomposition of the type SNR1 holds. However, the rank conditions on the deviation matrix R are different. Specifically, Lechene & Preston show that the rank of R can take any value between one and the number of public goods in the model. Recently, d'Aspremont & Dos Santos Ferreira (2009) introduced a general framework that provides a continuous link between the cooperative and the noncooperative solutions. In their setting, couples are characterized by a pair of parameters that indicate how cooperatively each agent behaves. Again, they derive an $\mathrm{SNR}(H-1)$ decomposition; however, the rank of matrix R can now take values between one and twice the number of public goods.

Several tests of $\mathrm{SNR}(H-1)$ have been empirically performed (Browning & Chiappori 1998, Dauphin & Fortin 2001, Dauphin 2003, Dauphin et al. 2008, Kapan 2009). They conclude that standard symmetry of the Slutsky matrix is strongly rejected for multiperson families, although quite interestingly it fails to be rejected for singles; moreover, SNR(1) is not rejected for couples. Finally, one can use these approaches to assess the number of actual decision makers in the family (see Dauphin et al. 2008, Kapan 2009).

5.2.2. Sufficiency of the SNR($H-1$) condition. The condition $\mathrm{SNR}(H-1)$ has been known to be necessary for some time. A more difficult question is with regard to sufficiency. Take a smooth demand function $\xi(\pi)$ that satisfies homogeneity, adding up, and $\mathrm{SNR}(H-1)$. Can it be constructed as the aggregate demand of a Pareto-efficient group? Formally, the sufficiency problem thus can be stated as follows: Is it possible to find (*a*) functions $[x_1(\pi), \ldots, x_H(\pi), X(\pi)]$, (*b*) increasing, concave utility functions $U^1(x_1, \ldots, x_H, X), \ldots, U^H(x_1, \ldots, x_H, X)$, and (*c*) a vector function $\mu(\pi)$ in the H-dimensional simplex, such that $[\xi(\pi), x_1(\pi), \ldots, x_H(\pi), X(\pi)]$ solves the program given in Equation 18?

In other words, we are looking for an equivalent, in the collective setting, to the integrability theorem in the unitary case, whereby Slutsky conditions (with homogeneity and adding up) are sufficient for the existence of a well-behaved utility function generating the demand function under consideration.

We start with a simple methodological point, namely that to prove sufficiency, one has to prove the existence of only one set of utility and production functions, however simple. In particular, it suffices to prove sufficiency for the set of egoistic preferences of the form $U^h(x_h, X)$.

As it turns out, any demand that is (locally) compatible with the collective approach is compatible with the collective approach with egoistic preferences. Two caveats must be made, however. First, the proof requires some degree of smoothness of the demand; in practice, we assume that the function ξ is continuously differentiable. Second, the construction of individual utilities and Pareto weights is only local; i.e., we prove sufficiency in an open neighborhood of any regular point (in a sense that is precisely defined below). The global construction is still an open problem.

Our first task is to describe the basic mathematical structure of the identification problem. We start with introductory examples that show how the structure obtains in two specific but intuitive cases—namely, commodities are either all public or all private. We then address the general setting.

Two introductory examples. We now describe the mathematical structure of the problem in more detail. Our main conclusion is that some known function (aggregate demand, aggregate inverse demand, or a function derived from these) must be written as a convex combination of gradients. In other words, the key structure is the same as for the aggregate excess or market demand of a market economy, as discussed in the previous sections, despite the fact that the model is much more general.

We start with two simple examples that illustrate the main result in an intuitive way. For expository convenience, we disregard distribution factors for the moment.

Public goods only. We first consider a version of the model in which all commodities are publicly consumed (therefore, $\xi = X$ and $\pi = P$). Keeping the normalization $y = 1$, the program given in Equation 18 above can be written as

$$\begin{cases} \max_X \sum_h \mu^h(P) U^h(X) \\ P^T X = 1 \end{cases}. \tag{23}$$

Let $X^*(P)$ denote its solution. Assuming an interior solution, first-order conditions give

$$\sum_h \mu^h(P) D_X U^h(X) = \lambda(P) \cdot P, \tag{24}$$

where λ denotes the Lagrange multiplier of the budget constraint, and λ is a scalar function of P.

Next we assume that the Jacobian matrix $D_P X$ is of full rank on some open set. It follows that the function $X(P)$ is invertible, and we can define the inverse demand function $P(X)$. Then Equation 24 becomes

$$\sum_h \frac{\mu^h[P(X)]}{\lambda[P(X)]} D_X U^h(X) = P(X).$$

In this equation, the right-hand side is the known (inverse) demand function, whereas all functions in the left-hand side are unknown, and we want to prove their existence. The specific structure here is that the inverse demand function must be a linear

combination of gradients of increasing, concave functions; moreover, the coefficients of the combination must be nonnegative. Note that when $H = 1$, this equation boils down to a well-known result, namely that the inverse demand function stemming from the maximization of a unique utility under a budget constraint must be proportional to the gradient of the utility function.

Finally, assume, conversely, that some given C^1 demand $X(P)$, satisfying $P^T \cdot X(P) = 1$, is regular in the sense just defined in some neighborhood and such that the inverse demand $P(X)$ can be written as

$$P(X) = \sum_h \bar{\mu}^h(X) D_X U^h(X),$$

where the $\bar{\mu}^h$ are positive, and the U^h are increasing and strongly concave. Define $\tilde{\mu}^h(P) = \bar{\mu}^h[X(P)]$ for $h = 1, \ldots, H$, and consider the program

$$\begin{cases} \max_X \sum_h^h \tilde{\mu}(P) U^h(X) \\ P^T X = 1 \end{cases}. \tag{25}$$

Because the maximand is strongly concave, the first-order conditions are sufficient for a global optimum. Hence $X(P)$ is the aggregate demand of the group thus defined.

Private goods only. The previous argument may seem specific to the public-good structure in which it was constructed. As it turns out, the underlying intuition is more general. To see why, let us briefly discuss an alternative polar case in which all commodities are privately consumed and individual utilities belong to the egoistic family. This case has been repeatedly studied in the literature, starting with Chiappori (1988a,b, 1992). Now the demand function $\xi(\pi)$ is in fact $x(p)$; the program is therefore

$$\begin{gathered} \max_{x_1, \ldots, x_H} \sum_h \mu^h U^h(x_h) \quad \text{subject to} \\ p^T \left(\sum_h x_h \right) = 1, \end{gathered} \tag{26}$$

where y has again been normalized to one. Let $(x_1^*, \ldots, x_H^*)$ denote the solution to this program.

The notion of a sharing rule provides an equivalent but often more tractable version of this program. It relies on the following result.

> **Proposition 2:** There exist H scalar functions $\rho^1, \ldots, \rho^H$ of p, with $\sum_h \rho^h(p) = 1$, such that for any $h = 1, \ldots, H$, x_h^* solves
>
> $$\begin{gathered} \max_{x_h} U^h(x_h) \quad \text{subject to} \\ p^T x_h = \rho^h(p). \end{gathered} \tag{27}$$
>
> **Proof:** Define $\rho^h = p^T x_h^*$, and assume that x_h^* does not solve Equation 27. Then there exists some $\bar{x}_h$ such that $p^T \bar{x}_h = p^T x_h^*$ and $U^h(\bar{x}_h) > U^h(x_h^*)$. But then the allocation $(x_1^*, \ldots, \bar{x}_h, \ldots, x_H^*)$ is feasible and Pareto dominates $(x_1^*, \ldots, x_H^*)$, a contradiction.

This is just a particular application of the second welfare theorem. Consider the group as a small, convex economy, in which all commodities $1, \ldots, N$ can be produced from a

single input, money, according to the linear production technology $p^T(\sum_h x_h) = 1$. Then any Pareto-efficient allocation can be decentralized as an equilibrium; moreover, the linear technology requires that the prices within the economy be proportional to market prices p, hence the result.

In other words, when commodities are all private, an efficient allocation can always be seen as stemming from a two-stage decision process.[11] In the first stage, members decide on the allocation of total income $y = 1$ between them; member h receives ρ^h. In the second stage, agents each chose their vector of private consumption subject to their own budget constraints.

The vector $(\rho^1, \ldots, \rho^H)$ is the group's sharing rule. In a private-good context, the intragroup decision process is fully summarized by the sharing rule; in particular, there is a one-to-one mapping between (normalized) Pareto weights and the sharing rule. Moreover, this mapping is monotonic in the following sense: If we increase the Pareto weight of member i while keeping the other weights constant (possibly before renormalization), then the new sharing rule allocates more income to i than the initial one. A nice property of the sharing rule is that it does not depend on the particular cardinalization of individual utilities (it is expressed in dollars). The price to pay for this superior tractability is that sharing rules are less general, being defined for private goods only—although we extend the concept to a more general setting below.

Let $W^h(p)$ denote the value of the program given in Equation 27: It is called the collective indirect utility. It is defined as the utility reached by agent h, taking into account the intragroup decision process. If V^h denotes the standard, individual indirect utility of member h, we have

$$W^h(p) = V^h\left[p, \rho^h(p)\right]. \tag{28}$$

By the envelope theorem applied to the program given in Equation 27,

$$D_p W^h = \lambda^h\left(x_h - D_p \rho^h\right),$$

where λ^h is the Lagrange multiplier of the budget constraint, i.e., the marginal utility of the money of h. Therefore,

$$\sum_h \frac{D_p W^h}{\lambda^h} = \sum_h \left(x_h - D_p \rho^h\right).$$

Hence

$$\sum_h \frac{D_p W^h}{\lambda^h} = x(p),$$

as $\sum_h \rho^h(p) = 1$ implies $\sum_h D_p \rho^h(p) = 0$.

We can rewrite this equation in a slightly different way. Define $\tilde{W}(p) = -W(p)$; if $\alpha^h = 1/\lambda^h$, we have

$$-x(p) = \sum_h \alpha^h D_p^h \tilde{W}^h. \tag{29}$$

[11]Needless to say, we are not assuming that the actual decision process occurs in two stages. The result simply states that any efficient group behaves as if it were following a process of this type.

This time, it is the direct group demand function that is equal to a linear combination of gradients. Note that when $H = 1$, this equation boils down to the well-known Roy's identity, which states that a demand function stemming from the maximization of a unique utility under a budget constraint must be proportional to the gradient of the indirect utility [indeed, when $H = 1$, then $\rho(p) = 1$ and W is the standard indirect utility].

Conversely, assume that some smooth function $x(p)$, satisfying the Walras law, also satisfies Equation 29 in the neighborhood of some $\bar{p}$ for some positive α^h and some strictly decreasing, strongly convex $\tilde{W}^h$ (so that the W^h are strictly increasing and strongly concave). We now show that x can be decomposed as the aggregate demand of a group in which all commodities are privately consumed.

For each h, define a function $\rho^h(p)$ by

$$\rho^h(p) = p^T \cdot \left[D_p \rho^h - \alpha^h(p) D_p \tilde{W}^h \right]. \tag{30}$$

This is a linear first-order partial differential equation for $\rho^h(p)$. Note that the sum $\rho(p) = \sum \rho^h(p)$ satisfies a similar equation:

$$\rho = p^T D_p \rho + p^T x = p^T D_p \rho + 1, \tag{31}$$

which has the obvious solution $\rho(p) = 1$.

Equation 30 can be solved by the method of characteristics.[12] It follows that $\rho^h(p)$ can be prescribed arbitrarily on the affine hyperplane H defined as the set of p where $\bar{p}^T(p - \bar{p}) = 0$ (technically speaking, this is a noncharacteristic hypersurface, at least in some neighborhood of $\bar{p}$). We choose $\rho^h(p) = 1/S$ on H. It follows that $\rho = \sum \rho^h = 1$ on H, and as ρ satisfies Equation 31, $\sum \rho^h(p) = 1$ everywhere. As a consequence, we have

$$\sum D_p \rho^h = 0.$$

Now define

$$x_h(p) = D_p \rho^h - \alpha^h(p) D_p \tilde{W}^h. \tag{32}$$

We have

$$p^T x_h(p) = \rho^h(p), \quad 1 \le h \le S,$$
$$\sum_h x_h(p) = x(p).$$

We now have to show that the $x_h(p)$ solve the consumer's problem. For each h, consider the function

$$U^h(x) = \min_p \left\{ \tilde{W}^h(p) \,|\, p^T x \le \rho^h(p) \right\}. \tag{33}$$

Note that, by the envelope theorem, U^h is differentiable and strictly increasing, and $D_x U^h[x_h(p)]$ is proportional to p. But Equation 32 is the optimality condition for this problem. Because $\tilde{W}^h$ is strongly convex, this condition is sufficient, so that

[12] In the case at hand, the method of characteristics consists of considering the flow $\frac{dp}{dt} = p$ in R^N, the solutions of which are given by $p(t) = p(0)e^t$. We also note that the function $\bar{\rho}^h(t) := \rho^h[p(t)]$ solves the differential equation $\dot{\bar{\rho}}^h(t) = \frac{d\bar{\rho}^h}{dt}(t) - \alpha_s[p(t)]\, p(t)^T \cdot D_p \tilde{W}^h[p(t)]$ on R. This determines the solution $\bar{\rho}^h(p)$ on each trajectory of the flow (see, for instance, Bryant et al. 1991 for details).

$$U^h[x_h(p)] = \tilde{W}^h(p). \tag{34}$$

Now set

$$\bar{W}^h(p) = \sup_x \left\{ U^h(x) \mid p^T x \le \rho^h(p) \right\}. \tag{35}$$

We have $\bar{W}^h(p) \ge U^h[x_h(p)] = \tilde{W}^h(p)$. Alternatively, for every x such that $p^T x \le \rho^h(p)$, we have $U^h(x) \le \tilde{W}^h(p)$. Taking the supremum with respect to all such x, we get $\bar{W}^h(p) \le \tilde{W}^h(p)$. Finally $\bar{W}^h = \tilde{W}^h$, and Equation 35 becomes

$$\tilde{W}^h(p) = \max_x \left\{ U^h(x) \,|\, p^T x \le \rho^h(p) \right\} = U^h[x_h(p)],$$

which tells us that $x_h(p)$ solves the consumer's problem for the utilities $U^h(x)$ and the sharing rule $\rho^h(p)$.

It remains to show that the U^h are quasi-concave, at least in some neighborhood of $\bar{p}$. To do this, pick x_1 and x_2 and a number a such that $U^h(x_1) \ge a$ and $U^h(x_2) \ge a$. We have

$$U^h\left(\frac{x_1 + x_2}{2}\right) = \min_p \left\{ \tilde{W}^h(p) \mid p^T \left(\frac{x_1 + x_2}{2}\right) \le \rho^h(p) \right\}.$$

Now, if $\frac{1}{2} p^T x_1 + \frac{1}{2} p^T x_2 \le \rho^h(p)$, then we must have $p^T x_i \le \rho^h(p)$ for $i = 1$ or $i = 2$. Hence

$$\left\{ p \,|\, p^T \left(\frac{x_1 + x_2}{2}\right) \le \rho^h(p) \right\} \subset \left\{ p \,|\, p^T x_i \le \rho^h(p) \right\} \cup \left\{ p \,|\, p^T x_2 \le \rho^h(p) \right\},$$

$$U^h\left(\frac{x_1 + x_2}{2}\right) \ge \min_{i=1,2} \left\{ \tilde{W}^h(p) \,|\, p^T x_i \le \rho^h(p) \right\} = \min_{i=1,2} U^h(x_i) = a.$$

So the U^h are differentiable and quasi-concave.

The general case. In the two polar examples just considered—all goods are privately consumed, and all goods are publicly consumed—the sufficiency problem can thus be reformulated as follows: When can a given map from $\mathbb{R}^N$ to $\mathbb{R}^N$ be written as a linear combination of H gradients of increasing, strongly concave functions from $\mathbb{R}^N$ to $\mathbb{R}$? Specifically, this condition is necessary in both cases; furthermore, the condition is also sufficient, in the sense that whenever it is fulfilled one could construct a group for which the function at stake is indeed the aggregate demand.

We now show that this gradient structure is in fact general and that it fully characterizes the collective conditions. As explained above, it is sufficient to consider egoistic preferences without intragroup production. Therefore, we study the program

$$\begin{cases} \max_{x_1, \ldots x_H, X} \sum \mu^h(p, P) U^h(x_h, X) \\ p^T(x_1 + \ldots + x_H) + P^T X = 1. \end{cases} \tag{36}$$

Let $x_1(p, P), \ldots, x_H(p, P), X(p, P)$ denote its solution. The household demand function is then $\xi(p, P) = [x(p, P), X(p, P)]$, where $x = \sum_h x_h$.

In what follows, we repeatedly use the duality between private and public consumption, a standard tool in public economics. Assuming that the Jacobian matrix D_pX is of full rank, we consider the following change in variables:

$$\begin{aligned} &\psi : \mathbb{R}^N \to \mathbb{R}^N, \\ &(p, P) \to (p, X). \end{aligned} \tag{37}$$

The economic motivation for such a change in variables is clear. A basic insight underlying the duality between private and public goods is that, broadly speaking, quantities play for public goods the role of prices for private goods and vice versa. Intuitively, in the case of private goods, all agents face the same price but consume different quantities, which add up to the group's demand. With public goods, agents consume the same quantity, but face different (Lindahl) prices, which add up to the market price if the allocation is efficient. This suggests that whenever the direct demand function $x(p)$ is a relevant concept for private consumption, then the inverse demand function $P(X)$ should be used for public goods. The change of variable ψ allows us to implement this intuition.

In particular, instead of considering the demand function (x, X) as a function of (p, P), we often consider (x, P) as a function of (p, X) (then the public prices P are implicitly determined by the condition that the demand for public goods equals X while private prices equal p). Although these two viewpoints are clearly equivalent (one can switch from the first to the second and back using the change ψ), the computations are much easier (and more natural) in the second setting.

Conditional sharing rule. It is convenient, at this point, to introduce the notion of a conditional sharing rule, which directly generalizes the sharing rule introduced above in the case of private goods. It stems from the following result.

> **Lemma 2:** For any given (p, P), let $\left(\bar{x}_1, \ldots, \bar{x}_H, \bar{X}\right)$ denote a solution to Equation 36. Define $\rho^h = p^T \bar{x}_h$ for $h = 1, \ldots, H$. Then for $h = 1, \ldots, H$, $\bar{x}_h$ solves
>
> $$\begin{aligned} &\max_{x_h} U^h(x_h, \bar{X}) \text{ subject to} \\ &p^T x_h \leq \rho^h. \end{aligned} \tag{38}$$
>
> **Proof**: Assume then there does not exist some $\tilde{x}_h$ such that $p^T \tilde{x}_h \leq \rho^h$ and $U^h(\tilde{x}_h, \bar{X}) > U^h(\bar{x}_h, \bar{X})$. But then the allocation $\left(\bar{x}_1, \ldots, \tilde{x}_h, \ldots \bar{x}_H, \bar{X}\right)$ is feasible and Pareto dominates $\left(\bar{x}_1, \ldots, \bar{x}_H, \bar{X}\right)$, a contradiction.

In words, an efficient allocation can be seen as stemming from a two-stage decision process. In the first stage, members decide on the public purchases X and on the allocation of the remaining income $y - P^T X$ between the members; member h receives ρ^h. In the second stage, agents each chose their vector of private consumption, subject to their own budget constraint and taking the level of public consumption as given. The vector $\rho = (\rho_1, \ldots, \rho_H)$ is the conditional sharing rule; it generalizes the notion of a sharing rule developed in collective models with private goods only because it is defined conditionally on the level of public consumption previously chosen. Of course, if all commodities are private ($K = 0$), then the conditional sharing rule boils down to the previous notion. In all cases, the conditional sharing rules satisfy the budget constraint

$$\sum_h \rho^h = 1 - P^T X. \tag{39}$$

As above, the conditional sharing rule can be expressed either as a function of (p, P) or, using the change in variable ψ, as a function of (p, X). We define the conditional indirect utility of member h as the value of the program given in Equation 27; hence

$$V^h(p, X, \rho) = \max\{U^h(x_h, X)\} \quad \text{subject to } p^T x_h = \rho, \tag{40}$$

which can be interpreted as the utility reached by member h when consuming X and being allocated an amount ρ for her private expenditures. Obviously, V^h is zero homogeneous in (p, ρ).

Collective indirect utility. Following Chiappori (2005) and Blundell et al. (2005), we introduce the following key definition, which again generalizes that introduced in the private-good case.

Definition 1: The collective indirect utility of agent h is defined by

$$W^h(p, X) = V^h\left[p, X, \rho^h(p, X)\right].$$

In words, W^h denotes the utility level reached by agent h, at prices p and with total income y, in an efficient allocation such that the household demand for public goods is X, taking into account the conditional sharing rule at stake. Note that W^h depends not only on the preferences of agent h (through the conditional indirect utility V^h), but also on the decision process (through the conditional sharing rule ρ^h). Hence W^h summarizes the impact on h of the interactions taking place within the group. As such, it is the main concept required for welfare analysis: Knowing each W^h, one can assess the impact of any reform (i.e., any change in prices and incomes) on the welfare of each group member. Also, in the case of public consumption only, W^h is simply equal to the direct utility U^h. Finally, remember that we are using the normalization $y = 1$. Without it, W^h would be a function of (p, X, y).

One can then prove (Chiappori & Ekeland 2006, 2009a) the following result: There exist scalar functions $(\gamma^1, \ldots, \gamma^h)$ such that

$$\begin{aligned} \textstyle\sum_h \gamma^h D_p W^h &= -x - D_p A, \\ \textstyle\sum_h \gamma^h D_X W^h &= P - D_X A, \end{aligned} \tag{41}$$

where $A(p, X) = P(p, X)^T \cdot X$ denote the group's total expenditures on public goods. We thus see that in the general case under consideration, the sufficiency problem can be expressed as follows: Find a family of differentiable functions $W^h(p, X)$ on $\mathbb{R}^N$, each defined up to some increasing transform, such that the vector $\begin{pmatrix} -x - D_p A \\ P - D_X A \end{pmatrix}$ can be expressed as a linear combination of the gradients of W^h.

The main result. We can now state the main result.

Theorem 1: Suppose a positive C^1 function $\xi(\pi)$ satisfies the Walras law $\pi^T \xi(\pi) = 1$ and condition SNR$(H-1)$ in some neighborhood of $\bar{\pi}$:

$$S(\pi) = (D_{\boldsymbol{\pi}}\boldsymbol{\xi})\left(I - \pi\xi^T\right) = \Sigma(\pi) + \sum_{h=1}^{H-1} a_h(\pi)b_h^T(\pi), \tag{42}$$

where $\Sigma(\pi)$ is symmetric, negative semidefinite, and the vectors $\xi(\pi)$, $a_h(\pi)$, and $b_h(\pi)$ are linearly independent. Then there are positive functions $\lambda_h(\pi)$ and increasing, strongly concave functions $V^h(\pi)$, $1 \leq h \leq H$, both defined on some neighborhood $\mathcal{N}$ of $\bar{\pi}$, such that the decomposition

$$\xi(\pi) = \sum_{h=1}^{H} \lambda_h(\pi) D_\pi V^h(\pi) \tag{43}$$

holds true on $\mathcal{N}$.

Proof: For the proof, the reader is referred to Chiappori & Ekeland (2009b).

In words, SNR($H-1$) is a necessary and locally sufficient characterization of the aggregate demand of an efficient group. Some remarks are in order on that point. First, SNR($H-1$) remains necessary and sufficient even when one assumes either that all goods are publicly consumed or that all goods are privately consumed. In other words, the private versus public nature of intragroup consumption is not testable without additional assumptions. Second, the SNR($H-1$) condition is restrictive if and only if the number of commodities is larger than the number of agents. Indeed, in the opposite case, one can always write the decomposition in Equation 22 with $\Sigma(\pi) = 0$ and $R(\pi) = S(\pi)$. Quite interestingly, we confirm in this general framework an intuition already generated in the very specific case of a market economy—namely, that the individualistic foundations of the model induce some structure on the group's aggregate demand if and only if the group is small enough (technically, if it has fewer agents than commodities). Finally, note, however, that the key ingredient for this testability is Pareto efficiency. In that sense, the exclusive emphasis in the DMS literature on competitive equilibria in a market economy seems misleading ex post. Equilibria are but a specific form of Pareto-efficient allocations in a specific context (characterized by egoistic preferences, the absence of public goods and external effects), and the market economy literature in addition imposes highly specific types of intragroup allocation of income. The results just described imply that, perhaps surprisingly, none of these restrictions makes any difference for the basic conclusion.

5.2.3. Revealed preferences. The conditions described above characterize smooth demand functions and test for the generalized Slutsky conditions for integrability. An alternative approach to empirical demand analysis that has gained ground in the past few years is the RP approach derived from Afriat (1967) and Varian (1982). This style of analysis explicitly recognizes that we only ever have a finite set of observations on prices and quantities, which cannot be used to directly construct smooth demand functions without auxiliary assumptions. The RP approach instead identifies linear inequality conditions on the finite data set that characterizes rational behavior. The most-attractive feature of the Afriat-Varian approach is that no functional form assumptions are imposed. Moreover, powerful numerical methods are available to implement the RP tests. The drawback of the RP approach is that even when the data satisfy the RP conditions, we can only set identify preferences (see Blundell et al. 2008).

Chiappori (1988b) first generalized the unitary model RP conditions to the collective setting for a specific version of the collective model. The conditions for the general model have been established in Cherchye et al. (2007, 2008, 2009); these papers provide a complete characterization of the collective model in an RP context. This requires several significant extensions to the RP approach for the unitary model. For example, these authors allow for nonconvex preferences and develop novel (integer programming) methods because the linear programming techniques that work for the unitary model are not applicable to the collective model. The tests for collective rationality require that one find individual utility levels, individual marginal utilities of money (implying Pareto weights), and individual assignments for private goods and Lindahl prices for public goods. As in the unitary model, these methods can set identify only the preferences of the household members and the Pareto weight. Cherchye et al. (2011) apply these methods to a Russian expenditure panel.

5.3. Aggregate Demand of an Efficient Group: Identification

Broadly speaking, the identification question can be stated as follows: When is it possible to recover the underlying structure—namely, individual preferences, the effective distribution of power, and the resulting intragroup transfers—from the sole observation of the group's aggregate behavior?

Recent results in the literature on household behavior suggest that, surprisingly enough, when the group is small, the structure can be recovered under reasonably mild assumptions. For instance, in the model of household labor supply proposed by Chiappori (1988b, 1992), two individuals privately consume leisure and some Hicksian composite good. The main conclusion is that the two individual preferences and the decision process can generically be recovered (up to an additive constant) from the two labor supply functions. This result has been empirically applied, for example, by Fortin & Lacroix (1997) and Chiappori et al. (2002b) and extended by Chiappori (1997) to household production and by Blundell et al. (2007) and Donni (2003) to discrete participation decisions. Fong & Zhang (2001) consider a more general model in which leisure can be consumed both privately and publicly. Although the two alternative uses are not independently observed, in general they can be identified under a separability restriction, provided that the consumption of another exclusive good (e.g., clothing) is observed.

Taken together, these results suggest that multiperson groups need not remain black boxes, for which the structure cannot be investigated without precise information on intragroup decision processes. On the contrary, the group's aggregate behavior, as summarized by its demand function, contains potentially rich information on its structure—i.e., individual preferences and the distribution of powers between its members. We now substantiate this claim.

Define a structure as a set of individual utilities and Pareto weights (normalized, for instance, by the condition that their sum is one). Moreover, two structures $(U^1,\ldots,U^H;\mu_1,\ldots,\mu_H)$ and $(\bar{U}^1,\ldots,\bar{U}^H;\bar{\mu}_1,\ldots,\bar{\mu}_H)$ are equivalent if (*a*) for each h, there exists some increasing mapping F^h such that $U^h = F^h(\bar{U}^h)$, and (*b*) for any (π, y), $(\mu_1,\ldots,\mu_H)$ and $(\bar{\mu}_1,\ldots,\bar{\mu}_H)$ correspond to parameterizations of the same Pareto-efficient allocation for the respective cardinalizations of individual preferences; two structures are different if they are not equivalent.

A first result is the following.

> **Proposition 3**: In the most general version of the model, there exists a continuum of different structures that generate the same aggregate demand function. Moreover, the result remains valid even when all commodities are privately consumed or all commodities are publicly consumed.

Proof: For the proof, the reader is referred to Chiappori & Ekeland (2009a,b).

In the most general case, there thus exists a continuum of observationally equivalent models—i.e., a continuum of structurally different settings generating identical observable behavior. This negative result implies that additional assumptions are required.

As it turns out, such assumptions are surprisingly mild. Essentially, it is sufficient that each agent in the group be excluded from the consumption of (at least) one commodity. We start with the case in which all commodities are publicly consumed. Then the following result holds.

> **Proposition 4**: In the collective model with H agents and public consumption only, if member 1 does not consume at least one good, then generically the utility of member 1 is exactly (ordinally) identifiable from household demand. If each member is excluded from the consumption of at least one specific good, then generically individual preferences are exactly (ordinally) identifiable from household demand, and for any cardinalization of individual utilities, the Pareto weights are exactly identifiable.

Proof: For the proof, the reader is referred to Chiappori & Ekeland (2009a,b).

This result, in particular, has been applied to the collective formulation of household behavior. A large literature has been devoted to the analysis of labor supply, following the initial contribution of Chiappori (1988b, 1992). The idea is to consider the household as a two-person group making Pareto-efficient decisions on consumption and labor supply. Let L^h denote the leisure of member h, and w_h the corresponding wage. Various versions of the model can be considered. In each, Proposition 4 applies, leading to the full identifiability of the model (see Chiappori & Ekeland 2009b).

The general case (in which some goods are consumed privately and some publicly) is slightly more complex.

> **Proposition 5**: In the general, collective model with two agents, if each member is excluded from the consumption of at least one specific good, then generically the indirect collective utility of each member is exactly (ordinally) identifiable from household demand. For any cardinalization of indirect collective utilities, the Pareto weights are exactly identifiable.

Proof: For the proof, the reader is referred to Chiappori & Ekeland (2009a,b).

Here, what is identified is the structure that is relevant to formulate welfare judgments (namely, the indirect collective utility W^h of each agent h). Remember that W^h is not identical to the standard indirect utility function V^h. The difference indeed is that W^h captures both the preferences of agent h (through V^h) and the decision process (which governs the way private commodities are allocated). In particular, identifying W^h is not

equivalent to identifying V^h (hence U^h). If, for instance, all commodities are private, we have

$$W^h(p) = V^h\left[p, \rho^h(p)\right] = V^h\left[\frac{p}{\rho^h(p)}, 1\right], \tag{44}$$

and it is easy to prove that knowledge of W^h is not sufficient to independently identify both ρ^h and V^h. For any W^h, there exists a continuum of pairs (ρ^h, V^h) such that Equation 44 is satisfied.[13] In contrast to the public-good case, knowledge of the collective indirect utilities is therefore not sufficient, in the presence of private consumption, to identify individual preferences and the decision process (as summarized by the sharing rule). However, the indeterminacy is welfare irrelevant: Any welfare conclusion reached using one particular solution would remain valid for all the others (this is exactly the scope of the indirect collective utilities).

Finally, the previous identification result is only generic. One can find cases in which it does not obtain, but these cases are not robust to small perturbations.[14] Among these pathological contexts is the Samuelson index case, in which the group behaves as a single consumer. Intuitively, the basic condition (that some function must be decomposed as a linear combination of gradients) is then degenerate: The function is in fact proportional to a single gradient, which can itself be decomposed into a continuum of different sums. In other words, when a group behaves as a single consumer, then individual preferences are not identifiable. Ironically, a large fraction of the literature devoted to household behavior tends to assume a unitary setting, in which the group is described as a unique decision maker. Our conclusions show that this approach, although analytically convenient, entails a huge cost, as it precludes the (nonparametric) identification of individual consumption and welfare. In a general sense, nonunitary models are indispensable to address issues related to intragroup allocation.

6. CONCLUSION

The old literature on aggregation concentrated mainly on two issues. One was related to the structure of the aggregate (market or excess) demand of a large market economy; the other dealt with the conditions under which a small group would behave as a single decision maker. The research programs represented by these issues have mostly been completed. The questions raised by Sonnenschein (1973) have been answered (some quite recently), and Hildenbrand's contributions have illuminated how the aggregation of sufficiently heterogeneous individual behaviors could in fact create structure. Alternatively, the unitary representation of small groups (mostly families) has been the basis of a considerable theoretical and empirical literature.

Modern approaches have recently triggered a deep reconsideration of these views. The claim that general equilibrium theory could not generate testable predictions has been challenged; the consensus is now that testable implications exist, but they typically require micro data. What is dubious is that testable restrictions could be generated only if aggregate data are available, at least without very strong (and microempirically unrealistic) restrictions.

[13]For instance, pick up some arbitrary $\phi(p)$ mapping $\mathbb{R}^N$ into $\mathbb{R}$ and define an alternative solution $(\bar{\rho}^s, \bar{V}^s)$ by $\bar{\rho}^s(p) = \phi(p)\rho^s(p)$ and $\bar{V}^s(p, 1) = V^s[\phi(p)p, 1]$. Then Equation 44 is satisfied for the alternative solution.

[14]Technically, demands for which identification does not obtain must satisfy a specific partial differential equation (see Chiappori & Ekeland 2009b).

More importantly, the emphasis has shifted from aggregation in the large to aggregation in the small. Recent approaches have taken seriously the idea that the aggregate behavior of a (small) group exhibits specific features, which cannot in general and should not in any case be reduced to an individual decision process. These features actually raise fascinating issues about power relationships within groups and their impact on aggregate behavior, and a set of new results suggests that much can be learned about the former from a careful investigation of the latter. From this perspective, the macro fiction of a representative consumer no longer seems too attractive.

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LITERATURE CITED

Afriat S. 1967. The construction of a utility function from expenditure data. *Int. Econ. Rev.* 8:67–77

Andreu J. 1982. Rationalization of market demand on finite domains. *J. Econ. Theory* 28:201–4

Antonelli GB. 1971 (1886). Sulla teoria matematica della economia politica. Transl. in *Preferences, Utility and Demand: A Minnesota Symposium*, ed. JS Chipman, L Hurwicz, MK Richter, HF Sonnenschein, pp. 333–64. New York: Harcourt Brace Jovanovich

Arrow K. 1991. Economic theory and the hypothesis of rationality. In *The New Palgrave Dictionary of Economics*, ed. J Eatwell, M Milgate, P Newman, pp. 198–210. London: MacMillan

Banks J, Blundell R, Lewbel A. 1997. Quadratic Engel curves and consumer demand. *Rev. Econ. Stat.* 79:527–39

Bergstrom TC. 1989. A fresh look at the rotten kid theorem—and other household mysteries. *J. Polit. Econ.* 97:1138–59

Bergstrom TC, Cornes R. 1983. Independence of allocative efficiency from distribution in the theory of public goods. *Econometrica* 51:1753–65

Blundell R, Browning M, Crawford I. 2008. Best nonparametric bounds on demand responses. *Econometrica* 76:1227–62

Blundell R, Chiappori PA, Magnac T, Meghir C. 2007. Collective labor supply: heterogeneity and nonparticipation. *Rev. Econ. Stud.* 74:417–47

Blundell R, Chiappori PA, Meghir C. 2005. Collective labor supply with children. *J. Polit. Econ.* 113:1277–306

Brown D, Matzkin R. 1996. Testable restrictions on the equilibrium manifold. *Econometrica* 64:1249–62

Brown D, Shannon C. 2000. Uniqueness, stability, and comparative statics in rationalizable Walrasian markets. *Econometrica* 68:1529–40

Browning M, Chiappori PA. 1998. Efficient intra-household allocations: a general characterization and empirical tests. *Econometrica* 66:1241–78

Browning M, Chiappori PA, Weiss Y. 2011. *Household Economics*. Cambridge, UK: Cambridge Univ. Press. In press

Bryant R, Chern S, Gardner R, Goldschmidt H, Griffiths P. 1991. *Exterior Differential Systems*. New York: Springer-Verlag

Cartan E. 1945. *Les Systèmes Différentiels Extérieurs et Leurs Applications Géométriques*. Paris: Hermann

Cherchye L, De Rock B, Sabbe J, Vermeulen F. 2008. Nonparametric tests of collectively rational consumption behavior: an integer programming procedure. *J. Econom.* 147:258–65

Cherchye L, De Rock B, Vermeulen F. 2007. The collective model of household consumption: a nonparametric characterization. *Econometrica* 75:553–74

Cherchye L, De Rock B, Vermeulen F. 2009. Opening the black box of intra-household decision-making: theory and non-parametric empirical tests of general collective consumption models. *J. Polit. Econ.* 117:1074–104

Cherchye L, De Rock B, Vermeulen F. 2011. The revealed preference approach to collective consumption behavior: testing and sharing rule recovery. *Rev. Econ. Stud.* 78:176–98

Chiappori PA. 1985. Distribution of income and the "law of demand." *Econometrica* 53:109–28

Chiappori PA. 1988a. Nash-bargained household decisions: a comment. *Int. Econ. Rev.* 29:791–96

Chiappori PA. 1988b. Rational household labor supply. *Econometrica* 56:63–89

Chiappori PA. 1992. Collective labor supply and welfare. *J. Polit. Econ.* 100:437–67

Chiappori PA. 1997. Introducing household production in collective models of labor supply. *J. Polit. Econ.* 105:191–209

Chiappori PA. 2005. Modèle collectif et analyse de bien-être. *Actual. Econ./Rev. Anal. Econ.* 81:405–19

Chiappori PA. 2010. Testable implications of transferable utility. *J. Econ. Theory* 145:1302–17

Chiappori PA, Ekeland I. 1997. A convex Darboux theorem. *Ann. Sc. Norm. Super. Pisa* 4:287–97

Chiappori PA, Ekeland I. 1999a. Aggregation and market demand: an exterior differential calculus viewpoint. *Econometrica* 67:1435–58

Chiappori PA, Ekeland I. 1999b. Disaggregation of excess demand functions in incomplete markets. *J. Math. Econ.* 31:111–29

Chiappori PA, Ekeland I. 2000. Corrigendum to "Disaggregation of excess demand functions in incomplete markets." *J. Math. Econ.* 33:531–32

Chiappori PA, Ekeland I. 2004. Individual excess demand. *J. Math. Econ.* 40:41–57

Chiappori PA, Ekeland I. 2006. The micro economics of group behavior: general characterization. *J. Econ. Theory* 130:1–26

Chiappori PA, Ekeland I. 2009a. *The Economics and Mathematics of Aggregation.* Found. Trends Microecon. 5. Hanover, MA: Now

Chiappori PA, Ekeland I. 2009b. The micro economics of efficient group behavior: identification. *Econometrica* 77:763–99

Chiappori PA, Ekeland I, Kubler F, Polemarchakis H. 2002a. The identification of preferences from equilibrium prices under uncertainty. *J. Econ. Theory* 102:403–20

Chiappori PA, Ekeland I, Kubler F, Polemarchakis HM. 2004. Testable implications of general equilibrium theory: a differentiable approach. *J. Math. Econ.* 40:105–19

Chiappori PA, Fortin B, Lacroix G. 2002b. Marriage market, divorce legislation and household labor supply. *J. Polit. Econ.* 110:37–72

d'Aspremont C, Dos Santos Ferreira R. 2009. Household behavior and individual autonomy. *CORE Discuss. Pap. 2009022*, Cent. Oper. Res. Econom., Univ. Cathol. Louvain

Dauphin A. 2003. *Rationalité collective des ménages comportant plusieurs membres: résultats théoriques et applications au Burkina Faso*. PhD thesis. Univ. Laval

Dauphin A, El Lahga AR, Fortin B, Lacroix G. 2008. Are children decision-makers within the household? *IZA Discuss. Pap. 3728*, Bonn, Ger.

Dauphin A, Fortin B. 2001. A test of collective rationality for multi-person households. *Econ. Lett.* 71:211–16

Deaton A, Muelbauer J. 1980. *Economics and Consumer Behavior.* Cambridge, UK: Cambridge Univ. Press
Debreu G. 1974. Excess demand functions. *J. Math. Econ.* 1:15–23
Diewert WE. 1977. Generalized Slutsky conditions for aggregate consumer demand functions. *J. Econ. Theory* 15:353–62
Donni O. 2003. Collective household labor supply: non-participation and income taxation. *J. Public Econ.* 87:1179–98
Dow J, da Costa Werlang SR. 1988. The consistency of welfare judgments with a representative consumer. *J. Econ. Theory* 44:269–80
Ekeland I, Djitte N. 2006. An inverse problem in the economic theory of demand. *Ann. Inst. Henri Poincaré* 23:269–81
Ekeland I, Nirenberg L. 2002. The convex Darboux theorem. *Methods Appl. Anal.* 9:329–44
Fong Y-F, Zhang J. 2001. The identification of unobservable independent and spousal leisure. *J. Polit. Econ.* 109:191–202
Fortin B, Lacroix G. 1997. A test of neoclassical and collective models of household labor supply. *Econ. J.* 107:933–55
Geanakoplos J, Polemarchakis H. 1980. On the disaggregation of excess demand functions. *Econometrica* 48:315–31
Gorman WM. 1981. Some Engel curves. In *Essays in the Theory and Measurement of Consumer Behavior in Honor of Sir Richard Stone*, ed. A Deaton, pp. 7–30. Cambridge, UK: Cambridge Univ. Press
Grandmont JM. 1992. Transformation of the commodity space, behavioural heterogeneity, and the aggregation problem. *J. Econ. Theory* 57:1–35
Härdle W, Hildenbrand W, Jerison M. 1991. Empirical evidence of the law of demand. *Econometrica* 59:1525–49
Hicks JR. 1956. *A Revision of Demand Theory.* Oxford: Clarendon
Hildenbrand W. 1983. On the law of demand. *Econometrica* 51:997–1019
Hildenbrand W. 1994. *Market Demand: Theory and Empirical Evidence.* Princeton, NJ: Princeton Univ. Press
Grossbard-Schechtman S, Neuman S. 2003. Marriage and work for pay. In *Marriage and the Economy: Theory and Evidence from Advanced Societies*, ed. S Grossbard-Schechtman, pp. 222–47. Cambridge, UK: Cambridge Univ. Press
Jerison M. 1982. *The representative consumer and the weak axiom when the distribution of income is fixed.* Work. Pap. 150, State Univ. New York, Albany
Jerison M. 1984a. Aggregation and pairwise aggregation of demand when the distribution of income is fixed. *J. Econ. Theory* 33:1–31
Jerison M. 1984b. Social welfare and the nonrepresentative representative consumer. *Discuss. Pap.*, State Univ. New York, Albany
Jerison M. 1999. Dispersed excess demands, the weak axiom and uniqueness of equilibrium. *J. Math. Econ.* 31:15–48
Kähler E. 1934. *Einführung in die Theorie der Systeme von Differentialgleichungen.* Leipzig: Teubner
Kapan T. 2009. *Essays in household behavior.* PhD diss. Columbia Univ.
Kneip A. 1999. Behavioural heterogeneity and structural properties of aggregate demand. *J. Math. Econ.* 31:49–79
Kubler F. 2003. Observable restrictions of general equilibrium with financial markets. *J. Econ. Theory* 110:137–53
Lau L. 1982. A note on the fundamental theorem of exact aggregation. *Econ. Lett.* 9:119–26
Lechene V, Preston I. 2011. Non cooperative household demand. *J. Econ. Theory* 146:504–27
Lewbel A. 1991. The rank of demand systems: theory and nonparametric estimation. *Econometrica* 59:711–30
Mas Colell A, Whinston M, Green J. 1994. *Microeconomic Theory.* New York: Oxford Univ. Press

Manser M, Brown M. 1980. Marriage and household decisionmaking: a bargaining analysis. *Int. Econ. Rev.* 21:31–44

Mantel R. 1974. On the characterization of aggregate excess demand. *J. Econ. Theory* 7:348–53

Mantel R. 1976. Homothetic preferences and community excess demand functions. *J. Econ. Theory* 12:197–201

McElroy MB, Horney MJ. 1981. Nash-bargained household decisions: toward a generalization of the theory of demand. *Int. Econ. Rev.* 22:333–49

Shafer W, Sonnenschein H. 1982. Market demand and excess demand functions. In *Handbook of Mathematical Economics*, Vol. 2, ed. K Arrow, M Intriligator, pp. 672–93. Amsterdam: North-Holland

Snyder S. 1999. Testable restrictions of Pareto optimal public good provision. *J. Public Econ.* 71:97–119

Sonnenschein H. 1973. The utility hypothesis and market demand theory. *West. Econ. J.* 11:404–10

Varian HR. 1982. The nonparametric approach to demand analysis. *Econometrica* 50:945–73

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The influence of spouses on household decision making under risk: an experiment in rural China

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Abstract We study household decision making in a high-stakes experiment with a random sample of households in rural China. Spouses have to choose between risky lotteries, first separately and then jointly. We find that spouses' individual risk preferences are more similar the richer the household and the higher the wife's relative income contribution. A couple's joint decision is typically very similar to the husband's preferences, but women who contribute relatively more to the household income, women in high-income households, and women with communist party membership have a stronger influence on the joint decision.

Keywords Household decision making · Risk · Experiment in the field · China

JEL Classification C91 · C92 · C93 · D10

1 Introduction

Many important economic decisions—e.g., labor supply, residential location, buying insurance or a new car, investing in stocks and bonds or in children's education—are

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often made by households rather than by individuals. This implies that the decisions will be a function of the preferences of the household members and the decision making process. In particular, it has been shown that decisions and outcomes in a household—such as child health, nutrition, and expenditures for different goods and services (e.g., tobacco versus child care)—depend strongly on whether its income is controlled by the husband or the wife (see Thomas 1994; Lundberg et al. 1997; Phipps and Burton 1998; Duflo 2003). Qian (2008), for instance, reports that the relative female income (as a share of total household income) in Chinese rural households has had significantly positive impacts on the survival rates for girls and on the educational attainment of children.

In this paper we present an experiment that was run in the homes of 117 randomly selected married couples in rural China. Wives and husbands had to choose between different lotteries first individually and then jointly. Our aim is to provide controlled experimental evidence on two important aspects of household decision making. First, we address how similar the two spouses' individual decisions are when decisions are made separately, and which socioeconomic factors influence the level of similarity. Second, we study how a couple's joint decision relates to the spouses' separate decisions, and which conditions are related to a stronger influence of the wife on the joint decision. Thus, we can study the circumstances that determine the outcome of an implicit bargaining process that is assumed to take place in many household decisions.

We find that spouses in richer households have more similar individual risk attitudes. In general, a couple's joint decision is closer to the husband's individual decision. However, we show that the preferences of women are better reflected in joint decisions if women contribute relatively more to household income, live in households of higher joint income, or are communist party members.

Recently, experiments have become increasingly popular as a method for gaining deeper insights into household behavior by carefully controlling—and varying—the conditions under which household members can make decisions (see, e.g., Peters et al. 2004; Bateman and Munro 2005; Ashraf 2009; de Palma et al. 2011; Abdellaoui et al. 2011). These experiments are a result of a shift in the theoretical modeling of decision making in a household from using unitary models, which assume a unique decision-maker, to collective models (see, for instance, Lundberg and Pollak 1996; Vermeulen 2002; de Palma et al. 2011). Our paper is most closely related to contributions by Bateman and Munro (2005) and de Palma et al. (2011). Bateman and Munro (2005) examine whether decisions made by couples conform more or less to the axioms of expected utility theory compared to decisions made by spouses individually. To do this, they invited 76 couples and let the spouses make risky decisions both separately and jointly. Their results suggest that couples exhibit the same kinds of departures from expected utility theory as individuals. Furthermore, they find joint decisions to be typically more risk averse than the spouses' individual decisions. de Palma et al. (2011) focus on the question of which spouse has more influence on joint decisions. Based on observations from 22 couples, they conclude that husbands generally have a stronger influence on joint decisions than wives, although wives gain influence if they control the computer keyboard while entering the joint decisions in the experiment. Contrary to Bateman and Munro (2005), de Palma et al. (2011) also report that the joint decision of a couple tended to be less risk averse than the spouses' individual decisions.

Our paper distinguishes itself from these important contributions in several dimensions: First, the subject pools are completely different. While Bateman and Munro (2005) and de Palma et al. (2011) ran their experiments in highly developed countries, ours was conducted in the field in a rather poor area of China, which by many accounts is still a developing country. The experiment was run in the *Guizhou* province in the southwest of China. This is the poorest province in China. The average yearly per-capita income of the couples participating in our experiment was 570 US-Dollars and they had on average only 4.8 years of schooling, allowing us to study household decision making in a very different environment than in the studies of Bateman and Munro (2005) and de Palma et al. (2011).[1] Second, our sample is random. This means that the subjects were not invited through flyers or newspaper ads to participate in an experiment, which might give rise to endogeneity effects as to who is going to participate. Instead the participants in our experiment were randomly selected by the village council (as described in more detail in Sect. 3) and then approached by the experimenters in their homes. Although participation was voluntary, no couple refused the invitation to participate. Third, our experiment involves considerably higher stakes than those used in the UK by Bateman and Munro (2005) or in Germany by de Palma et al. (2011). In our experiment, the average earnings from participating in the experiment were roughly equivalent to the average income earned from three days of off-farm work.[2] Fourth, our research focus is different. Unlike Bateman and Munro (2005), we are not interested in whether couple decisions exhibit more or less so-called anomalies in decision making than decisions made individually; instead we examine the socio-demographic conditions under which (i) a couple's separate decisions are more similar and (ii) a couple's joint decision is more likely to be driven by the wife's individual preferences. Although de Palma et al. (2011) did address item (ii), they only took account of who was holding the computer mouse when entering the joint decision, while we consider a set of socio-demographic variables to estimate how individual decisions of spouses relate to the couple's joint decision.

Studying decision making in couples is also related to a recent strand of literature that addresses how groups make decisions in risky choices. The evidence with randomly formed groups is quite mixed.[3] There are, however, important differences

[1] The experiment of Ashraf (2009) was also run in a developing country (the Philippines). She showed that financial decisions of spouses are influenced by whether the (experimental) income is known to the other spouse and whether spouses communicate about how to spend the experimental earnings before making a final decision on how to use them. Hence, the focus of Ashraf's (2009) study is clearly different from ours.

[2] Kachelmeier and Shehata (1992) also ran a high-stakes experiment on risky decision making in China. They focused on the question of how the level of incentives affects revealed risk preferences. The experiment was run with students from Peking University, and is thus unrelated to household decision making. Tanaka et al. (2010) studied individual risk and time preferences in households in Vietnam, but were not interested in the joint decisions of couples and their determinants.

[3] For instance, Baker et al. (2008) and Masclet et al. (2009) report that groups are more risk averse in lottery choices than individuals, while Harrison et al. (2005) find no significant difference between individuals and groups, and Zhang and Casari (2011) find that groups are less risk averse than individuals. Shupp and Williams (2008) seem to offer some reconciliatory evidence by reporting that the average group is *more* risk averse than the average individual in high-risk situations, but groups tend to be *less* risk averse in low-risk situations. There is also research investigating whether (randomly formed) groups violate expected utility theory to the same degree as individuals do (e.g., Bone 1998: Bone et al. 1999, 2004,

between randomly formed groups in the laboratory and married couples, making it difficult to draw direct comparisons. Married couples do have a history with repeated interactions, while randomly formed groups in the laboratory only meet for a very short period for a specific (experimental) task, after which they separate immediately. The process of sharing information, the degree of potential altruism and willingness to find compromises are most likely different in real couples than in ad hoc groups as a consequence of repeated interaction in couples. The closest paper on groups and risk taking to our approach is He et al. (2012) who ran risk-taking experiments with student couples to bridge the gap between ad hoc created groups and (long-married) couples, and they find that student couples are more risk neutral than the choices of individual students.

The rest of the paper is organized as follows. Section 2 provides background information on our subject pool and on the Chinese province where the experiment was conducted. Section 3 introduces the experimental design and procedure. Section 4 presents the experimental results, and Sect. 5 concludes the paper.

2 Location of the experiment and background information on sampling and the actual sample

The experiment was conducted in rural communities in the *Guizhou* province, which is the 16th largest out of 32 provinces in China and is located in the southwest part of the country. *Guizhou's* total population is 39 million, and its main industries are mining, timber, and forestry. The gross domestic product per capita was around 6,700 Chinese Yuan in 2007.[4] This figure—the lowest among all provinces—corresponds to approximately 34 % of the national average (20,000 Chinese Yuan in 2007; see NBS 2008).

The University of Gothenburg supports a research program at Peking University. The *Guizhou* province is one of the regions where this program conducts research on issues related to the environment and resource use, both of which are inherently linked to risky decision making, which is the reason for choosing this province for our experiment.

The sampled region is *Majiang*, located in the eastern part of *Guizhou* and around 100 kilometers away from the province's capital city. The local forestry bureau officials provided us with a list of villages and townships in this region, from which they then randomly selected seven villages from five different townships. In each village, the local village council randomly selected from the household registration list—which includes all officially married couples—between 10 and 24 households, depending on the size of the village in order to sample roughly the same fractions of households in each village. Together with one member of the village cadre (i.e.,

Rockenbach et al. 2007). While no clear-cut bottom line has resulted from this strand of literature, it seems fair to conclude that groups are not considerably better in avoiding violations of axioms of rationality than individuals.

[4] 1 US Dollar corresponded to 7.42 Chinese Yuan at the time of running the experiment (November 2007).

a local official), two interviewers[5] were then accompanied by one member of the village cadre to these randomly selected households. If one of the spouses was not at home at the time of the interviewers' visit, the household next door was approached.[6] Once the two interviewers had met a couple, the member of the village cadre left again. Upon entering the homes, the couples were first surveyed by the interviewers on several issues concerning farming and forestry (as part of the *Environment for Development* project at the University of Gothenburg), and were then invited to participate in an experiment on decision making under risk. In total, 117 households were interviewed, and all of them participated voluntarily in the experiment.

Table 1 reports background statistics of the sampled households. The average yearly income per capita is 3,919 Chinese Yuan, which is about 40 % lower than the *Guizhou* province yearly average, but close to the *Majiang* region average.[7] Forty-two percent of the household income is generated from off-farm sources, and 36 % from agriculture. The remaining income originates from forestry, remittances, and other sources. Women contribute on average 42 % of the total household income. Among the couples in our sample, only one had been married for less than one year. The maximum length of marriage was 52 years, and the average was 27 years. It is important to note that many families in this region are not affected by the official one-child policy, and therefore the average number of children is larger than one. The reason for this is that the one-child policy is mainly for *Han* Chinese, and in our sampled region more than one-third of the inhabitants belong to other ethnic groups. The level of education is very low in our sample; the average number of years of schooling is 6.09 for husbands and 3.62 for wives. The overall average in the *Guizhou* province is 6.75 years of schooling, which indicates that the *Majiang* region is relatively underdeveloped. Eight percent of the women are party members, while 18 percent of men are.[8]

[5] In order to prevent villagers from spreading the word about the experiment within a village, we employed 20 interviewers. All interviewers were selected and their training was supervised by one of the authors, a native Chinese. Among the 20 interviewers, 12 were recruited from a local university, Guizhou University. They were able to understand and speak local village dialects, and one of them was present in each pair of interviewers. Three of the interviewers had worked in a similar risk experiment project before and were therefore chosen to give a two hour-training lecture for all other interviewers. After this lecture, two of them came to a stage to simulate an experiment and how it should be conducted (e.g., how to explain the experimental task, how to respond to questions and which questions interviewers should expect). Then all other interviewers had to come to the stage as well and simulate a real experiment. Those who made mistakes (such as, e.g., being unclear or suggestive) received more training until they could properly conduct the experiment.

[6] This happened in around 20 cases, probably because some households were engaged in the rice harvest at that time.

[7] The regional average in *Majiang* is around 3,500 Yuan (according to information from local cadres).

[8] This fraction is higher than the national average party membership of about 6 %, however there is significant volatility of party membership, which is often heavily influenced by local traditions (Guo and Bernstein 2004).

Table 1 Descriptive statistics ($N = 117$ households)

Variable	Description	Mean	St Dev	Min	Max
Income per capita	Household yearly income in Chinese Yuan per capita	3,919	8,200	200	84,117
Log Equivalence scaled income	Log of equivalence scaled household income in Chinese Yuan. Equivalence scale = $(\text{Adults} + 0.5 \times \text{Kids})^{0.75}$	8.058	1.024	5.645	11.751
Wife income contribution	Wife's share of total household income	0.418	0.152	0	1
Length of marriage	Number of years the couple has been married	26.465	12.458	1	52
Number of children	Number of children the couple has	1.077	1.043	0	6
Wife more educated	= 1 if wife has a higher education than the husband	0.145	0.354	0	1
Education difference between spouses	Education difference between spouses in absolute value	3.235	2.513	0	10
Wife older	= 1 if wife is older than husband	0.291	0.456	0	1
Age difference between spouses	Age difference between spouses in absolute value	2.863	3.109	0	19
Wife, party member	= 1 if wife is party/cadre member	0.077	0.268	0	1
Husband, party member	= 1 if husband is party/cadre member	0.179	0.385	0	1
Both spouses party members	= 1 if both spouses are party/cadre members	0.043	0.203	0	1

3 Experimental design and procedure

3.1 The experimental task

We used the choice list introduced by Holt and Laury (2002) to let subjects make risky decisions. Table 2 shows the ten pairwise choices. In each choice task, subjects had to choose either Option A (which can be regarded the relatively safe option) or Option B (the relatively risky option). While the possible payoffs in both options were fixed in all ten choices, the probability for the high payoff in each option increased in steps of 10 percentage points from 10 % to 100 %. Consequently, the probability for the low payoff decreased by 10 percentage points from 90 % to 0 %. For example, in the first decision the respondents had to choose between an Option A of earning either 20 Chinese Yuan with a probability of 10 % or 16 Chinese Yuan with a probability of 90 %, and an Option B of earning either 38.5 Chinese Yuan with a 10 % probability or 1 Chinese Yuan with a 90 % probability.

The far-right column of Table 2 indicates the difference in expected payoffs. In the first four (final six) rows, Option A (Option B) has a higher expected payoff. Therefore, a risk neutral subject would choose Option A in the first four decisions and Option B in the last six decisions. Subjects who switch to Option B after the fifth choice can be classified as risk averse, whereas subjects switching to Option B prior to the fifth choice are considered risk loving.

Table 2 The ten paired lottery-choice decisions in amounts of Chinese Yuan (¥)

Decision	Option A	Option B	Difference in expected payoff (Option A –Option B)
[1]	1/10 of ¥20, 9/10 of ¥16	1/10 of ¥38.5, 9/10 of ¥1	¥11.7
[2]	2/10 of ¥20, 8/10 of ¥16	2/10 of ¥38.5, 8/10 of ¥1	¥8.3
[3]	3/10 of ¥20, 7/10 of ¥16	3/10 of ¥38.5, 7/10 of ¥1	¥5.0
[4]	4/10 of ¥20, 6/10 of ¥16	4/10 of ¥38.5, 6/10 of ¥1	¥1.6
[5]	5/10 of ¥20, 5/10 of ¥16	5/10 of ¥38.5, 5/10 of ¥1	-¥1.8
[6]	6/10 of ¥20, 4/10 of ¥16	6/10 of ¥38.5, 4/10 of ¥1	-¥5.1
[7]	7/10 of ¥20, 3/10 of ¥16	7/10 of ¥38.5, 3/10 of ¥1	-¥8.5
[8]	8/10 of ¥20, 2/10 of ¥16	8/10 of ¥38.5, 2/10 of ¥1	-¥11.8
[9]	9/10 of ¥20, 1/10 of ¥16	9/10 of ¥38.5, 1/10 of ¥1	-¥15.2
[10]	10/10 of ¥20, 0/10 of ¥16	10/10 of ¥38.5, 0/10 of ¥1	-¥18.5

"$p/10$ of ¥x, $q/10$ of ¥y" reads that the amount x is gained with probability $p/10$ and the amount y with the probability $q/10$ $(= 1 - p/10)$

3.2 Procedure

In total, there were several stages in the experiment.[9] Each stage was explained only after the previous stage had been finished. Before Stage 1, spouses were separated into two different rooms, each of them accompanied by an interviewer (henceforth called experimenter).[10] This was done to avoid that the answers of one spouse would be influenced by the presence of the other spouse. In Stage 1, each spouse had to answer a detailed questionnaire on socio-demographic characteristics, health status, and social capital individually. In Stage 2, each spouse made individual decisions in the choice task of Holt and Laury (2002). In Stage 3, the two spouses were reunited and had to give joint answers regarding the financial situation of the household and some additional household characteristics. In this stage and the following, the spouses could talk to each other. Stage 4 was identical to Stage 2, except that the spouses had to make a joint decision, which means that they had to agree on which option to choose in the ten choice tasks. In the introduction to Stage 4, the participants were informed that the amounts in each option would be paid to each of the spouses. This procedure was chosen to keep each spouse's incentives constant across Stage 2 and Stage 4. The experimenters were present in the same room to be able to answer any questions immediately, and they recorded a joint decision as fixed only after both spouses had given their consent. Both in Stage 2 and Stage 4, participants were

[9]The experiment also included two stages on the elicitation of time preferences. They are analyzed separately in a companion paper (see Carlsson et al. 2012), for which reason we do not report these data here.

[10]Note that we randomly reshuffled the pairs of experimenters each day in the field to avoid any experimenter effects. Furthermore, we balanced the genders of the two experimenters in each household and instructed the experimenters to switch back and forth between interviewing the wife and interviewing the husband when moving from one household to the next.

instructed that one of the ten decisions in each stage would be played out for real at the end of the experiment. Thus, at Stage 4 the participants still did not know the outcome of Stage 2. Furthermore, in Stage 2 it was stressed that the payment for Stage 2 would be done separately for husbands and wives in different rooms at the end of the whole experiment.

Given the generally low educational level of our participants, we took great care to explain the rules of the experiment as clearly as possible. To do so, the task at hand was first explained orally and then demonstrated visually both in Stage 2 and Stage 4. The probabilities for the high and low payoff in a given option were illustrated by using white and black chips on two separate boards that illustrated an Option A and an Option B. On the left-hand side of each board, we wrote down the high amount and on the right-hand side the low amount. For example, for the first decision (see Table 2), we placed one white chip next to the high amount and nine black chips next to the low amount. Then we put all chips in a bag and told the participants that at the end of the experiment they would be able to draw one chip from such a bag, and that drawing a white (black) chip would yield the high (low) payoff in the chosen option.

At the end of the experiment, the spouses were sent to two separate rooms again. There each spouse had to draw one card from a deck of ten numbered cards to determine which Stage 2 decision would be played for real. Then, as described above, he/she got to draw a chip from a bag with the corresponding distribution of white and black chips. Since this procedure was executed in two separate rooms, each spouse could receive his/her income privately, which means that spouses could hide their earnings from their partner if they wished to (earnings from Stage 2 were not disclosed to the other spouse by the experimenters). To determine Stage 4 payoffs, the couple was brought together again. Then, one spouse had to draw one card from the deck, and the other picked one chip from a bag that contained a corresponding distribution of chips. In total, executing the four stages took about 1.5 hours. On average, participants earned 37 Yuan, which equals roughly 1 % of an average yearly income, or three days of off-farm work.

Before proceeding to the results, it seems important to note that our design implies that individual decisions were always made before joint decisions. We did not consider the reverse order since we are interested in how the individual decisions of each spouse are reflected in the joint household decision. We assume, thus, that the starting point in a household bargaining process is how a spouse would decide him-/herself. It seems realistic that a spouse takes into account his or her own preferences when a joint decision has to be made in the household. This calls for an observation of individual decisions first to identify them properly. We think it is reassuring to note in addition that Baker et al. (2008) did not find any order effects with respect to sequential decision making individually or in (ad hoc) teams in a risky choice task.

4 Results

4.1 Analysis of aggregate data

Table 3 shows the relative frequency with which husbands, wives, and couples chose the safer Option A over the more risky Option B. We report only consistent choices,

Table 3 Risk-aversion classification based on lottery choices

Number of safe choices	Proportion of choices		
	Husbands ($N = 105$)	Wives ($N = 108$)	Couples ($N = 105$)
0–1	0.02	0.09	0.06
2	0.06	0.05	0.03
3	0.10	0.09	0.04
4	0.16	0.10	0.12
5	0.10	0.19	0.26
6	0.16	0.14	0.16
7	0.09	0.09	0.11
8	0.06	0.08	0.09
9	0.25	0.17	0.14
Average number of safe choices	5.82	5.39	5.65

meaning that we exclude all observations where a decision maker switched back at least once to Option A after having chosen Option B earlier, or where Option A was chosen in the tenth decision (i.e., preferring 20 Chinese Yuan for sure over 38.5 Chinese Yuan for sure). In total, 105 (out of 117) husbands, 108 wives, and 105 couples made consistent decisions. Hence, 318 out of 351 choice sets (90.5 %) are fully consistent. This fraction of inconsistent choices is well in the range reported in the literature, despite the low educational level in our sample.[11]

The bottom row of Table 3 indicates the average number of safe choices. Recall that a risk-neutral decision maker would choose the relatively safer Option A four times, and then switch to Option B. On average, however, we observe 5.52 safe choices, indicating risk aversion in the aggregate data. The large fraction of extremely risk-averse husbands (25 % chose Option A nine times and only then switched to Option B) and wives (17 %) might seem unusual at first sight. However, these fractions are in the range of extremely risk-averse choices reported in Holt and Laury (2002) for their treatments with relatively high stakes.[12]

The average number of safe choices made by couples is between the corresponding figures for husbands and wives. Although the data in Table 3 might look as if the decisions of couples were less extreme than individual decisions (perhaps because of

[11] Note that the fraction of inconsistent choices ranged from 5 % to 13 % in Holt and Laury (2002), depending upon treatment. Between 9 % and 23 % of all choices were inconsistent in de Palma et al. (2011). In Bateman and Munro (2005), 6 % of the participants chose strictly dominated options. It is also noteworthy that in our experiment making decisions as a couple did not affect the rate of consistent choices, most likely because individual consistency rates are already at a high level.

[12] When the high payoff from the safe (risky) option was 100 USD (192.50 USD), 15 % of all subjects in Holt and Laury (2002) chose the safe option nine times and only shifted to the risky option in the final, tenth choice (when there is no longer risk involved). In their treatment with very high stakes—with the high payoff in the safe (risky) option yielding 180 USD (346.50 USD)—Holt and Laury (2002) observed that even 40 % of their subjects chose the safe option nine times.

Table 4 Marginal effect of Negative Binomial Model on the determinants of safe choices (p-values in parentheses)

Variable	Coefficient
Log equivalence scaled household income	−0.224
	(0.266)
Ethnic group is Han (= 1)	0.719*
	(0.099)
Length of marriage in years	0.025
	(0.263)
Age	0.127
	(0.308)
Age square	−0.002
	(0.137)
Male (= 1)	0.715*
	(0.070)
Number of children	0.073
	(0.622)
Education level	−0.088
	(0.219)
If communist party member (= 1)	0.149
	(0.768)

Dependent variable: number of safe choices. Robust standard errors are estimated. *** (**) [*] significant at 1 % (5 %) [10 %] level

a willingness to compromise), Kolmogorov-Smirnov tests do not reveal any significant distributional differences in terms of number of safe choices between couples and husbands, respectively wives.[13]

Before attending to our main research questions about what makes spouses' individual decisions similar and which spouse has more influence on a couple's joint decision, we analyze individual subjects' risk attitudes. Table 4 presents results from a negative binominal regression model to allow for the fact that the dependent variable, number of safe choices, is only a non-negative integer number. As explanatory variables we include a set of variables that have been shown to be correlated with risk attitudes, including income, age and gender (see, e.g., Dohmen et al. 2011).[14] In addition we include a variable indicating if the individual spouse is a member of the communist party. The main reason for including it here is that we wish to test later on if this variable is correlated with the influence on the joint decision. The table shows a few marginally significant results (at the 10 %-level). Belonging to the ethnic majority of the Han-group is associated with more safe choices. Somewhat surprisingly, men are estimated to be more risk averse by making more safe choices (while most of the literature suggests that women are more risk averse; see Croson and Gneezy 2009). Given that the significance is marginal, however, one should not put too much weight on this finding. Other variables such as education, as found to be significant in Dohmen et al. (2011), are insignificant in our case.

[13] All tests reported in the paper are double-sided unless otherwise stated.

[14] There are also a number of variables that we do not have information about that could explain differences in risk attitudes, such as height and subjective health.

After examining the determinants of risk attitudes at the individual level, we now turn to an analysis of data at the household level. In the following we report data only for those households in which all three sets of decisions (those of the husband, of the wife, and of the couple) were fully consistent. Recall that twelve husbands and nine wives made inconsistent choices in the individual decision making part of Stage 2. Out of these, there were three couples where both the husband and the wife made inconsistent choices, implying a total of 18 households where at least one spouse made inconsistent choices. In addition, four couples made inconsistent choices while at the same time none of the spouses made any inconsistent decisions individually. Hence, the total sample of 117 households is reduced by 18 households with individual inconsistencies and four households where the joint decisions were inconsistent. This yields a total of 95 households with fully consistent choices to be considered in the following.[15]

4.2 Analysis of data at the household level

4.2.1 Similarity of spouses in individual decisions

The husband and the wife made the same number of safe choices in the individual decision making part in only six out of 95 households (6 %). Hence, we observe substantial heterogeneity in risk preferences between spouses. In 48 households (51 %), the husband is more risk averse, and in 41 households (43 %) the wife. If we look at the difference in the number of safe choices between wives and husbands, the mean value is -0.5 (standard deviation 3.66), the maximum $+7$, and the minimum -9. The average *absolute* difference in the number of safe choices between wives and husbands is $+3.0$ (standard deviation 2.13).

We will now analyze the conditions under which the spouses' individual decisions are more similar. We estimate a model with the absolute difference in the number of safe choices between the husband and the wife in a given household as the dependent variable.[16] This is estimated as a negative binominal regression model to allow for the fact that the dependent variable is only a non-negative integer number. Table 5 reports the results.

Household income has a significantly negative effect on the absolute difference in the number of safe choices; i.e., the higher the household income, the more similar the spouses' individual choices with respect to risk taking. The share of household income contributed by the wife has a strong and significant effect as well; an increase in this share by 10 percentage points reduces the absolute difference in the number of safe choices by 0.29.

[15] We did some robustness checks in which we included all inconsistent choices (by assigning the median switching point between the first and the last time a subject switched as an inconsistent subject's switching point). The results presented in Sect. 4 are robust to such an approach. In order to be conservative (and because it is not unambiguous how to extract a switching point from inconsistent choices) we report in the paper only data for consistent choices.

[16] The dependent variable is between zero and nine, since the maximum difference in the number of safe choices is nine.

Table 5 Marginal effect of Negative Binomial Model on the similarity of risk attitudes (p-values in parentheses)

Variable	Coefficient
Log equivalence scaled household income	−0.667***
	(0.000)
Wife's relative contribution to household income	−2.959**
	(0.024)
Length of marriage in years	0.003
	(0.890)
Number of children	0.006
	(0.976)
Absolute age difference between husband and wife	−0.023
	(0.766)
Absolute difference in years of education	−0.008
	(0.909)
Both spouses party members (= 1)	−0.996*
	(0.059)
Number of observations	95

Dependent variable: Absolute difference in number of safe choices of husband and wife. Robust standard errors are estimated. *** (**) [*] significant at 1 % (5 %) [10 %] level

We also find a significant effect of communist party membership. In households where both spouses are members of the communist party, the absolute difference in the number of safe choices is reduced by approximately one unit. None of the other variables we considered to be potentially important has any significant effect on the similarity of risk preferences. Among these, it seems particularly noteworthy that length of marriage does not have an effect. In addition, there is no significant influence of number of children, absolute difference in age (in years), or difference in years of education.

4.2.2 The relative influence of each spouse on a couple's joint decision

To analyze which spouse's risk preferences are better reflected in a couple's joint decision, we distinguish three possible cases: (i) The number of safe choices made by the couple is in the range of safe choices made by the husband and the wife individually. (ii) The couple makes more safe choices, i.e., is more risk averse, than each of the spouses individually. (iii) The couple makes fewer safe choices, i.e., is more risk loving, than the husband and the wife individually. If the couple's decision is closer to the husband's (wife's) individual decisions, we interpret this as the husband (wife) having a stronger influence on the joint decision since the other spouse accepted a larger deviation from her (his) individually preferred number of safe choices. Table 6 summarizes the three cases introduced above and indicates how the decisions of the couple relate to the spouses' individual decisions. In order to check whether the relationship between a couple's decisions and those of each spouse is different depending on how far apart the spouses' individual decisions are, Table 6 also splits the full sample at the median absolute difference of the number of safe choices (which is 2) and the subsamples are presented in Columns [B] and [C].

Table 6 Relation between couples' decisions and those of the husbands and wives individually

Relation between decisions	[A] Total	[B] Difference in number of safe choices of spouses ≤ 2	[C] Difference in number of safe choices of spouses > 2
[1] Safe choices of couple in the range of the husband and the wife (with husband different from wife)			
(a) Couple same as husband	24 (34 %)*	13 (52 %)	11 (24 %)
(b) Couple closer to husband	16 (23 %)		16 (35 %)
(c) Couple equally distant to husband and wife	7 (10 %)	4 (16 %)	3 (7 %)
(d) Couple closer to wife	11 (15 %)		11 (24 %)
(e) Couple same as wife	13 (18 %)	8 (32 %)	5 (11 %)
Total	*71 (100 %)*	*25 (100 %)*	*46 (100 %)*
[1′] Risk preference of couple is identical to husband's and wife's			
Couple equal to both	3 (100 %)	–	–
[2] Couple makes more safe choices than either spouse			
(a–b) Couple closer to husband	5 (83 %)	3 (75 %)	2 (100 %)
(c) Couple equally distant to husband and wife	0 (0 %)	0 (0 %)	0 (0 %)
(d–e) Couple closer to wife	1 (17 %)	1 (25 %)	0 (0 %)
Total	*6 (100 %)*	*4 (100 %)*	*2 (100 %)*
[3] Couple makes fewer safe choices than either spouse			
(a–b) Couple closer to husband	7 (47 %)	6 (55 %)	1 (25 %)
(c) Couple equally distant to husband and wife	3 (20 %)	3 (27 %)	0 (0 %)
(d–e) Couple closer to wife	5 (33 %)	2 (18 %)	3 (75 %)
Total	*15 (100 %)*	*11 (100 %)*	*4 (100 %)*

* Percentages in parentheses are in relation to the absolute number of cases within each panel

First note from panels [1] and [1′] in Table 6 that 74 out of 95 couples agree on a number of safe choices that is in the range of the husband's and the wife's number of safe choices. For the remaining 21 couples we observe more extreme decisions (in either direction) than made by the spouses individually (see panels [2] and [3]).[17] Within each panel, we classify the joint decisions in relation to the spouses' individual decisions as follows: (a) The number of safe choices made by the couple is identical to the husband's number of safe choices, but different from the wife's; (b) it is closer to the husband's number of safe decisions; (c) it is of equal distance to both spouses; (d) it is closer to the wife's number of safe choices; or (e) it is identical to the

[17] A model by Mazzocco (2004) can explain how differences in the spouses' individual risk attitudes can lead to more extreme choices of the household than those made by either of the spouses. Hence, couples that make more extreme decisions than either spouse individually can not simply be dismissed as having made a mistake. A paper by Eliaz et al. (2006) also shows that decisions in groups (like families) can lead to choice shifts that yield more extreme outcomes than the decisions of individual group members.

wife's number of safe choices, but different from the husband's. We use a χ^2 test to examine the null hypothesis that the couple's joint decision has the same probability of belonging to any of the five categories (a) to (e).[18] For panel [1], which covers the large majority of cases, we can clearly reject the null hypothesis (p-value $= 0.007$). Rather, Table 6 reveals that the couple's decision is significantly more often closer to the husband's decision. This raises the question about under what circumstances a couple's decision is more strongly influenced by the wife's preferences.

4.2.3 Econometric analysis of joint decisions

For the econometric analysis we estimate two different models for robustness reasons. In the first model, we use three categories of how the number of safe choices made by a couple relates to the number of safe choices made by the husband and the wife separately: (1) couple is closer to husband, (2) couple is equally distant from husband and wife, and (3) couple is closer to wife. We estimate the probability that the decision of the couple falls into one of the three categories with an ordered probit model.

In the second model we construct a measure (λ) of the weight put on the wife's preferences in the joint decision, where

$$\lambda = \frac{\textit{Couple Safe Choices} - \textit{Husband Safe Choices}}{\textit{Wife Safe Choices} - \textit{Husband Safe Choices}}.$$

When the number of safe choices is the same for the husband and the wife, then λ is set to 0.5. Note that a higher λ indicates that the couple's joint decision is relatively closer to the wife's individual decision. If λ exceeds 1 or is negative, then the couple's risk aversion is more extreme than the individual choices. This measure of weight put on the wife's preferences is used as the dependent variable in a simple OLS regression model.

The marginal effects of the ordered probit and the OLS model are presented in Table 7. For dummy variables, we report the discrete change of the variable from 0 to 1. The independent variables are intended to capture factors that influence both the absolute and the relative bargaining strength of the husband and the wife. With respect to age and education, we include variables measuring the difference in age and education years between the husband and the wife.[19]

Using model I and calculating the predicted probabilities for the three categories at sample means shows that the joint decision is closer to the husband's decision with a predicted probability of 56 %, but closer to the wife's decision with a predicted probability of only 28 %.[20] Hence, a couple's joint decision is to a larger extent influenced by the husband. Concerning the factors that increase the influence of wives, the

[18] Given the discrete choice set, it is clear that with an odd difference in the number of safe choices between the husband and the wife, category (c) is not feasible. When applying the χ^2 test, we therefore correct for the possibility of different probabilities of the five possible categories.

[19] We also estimated a model with years of marriage replaced by age of females since there is high correlation between age of females and length of marriage, but results remain robust to such a change.

[20] Using model II yields similar results.

Table 7 Regression of wives' influence on joint decision (p-values in parentheses)

Dependent variable	Model I (ordered probit)			Model II (OLS)
	(i) Couple closer to husband	(ii) Equal distance	(iii) Couple closer to wife	Weight on wife's preferences
Variable	Marginal	Marginal	Marginal	Marginal
Log equivalence scaled household income	−0.158**	0.022	0.135**	0.090
	(0.007)	(0.106)	(0.006)	(0.290)
Wife's relative income contribution	−0.761**	0.107	0.653**	0.773
	(0.050)	(0.164)	(0.044)	(0.118)
Length of marriage in years	0.007	−0.001	−0.006	−0.011
	(0.203)	(0.288)	(0.200)	(0.212)
Number of children	−0.021	0.003	0.018	0.038
	(0.669)	(0.671)	(0.669)	(0.496)
Female older (= 1)	0.101	−0.016	−0.058	−0.050
	(0.390)	(0.459)	(0.554)	(0.787)
Female more educated (= 1)	−0.282**	0.013	0.270**	0.601**
	(0.032)	(0.678)	(0.048)	(0.017)
Female education	0.020	−0.003	−0.017	−0.001
	(0.334)	(0.394)	(0.331)	(0.977)
Wife is party member (= 1)	−0.479***	−0.039	0.518***	0.786**
	(0.001)	(0.507)	(0.007)	(0.040)
Husband is party member (= 1)	0.069	−0.011	−0.058	0.144
	(0.648)	(0.697)	(0.638)	(0.574)
Husband is *Han (ethnic majority)*	0.144	−0.025	−0.118	−0.381
	(0.262)	(0.375)	(0.244)	(0.246)
Wife is *Han (ethnic majority)*	0.032	−0.005	−0.027	0.133
	(0.868)	(0.878)	(0.866)	(0.691)
Difference in safe choices (wife–husband)	−0.012	0.002	0.010	−0.019
	(0.436)	(0.463)	(0.436)	(0.291)
Threshold parameter 1 (standard error)	3.659			
	(1.353)			
Threshold parameter 2 (standard error)	4.077			
	(1.367)			
Pseudo $R2/R2$	0.113			0.20
Number of observations	95			95

two models yield largely similar results with respect to significance.[21] The only major difference between both models is found for the variables household income and

[21] We also ran a third model (an ordered probit like model I) in which we transformed the number of safe choices into ranges of relative risk aversion r for the utility function $U(x) = x^{1-r}(1-r)$ of monetary payoff x (see Holt and Laury 2002, for more details on the transformation) and then defined the dependent variable as the couple's joint relative risk aversion being (1) closer to the husband's relative risk aversion, (2) equally distant from both spouses' relative risk aversion, or (3) closer to the wife's relative risk aversion.

women's income contribution, which is insignificant in model II, while significant in model I. However, we also estimated the second model using different specifications by (i) removing five observations with a λ higher than 2 or less than -2, and (ii) truncating negative values at zero, and values higher than one at unity. These estimations show that the coefficient of the household income is sensitive to outliers, since in these models the household income coefficient is positive and significant. If we remove the same outliers in the ordered probit model, the coefficient of household income is still significant.

Our models identify the following variables that have a robust and significant relation to the wife's influence on the couple's decision: relative female contribution to the household income and party membership. It should be noted that there is a low correlation between household income and relative female contribution as well as party membership. Thus, relative female income contribution and party membership are important and independent of the magnitude of household income.

If the wife contributes relatively more to the household income, then the couple's number of safe choices is more likely to reflect the wife's risk preferences. Recall that this variable had also been found to make husbands and wives more similar with respect to their individual choices. The estimations in Tables 5 and 7 show that the relative income contribution of the wife has, in fact, two effects: one on individual similarity in risk attitudes, and one on the wife's influence on a couple's joint decision.

If the wife is a member of the communist party, the joint decision is closer to her individual preferences (increasing *ceteris paribus* the likelihood of the joint decision being closer to the wife's decision from 24 % without party membership to 76 % with party membership, or increasing λ by almost 0.78 units). A similar effect is not found for men, as their party membership does not shift the couple's decision significantly in their favored direction. It is interesting that communist party membership affects both the similarity of the spouses' individual decisions (when both are party members) and the closeness of the joint decision to the wife's individual decision. Although we can only speculate about the importance of party membership for the wife's influence on the joint decision there are at least two potential explanations. The first one is that women who are strong, self-confident and hold strong opinions, are more likely to become members of the party. The second one is that party meetings and education may help women to become stronger. It seems plausible that both explanations are valid.

We also find that in households where the wife is better educated than the husband, the wife has a stronger influence on the joint decision. The explanation of this is likely similar to the explanations of the importance of party membership.

The two econometric models have also controlled for other possibly important factors, such as the difference in age, ethnic background, the number of children, the length of the marriage, and the difference in the number of safe choices between wives and husbands. However, none of these has a significant influence on whether a couple's joint decision is closer to the husband's or the wife's number of safe choices.

The results of such a specification remain qualitatively (with respect to signs and significances) identical to model I.

Table 8 Questionnaire responses

Question	… it is mainly the wife who decides	… we decide jointly	… it is mainly the husband who decides
A) When it comes to daily decisions about what to do with the money in your household, for example buying food and clothes, would you say that …	38 (40 %)	45 (47 %)	12 (13 %)
B) When it comes to small investment decisions, for example buying equipment for the house, would you say that …	20 (21 %)	33 (35 %)	42 (44 %)
C) When it comes to big investment decisions or using a large amount of money to purchase some goods, for example furniture or a TV, would you say that …	10 (11 %)	60 (63 %)	25 (26 %)

Motivated by the insights from Ashraf (2009)—whose study shows that the allocation of control over household savings has a strong influence on spouses' joint financial decisions—we included in a post-experimental questionnaire some questions on who makes decisions in three different types of situations. Table 8 reports the three questions and the answers of the 95 couples. The responses to Question 1 reveal that women are ascribed a stronger influence on daily decisions, while men are indicated to have more influence in small investment decisions (Question 2). Concerning big investment decisions (Question 3), a large majority of couples report making joint decisions. The distribution of answers is significantly different across the three questions (p-value < 0.001, χ^2-test). However, including the answers to these questions in the regressions reported in Table 7 shows that none of them has a significant impact on how the couple's joint decision relates to the husband's or wife's number of safe choices.

5 Conclusion

In this paper we have investigated household decision making by running an experiment on Chinese couples' decision making under risk. We have studied the decision making of 117 randomly sampled couples in a poor rural area in the southwest of China. The average earnings from the experiment was equivalent to about 1 % of the average yearly income of participants, making it a high-stakes experiment on decision making under risk. We were particularly interested in examining (i) the conditions under which the individual decisions of spouses are similar and (ii) the main factors that are associated with a stronger influence of wives on joint decisions.

We found that spouses have more similar individual risk preferences the richer the household, the larger the income share contributed by the wife, or when both spouses are members of the communist party. However, these findings should not cover up the fact that the spouses' individual risk preferences were identical in only 6 % of the households. Hence, there is a large degree of heterogeneity within households.

We also found that a couple's joint decision is typically closer to the individual preferences of the husband, which is similar to what de Palma et al. (2011) report. However, we were also able to identify factors that go along with joint decisions being closer to wives' individual preferences. An increase in the relative share of household income contributed by the wife shifts the couple's joint decision in the direction of the wife's risk preferences. Furthermore, if the wife is a member of the communist party or if the wife has a higher education than the husband, then the husband's risk preferences are less reflected in the couple's joint decision.

These findings provide controlled evidence of factors that let joint decisions be more similar to wives' individual decisions, thus probably indicating a stronger influence of wives in the intra-household decision-making process. Note that we did not set up a structured bargaining procedure in our experiment since that could have been perceived as artificial by the participants. Rather, we asked couples to discuss the experimental task and come up with a joint decision on each lottery choice. This seems to be a natural environment for making decisions in a household. Contrary to earlier experiments on the decision making of couples, our experiment was run in the homes of the participating couples rather than in an external place like a bank or town hall in order to observe household decision making where it usually takes place, namely at home. By using high stakes, we wanted to make the decisions very salient, such that it is in the best interest of any participant to make a decision that fits his or her preferences best.

In sum, our experiment identified several important factors that are aligned with an increase in the decision-making power of wives. Historically, Chinese women have had very little say in household decisions, in particular in rural areas. They have also been discriminated against when it comes to access to education. For example, educating sons has been seen as an investment in old-age support since it has been regarded as more likely that sons will get paid work, therefore leaving women to work on the farmland (Hannum 2005). Our results, however, suggest that policy measures that improve the education and, consequently, labor force participation of women may go hand in hand with increasing the power of women in households through increasing their relative contribution to household income.

References

Abdellaoui, M., L'Haridon, O., & Paraschiv, C. (2011). *Individual vs. collective behaviour: an experimental investigation of risk and time preferences in couple*. Working Paper at Group HEC, France.

Ashraf, N. (2009). Spousal control and intra-household decision making: an experimental study in the Philippines. *American Economic Review*, *99*, 1245–1277.

Baker, R. J., Laury, S. K., & Williams, A. W. (2008). Comparing group and individual behavior in lottery-choice experiments. *Southern Economic Journal*, *75*, 367–382.

Bateman, I., & Munro, A. (2005). An experiment on risky choice amongst households. *Economic Journal*, *115*, C176–C189.

Bone, J. (1998). Risk-sharing CARA individuals are collectively EU. *Economics Letters*, *58*, 311–317.

Bone, J., Hey, J., & Suckling, J. (1999). Are groups more (or less) consistent than individuals? *Journal of Risk and Uncertainty*, *8*, 63–81.

Bone, J., Hey, J., & Suckling, J. (2004). A simple risk-sharing experiment. *Journal of Risk and Uncertainty*, *28*, 23–38.

Carlsson, F., He, H., Martinsson, P., Qin, P., & Sutter, M. (2012). Household decision making in rural China. Using experiments on intertemporal choice to estimate the relative influence of spouses. *Journal of Economic Behavior and Organization*. doi:10.1016/j.jebo.2012.08.010.

Croson, R., & Gneezy, U. (2009). Gender differences in preferences. *Journal of Economic Literature*, *47*, 1–27.

de Palma, A., Picard, N., & Ziegelmeyer, A. (2011). Individual and couple decision behavior under risk: evidence on the dynamics of power balance. *Theory and Decisions*, *70*(1), 45–64.

Dohmen, T., Falk, A., Huffman, D., Sunde, U., Schupp, J., & Wagner, G. G. (2011). Individual risk attitudes: measurement, determinants and behavioral consequences. *Journal of the European Economic Association*, *9*, 522–550.

Duflo, E. (2003). Grandmothers and granddaughters: old age pension and intra-household allocation in South Africa. *World Bank Economic Review*, *17*, 1–25.

Eliaz, K., Raj, D., & Razin, R. (2006). Choice shifts in groups: a decision-theoretic basis. *American Economic Review*, *96*, 1321–1332.

Guo, Z. L., & Bernstein, T. P. (2004). The impact of election on the village structure of power: the relation between village committees and the party branches. *Journal of Contemporary China*, *13*, 257–275.

Hannum, E. (2005). Market transition, educational disparities, and family strategies in rural China: new evidence on gender stratification and development. *Demography*, *42*, 275–299.

Harrison, G. W., Morten, I. L., Rutström, E. E., & Tarazona-Gómez, M. (2005). Preferences over social risk. Unpublished Manuscript.

He, H., Martinsson, P., & Sutter, M. (2012). Group decision making under risk: An experiment with student couples. *Economics Letters*, *117*, 691–693.

Holt, C. A., & Laury, S. K. (2002). Risk aversion and incentive effects. *American Economic Review*, *92*, 1644–1655.

Kachelmeier, S., & Shehata, M. (1992). Examining risk preferences under high monetary incentives: experimental evidence from the People's Republic of China. *American Economic Review*, *82*, 1120–1141.

Lundberg, S., Pollak, R. A., & Wales, T. J. (1997). Do husbands and wives pool their resources? Evidence from the U.K. child benefit. *Journal of Human Resources*, *22*, 463–480.

Lundberg, S., & Pollak, R. A. (1996). Bargaining and distribution in marriage. *Journal of Economic Perspectives*, *10*(4), 139–158.

Masclet, D., Colombier, N., Denant-Boemont, L., & Loheac, Y. (2009). Group and individual risk preferences: a lottery-choice experiment with self-employed and salaried workers. *Journal of Economic Behavior & Organization*, *70*, 470–484.

Mazzocco, M. (2004). Savings, risk sharing and preferences for risk. *American Economic Review*, *94*, 1169–1182.

NBS (2008). *China statistical yearbooks*. Beijing: China Statistical Publishing House.

Peters, E. A., Ünür, S., Clark, J., & Schulze, W. D. (2004). Free-riding and the provision of public goods in the family: a laboratory experiment. *International Economic Review*, *45*, 283–299.

Phipps, S., & Burton, P. (1998). What's mine is yours? The influence of male and female income on pattern of household expenditure. *Economica*, *65*, 599–613.

Qian, N. (2008). Missing women and the price of tea in China: the effect of sex-specific earnings on sex imbalance. *Quarterly Journal of Economics*, *123*, 1251–1285.

Rockenbach, B., Sadrich, A., & Mathauschek, B. (2007). Teams take the better risks. *Journal of Economic Behavior & Organization*, *63*, 412–442.

Shupp, R. S., & Williams, A. W. (2008). Risk preference differentials of small groups and individuals. *Economic Journal*, *118*, 258–283.

Tanaka, T., Camerer, C. F., & Nguyen, Q. (2010). Risk and time preferences: experimental and household survey data from Vietnam. *American Economic Review*, *100*, 557–571.

Thomas, D. (1994). Like father, like son: like mother, like daughter: parental resources and child height. *Journal of Human Resources*, *29*, 950–988.

Vermeulen, F. (2002). Collective household models: principles and main results. *Journal of Economic Surveys*, *16*(4), 533–564.

Zhang, J., & Casari, M. (2011). How groups reach agreement in risky choices: an experiment. *Economic Inquiry*, *50*(2), 502–515.

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DETERMINANTS AND CONSEQUENCES OF BARGAINING POWER IN HOUSEHOLDS

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ABSTRACT

A growing literature offers indirect evidence that the distribution of bargaining power within a household influences decisions made by the household. The indirect evidence links household outcomes to variables that are assumed to influence the distribution of power within the household. In this paper, we have data on whether a husband or wife in the Health and Retirement Study "has the final say" when making major decisions in a household. We use this variable to analyze determinants and some consequences of bargaining power. Our analysis overcomes endogeneity problems arising in many earlier studies and constitutes a missing link confirming the importance of household bargaining models.

We find that decision-making power depends on plausible individual variables and also influences important household outcomes, with the second set of results much stronger than the first set. Current and lifetime earnings have significant but moderate effects on decision-making power. On the other hand, decision-making power has important effects on financial decisions like stock market investment and total wealth accumulation and may help explain, for example, the relatively high poverty rate among widows.

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I. INTRODUCTION

A growing literature offers indirect evidence that the distribution of bargaining power within a household influences decisions made by the household. Yet, earlier papers were not able to measure actual bargaining power. We use information from a unique question in the Health and Retirement Study to analyze the determinants and some consequences of bargaining power.

Models of household bargaining have two important implications for understanding individual outcomes. First, the welfare of household members depends on the distribution of bargaining power. Second, household decisions are not the outcome of a single individual maximizing utility. Indirect evidence against "unitary" decision-making links household outcomes to variables that are assumed to influence the distribution of bargaining power within the household. Such outcomes include the amount and allocation of leisure time, spending (on women's and children's clothes versus men's clothes, on alcohol and tobacco, on food) and domestic violence (including female suicide rates).

However, none of those studies directly show how individual preferences affect household decisions. In this paper, we analyze data from the HRS reporting whether a husband or wife has "the final say" when making major decisions. We interpret the answers as revealing whose preferences are reflected to a greater degree in household choices. By directly observing decision-making power, our analysis overcomes endogeneity problems arising in many earlier studies and constitutes the missing link that confirms the importance of household bargaining.

To undertake this analysis, we develop an econometric framework and pose a set of intuitive identification assumptions to make use of multiple subjective reports. We find that decision-making power depends on plausible variables within the household and also influences important household outcomes. Moreover, the second set of results is much stronger than the first set. Current and lifetime earnings have a significant but only moderate influence on decision-making power. On the other hand, decision-making power has important effects on a sample of financial decisions that we examine.

In the first set of results, we analyze determinants of whether the husband or wife has more decision-making power. We find that decision-making power depends significantly on relative household earnings, and more so on average lifetime earnings than on current earnings. However, the magnitudes of these estimated effects are only moderate for this older sample – switching average lifetime earnings of husbands and wives reduces the predicted percentage of

men reported to have the final say by their wives from 31.1% to 21.6%. These estimates control for human capital variables that may be correlated with both labor supply and a comparative advantage in making important decisions. They also show that cultural factors like race, religion, and immigrant status affect decision-making power.

Next, we show that we can use this data to investigate outcomes that are both novel in the household bargaining literature and important. As an example, we investigate two financial outcomes that are well-recorded in the HRS. When husbands have greater decision-making power, we find that the household invests significantly and substantially more in equities, controlling for important factors like household wealth and stated risk preferences. This shows some practical consequences of evidence found by others that men are less risk averse. We also find an intriguing twist on the standard life cycle model. When husbands have the final say, we find that household wealth is significantly and substantially higher the older is the husband *but not* the wife, and when wives have the final say, household wealth is higher the older is the wife. Thus, life cycle planning motives appear driven in part by the interests of the spouse in charge.

Thus, our conclusions are twofold. Our results show that household bargaining can have important effects on the welfare of household members. For example, the relatively high rate of poverty among widows may result not only from aggregate longevity shocks, insurance market failures, and/or poor planning, but also from the nature of household bargaining earlier in life.[1] This, in turn, has implications for the design of dependent and survivor benefits available through Social Security and for the impact of the shift from annuitized defined benefit pensions to lump-sum defined contribution accounts. Our results also make it clear that more research is needed into the determination of bargaining power, as even important variables like earnings explain relatively little about the distribution of bargaining power.

II. PAST EVIDENCE ON HOUSEHOLD BARGAINING

A. Past empirical literature

While most consumption and wealth data is collected at the household level, many studies have raised doubts that households can be treated as unitary decision makers.[2] Theoretical work that began with McElroy and Horney (1981) and Manser and Brown (1981) assumed instead that spouses engage in cooperative bargaining. The resulting Nash-bargained

[1] 18.0% of widows aged 65 and over lived in poverty in 1997, compared to 13.1% of all elderly women and 13.3% of the total population (National Economic Council 1998).

[2] See recent surveys by Bergstrom (1995), Behrman (1995), Bergstrom (1996), and Lundberg and Pollack (1996).

equilibrium allocates marital surplus according to each spouse's bargaining power. Bargaining power depends in turn on spouses' threat points, assumed most often to be their utility from divorce.

Direct tests of such models are hampered by the unobservability of bargaining, threat points, and the allocation of marital surplus. Consequently, the empirical literature has employed indirect tests of implications of unitary decision-making models. Many of these tests rely on similar identification strategies, which we discuss in the next section, that test the "income pooling" hypothesis. Under unitary models, the distribution of resources within the family should not influence outcomes like expenditures. Empirical papers have shown, to the contrary, that variables which are plausibly related to threat points – like spouses' wages, earnings, or unearned income – alter household outcomes over which spouses might have different preferences – like time spent by spouses on leisure and chores (Friedberg and Webb 2005); spending on men's, women's, and children's clothing (Phipps and Burton 1998; Lundberg, Pollak and Wales 1997; Ward-Batts 2003), on alcohol and tobacco (Phipps and Burton; Hoddinot and Haddad 1995; Ward-Batts), and on food (Lundberg, Starz, and Stillman 2003; Duflo and Udry 2004; Ward-Batts); and child outcomes like health and education (Schultz 1990; Thomas 1990, 1994; Haddad and Hoddinott 1994; Rose 1999; Duflo 2003; Duflo and Udry).[3]

B. Comparison to our empirical strategy

Our approach offers three related advantages over recent studies. First, we have actual measures of decision-making power. Since earlier studies lacked such measures, they had to assume that the variables they studied influenced the distribution of bargaining power and were influenced by it. We do not have to assume any indirect relationships. Thus, our results constitute strong new evidence in favor of household bargaining models and about the specific nature of bargaining.

Second, because we have a measure of bargaining power, we are not constrained as earlier studies were in choosing outcomes to analyze. The studies mentioned above jointly test not only income pooling but also that spouses' preferences differ over the outcomes being studied. This is a key reason to study spending on men's and women's clothing, for example

[3] In addition, bargaining is an explanation for rejections of standard implications of individual preference axioms using household-level data (McElroy 1981). Examples include negative price elasticities and violations of Slutsky symmetry. Proceeding from that, Browning et al (1994) and Browning and Chiappori (1999) found that testable analogs of non-unitary models that assume Pareto efficient allocations within the household were not rejected.

(notwithstanding possible public good aspects of clothing choices!). It is less obvious, though, that men and women have different preferences for alcohol and tobacco, food at home versus away, and children's well-being. In contrast, we can directly test which outcomes depend on our measure of bargaining power. While we lack data on many potentially interesting outcomes, and we must condition on appropriate variables as other studies must, we can examine outcomes like financial behavior which less obviously reflect the preferences of a particular spouse.

Third, many of the variables which earlier studies used to explain the distribution of bargaining power were arguably endogenous. To give an extreme but relevant example, it would be difficult to believe that omitted factors played no role in explaining a correlation between religion and spending on clothing, unless we can show (as we do later) that religion directly influences bargaining power. More importantly, the earnings variation used in many tests of income pooling is not plausibly separable from the outcomes being explained. If spouses earn more because they work more, that reduces time that is available for home production and may alter spending on clothing, food, children, etc. Variation in unearned income is similarly problematic for reasons described by Lundberg and Pollak (1996). The cleanest evidence, then, comes from quasi-experiments, but those are limited to particular settings and mostly involve poor populations (Lundberg, Pollak, and Wales; Duflo; Duflo and Udry).

III. DATA

A. The HRS

We use data from the Health and Retirement Study (HRS), a longitudinal survey of over 7,600 households with a member aged 50-60 in 1991. The HRS began in 1992 and collected new data every two years. The HRS reports unprecedented detail about household characteristics, labor supply, finances, health, and so on. We use data from the first wave in 1992.[4]

Each spouse was asked the following question about decision-making power:

> *"When it comes to making major family decisions, who has the final say – you or your (husband/ wife/ partner)? By 'major family decisions' we mean things like when to retire, where to live, or how much money to spend on a major purchase."*

[4] The question about decision-making was asked again in 1994, and 2/3 of individuals gave the same answer. After that, it was only asked of new entrants to the HRS, a considerably smaller group. We do not attempt to analyze changes in bargaining power, which would require not only a theory of dynamic bargaining, but also an approach to distinguishing measurement error from true shifts in either bargaining power or reporting bias.

Individuals could answer that they themselves had the final say, that their spouses did, or that the division of responsibility was "about equal".[5]

Because the age range in the HRS is limited, the results are not representative of all households. In particular, since they are older and some unhappy marriages will already have ended, the households that we are observing are more harmonious than average.[6] On the other hand, the greater marital stability of the sample offers an advantage. We can view the observed outcomes as the steady state of a repeated game, and cooperative bargaining is more likely to be sustained than in a one-shot game.[7]

B. The distribution of the "final say" in the sample

We took the following steps in selecting our sample from the HRS:

- the HRS interviewed 7,607 households in 1992
- we selected couples, yielding a sample of 5,090
- we eliminated couples with no financial information, yielding a sample of 5,036
- we eliminated couples who were cohabiting, yielding a sample of 4,815
- we eliminated couples in which at least one spouse did not answer the bargaining question, yielding a final sample of 4,237.

Table 1 shows the distribution of decision making power in our sample, and Table 2 shows other sample statistics. In Table 1, both spouses report that husbands have more bargaining power, on average. When husbands answered the first question above (as shown across the bottom of the upper panel), 30.6% reported having the final say, 57.6% said it was about equal, and 11.8% reported that the wife had the final say. When the 30.6% of husbands with the final say answered the second question above (as shown in the lower panel), roughly

[5] People were asked a follow-up question if they did not answer "about equal": either, "Do you have a lot more say than your (husband/ wife/ partner), somewhat more, or only a little more?", or, vice versa. The answers to this second question did not provide us with significant additional information. In ordered probits, the estimated threshold values are not significantly different from each other when we try to explain answers to the second question, but they are when we try to explain answers to the first question in the estimates we report later.

[6] While the value of observed marriages in the HRS should be higher than the value of a representative marriage and thus disagreement should be less likely, this does not have clear-cut implications about the observed distribution of bargaining power relative to the underlying distribution for all couples. We find that controlling for the duration of marriage has no impact on the other coefficient estimates. Interestingly, we find smaller estimated effects of earnings on bargaining power in second marriages, perhaps because people enter a second marriage with more information about the likely distribution of bargaining power.

[7] Because we find significant effects later on, we believe that these answers are informative. Thus, it seems unlikely that one spouse has more power but delegates decision-making to the other spouse, knowing that the decisions will reflect their own preferences.

one-quarter reported having a lot more say, and the rest reported having somewhat or a little more say.

The marginal distribution of wives' answers to the first question is similar to husbands'. 16.0% of wives reporting that they themselves have the final say, 52.7% answering that it was about equal, and 31.3% reporting that their husbands have the final say.
Disagreements are apparent in the off-diagonal cells in the upper panel of Table 1. Spouses agreed on the answer 63.3% of the time. 84.2% of the disagreements occurred in adjacent cells, while the rest involved one spouse answering the wife and the other answering the husband. About 2/3 of these adjacent disagreements leaned toward the husband, with one spouse attributing more power to the husband and the other reporting equal power. It was also a little more common for disagreeing spouses to attribute extra power to themselves relative to the other spouse's opinion (adding together cells in the lower left) than it was for them to attribute extra power to the other spouse (cells in the upper right).

IV. EMPIRICAL APPROACH

We interpret answers to the question about decision-making power as revealing which spouse's preferences are reflected to a greater degree in household decisions.[8] However, we treat the answers as noisy measures of true decision-making power, both because the answers are discrete and because of the disagreements revealed in Table 1. Moreover, disagreements are correlated with some of our important explanatory variables in the results we present later.

In this section, we offer an econometric framework that suggests intuitive identification assumptions to disentangle these features. We first present a framework to deal with noisy, continuous measures of bargaining power, and then noisy, discrete measures. While the identification assumptions influence the interpretation of the reported coefficient estimates, they are not actually imposed in the process of estimation, so uninterested readers can proceed directly to the next section for the estimation results.

A. Estimating the determinants of noisy continuous measures of true bargaining power

[8] Household theory has emphasized the generalized Nash model of cooperative bargaining, in which the allocation of resources (U_h, U_w) maximizes $(U_h-R_h)^{\theta}(U_w-R_w)^{1-\theta}$, where R_j are reservation values and $0<\theta<1$ is h's relative bargaining weight. The equilibrium allocation U_j will depend on R and θ, and we view our measure of decision-making power (which we also refer to on occasion as "bargaining power") as an amalgam of R_h, R_w, and θ. In comparison, empirical tests of income pooling seek to determine whether components of R influence components of U. A natural extension of our work would be to incorporate additional information and estimate the full Nash-bargaining model, as several papers have done in labor market settings (cf. Flinn forthcoming).

We assume for the moment that spouses report continuous (rather than discrete) measures of bargaining power. We will focus first on determining how bargaining power, measured continuously, depends on household characteristics and then how it influences household outcomes. We will denote true bargaining power of a husband relative to his wife in household i by y_i^*. We will treat true bargaining power y_i^* as a function of observables X and an uncorrelated homoscedastic error term:

$$(1) \qquad y_i^* = X_i\alpha + u_i \, .$$

We do not observe y_i^* but rather the belief y_{ji}^* about true bargaining power that each spouse $j = \{h,w\}$ in household i reports. We write these beliefs as

$$(2a) \qquad y_{wi}^* = y_i^* + X_i\beta_w + u_{wi}$$

$$(2b) \qquad y_{hi}^* = y_i^* + X_i\beta_h + u_{hi} \, ,$$

so j's report about the husband's relative bargaining power depends on his true bargaining power but also on some reporting bias $X_i\beta_j$ and another uncorrelated homoscedastic error term.

Before proceeding with estimation issues, we will clarify some important identifying assumptions that lie behind (1)-(2b). First, the model assumes that the "true" measure of decision-making power y_i^*, rather than the reported measures y_{ji}^*, influence household decisions. Otherwise, we might have to consider a model of multi-dimensional bargaining in order to reconcile conflicting reports that are both true.[9] Second, the model assumes specific forms of heterogeneity in how everyone reports y_{ji}^*. Answers may disagree or not as a function of observables and error terms, but it assumes that couples whose answers disagree or not do not fundamentally differ in either how they answer the question or how they bargain.

To proceed, we can rewrite each spouse's report of bargaining power in (2a) and (2b) as

$$y_{wi}^* = X_i\,(\alpha+\beta_w) + u_i + u_{wi}$$

$$y_{hi}^* = X_i\,(\alpha+\beta_h) + u_i + u_{hi} \, ,$$

but, of course, we can only estimate the empirical analogs

$$(3a) \qquad y_{wi}^* = X_i\, b_w + \tilde{u}_{wi}$$

$$(3b) \qquad y_{hi}^* = X_i\, b_h + \tilde{u}_{hi} \, .$$

Thus, we have an identification problem since $b_j = \alpha + \beta_j$ combines the "true effect" α of X on y^* and the "reporting bias" β_j also engendered by X.

In order to identify the true effect α, we propose the following restriction:

(4) $\beta_h + \beta_w = 0$.

This condition requires that any disagreements between spouses about true bargaining power be equal and opposite in sign, so that they balance out on average across the sample.

This restriction is an intuitive extension of the assumption that respondents provide unbiased information. As an example, consider our result later that a wife's (W's) earnings reduces her husband's (H's) bargaining power but by amounts that are disagreed on. Suppose that higher W's earnings reduce true y_i by an average of 0.5. A symmetric disagreement arises if higher W's earnings lead Ws to claim a greater drop and Hs to claim a smaller drop. If instead they disagreed in the same direction (e.g., Hs and Ws report average reductions of 0.6 and 0.7, respectively), then we could not identify the true effect on bargaining power (which we would infer lies between 0.6 and 0.7) from this systematic reporting bias. Instead, we infer that anything that moves both spouses' reports in the same direction is the truth. Similarly, if the disagreement were opposite in direction but not symmetric (e.g., Hs and Ws report average reductions of 0.4 and 0.7), then we would correctly infer that the truth lies in between 0.4 and 0.7, but we would incorrectly infer where.[10] This assumption makes sense as long as, once again, both spouses interpret the question in the same way, on average.[11]

Once we estimate (3a) and (3b) and then impose (4), we can recover the underlying parameters of interest. Since $b_h = \alpha + \beta_h$ and $b_w = \alpha + \beta_w$, it can be shown that

(5a) $\alpha = (b_h + b_w)/2$

(5b) $\beta_j = b_j - \alpha = b_j - (b_h + b_w)/2$.

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[9] In such a model, spouses might report different answers because they engage in distinct bargaining over different decisions. Such models are theoretically intractable and would be difficult to identify using our data, since we would not know what "sphere" of bargaining each spouse has in mind when answering the question.

[10] We could generalize (4) by incorporating asymmetric effects of X on disagreement, such that $\beta_h+\beta_w = \beta$ $\forall |\beta_j| \geq |\beta|$. This allows β_h and β_w to differ in magnitude as long as they also differ in sign but does not yield point identification of α and β_j. If we suspected that an element of X had a greater effect on one spouse's reporting bias than on the other's, then $\beta > 0$ and we would know that the estimate of $\hat{\alpha}$ was an upper bound on the true α. Also, we could determine how large β (the asymmetry of disagreement) would have to be in order to undermine inference about the true sign of α.

[11] The HRS reported whether the other spouse was present and intervened much during an individual's interview. We find that wives are much more likely to be present for their husband's interviews, and that a spouse's presence is not systematically related to reported bargaining power. The theoretical implication is ambiguous – a spouse with more bargaining power may directly exercise control over the less powerful spouse's answers or may be confident of indirect control that makes intervention unnecessary. When we try controlling for the presence of the other spouse in the estimation, there is little qualitative impact on the estimated effect of earnings, which is our primary interest. It alters the estimated effect of some demographic and cultural variables (i.e., race, religion, children).

Thus, our estimate of the true effect $\hat{\alpha}$ equals the average of $\hat{b}_h$ and $\hat{b}_w$, and our estimate of the reporting bias $\hat{\beta}_j$ equals $\hat{b}_j$ minus $\hat{\alpha}$. In cases where there is little disagreement, $\hat{b}_w \approx \hat{b}_h$, so $\hat{b}_j \approx \hat{\alpha}$ and $\hat{\beta}_j \approx 0$.[12] A final issue is whether the errors in the reporting equations (2a)-(2b) and hence the estimating equations (3a)-(3b) are correlated.[13] We test this hypothesis later on and find a large, positive, statistically significant correlation.

B. Estimating the consequences of noisy continuous measures of true bargaining power

Using noisy measures of bargaining power also affects how we interpret estimates of the consequences of decision-making power on household outcomes. Suppose some outcome z_i depends on true continuous but unobserved bargaining power y_i*, as defined in (1), and on X (which affect true and reported bargaining power as well) and an uncorrelated homoscedastic error term, so that

$$(6) \qquad z_i = \gamma y_i^* + X_i\delta + v_i \, .$$

We can substitute (2a) and (2b) to obtain

$$z_i = \gamma y_{wi}^* + X_i (\delta - \gamma\beta_w) + v_i - \gamma u_{wi}$$

$$z_i = \gamma y_{hi}^* + X_i (\delta - \gamma\beta_h) + v_i - \gamma u_{hi}$$

and then add these together to arrive at

$$(7) \qquad z_i = \gamma\left(\frac{y_{hi}^* + y_{wi}^*}{2}\right) + X_i\left(\delta - \frac{\gamma}{2}(\beta_w + \beta_h)\right) + v_i - \frac{\gamma}{2}(u_{wi} + u_{hi}) \, .$$

The empirical analog of (7) is

$$(8) \qquad z_i = c\left(\frac{y_{hi}^* + y_{wi}^*}{2}\right) + X_i\, d + \tilde{v} \, .$$

If we estimate (8) and invoke the assumption in (4) that $\beta_h + \beta_w = 0$, then we can recover the true parameters from (6), which are simply $\gamma = c$ and $\delta = d$ The key point is that averaging y_{hi}* and y_{wi}* in the estimation cancels out the disagreement effects β_j.

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[12] In this framework, we cannot identify the true effect α by limiting the sample to couples who report the same answers for y. It is not the case that such couples have no reporting bias, but rather that their reporting errors u_{ji} happen to offset their reporting bias $X_i\beta_j$, that they have systematically lower values of variables associated with high reporting bias and vice versa, etc. With that in mind, we will mention the effect of limiting the sample when we present the estimation results later.

[13] We cannot identify a correlation between the disturbance in the true equation (1) and the reporting equations (2a)-(2b) without making a further assumption, analogous to (4), about the nature of the correlation.

C. Estimating the causes and consequences of discrete measures of bargaining power

At this point, we will address the fact that our observed reports of bargaining power are discrete rather than continuous. In order to estimate the determinants of bargaining power, we continue to assume that (1)-(2b) hold, with y_{ji}* now being some underlying continuous measure that we only observe discretely:

(9) y_{ji} = {husband has final say, about equal, wife has final say} = {*1, 0, -1*}

Assuming further that $\tilde{u}_{ji} \sim N(0, \sigma^2)$ yields an ordered probit framework that is the discrete choice analog to (3a) and (3b), where the contribution of each possible outcome of y_{ji} to the log likelihood function is

$$(10) \quad P(y_{ji} = -1) = \Phi(\mu_0 - X_i b_j)$$
$$P(y_{ji} = 0) = \Phi(\mu_1 - X_i b_j) - \Phi(\mu_0 - X_i b_j)$$
$$P(y_{ji} = 1) = 1 - \Phi(\mu_1 - X_i b_j),$$

and μ_0 and μ_1 are threshold values to be estimated. Since the relationship $b_j = \alpha + \beta_j$ continues to hold, then, after imposing (4), the same conditions (5a) and (5b) govern identification. Lastly, we will estimate a bivariate ordered probit that allows the errors $\tilde{u}_{ji}$ to be correlated for spouses j within a household i. Such a correlation may be expected if spouses share important characteristics that influence both bargaining and reports about bargaining and that are not observed in the data.

When we consider estimating the consequences of our noisy, discrete measure of bargaining power, the estimation strategy outlined in (8) becomes more complicated since we do not observe the continuous variables y_{ji}*. We deal with this using three approaches.[14]

- We try a two-stage procedure: first, estimate the ordered probits that determine bargaining power as laid out in (3a) and (3b) and obtain the predicted values $\hat{y}_{ji}^* = X_i \hat{b}_j$; second, substitute those into (8) and estimate the impact of bargaining power. The difficulty with this approach is in determining how to adjust the standard errors in the second stage.[15]

[14] Another approach which we will not use would be a joint estimation strategy that allows the error terms determining y_{hi}*, y_{wi}*, and z_i to be correlated. This approach would get rapidly more complicated as we analyze additional outcomes z, though, so we limit the joint estimation to y_{hi}* and y_{wi}*.

[15] Maddala (1983, Section 8.8) lays out estimators and, in some cases, covariance matrices for related examples in which the first and/or second stages are specified discretely. None pertain directly to the situation here, and for the most similar cases, he notes, "The derivation of the asymptotic covariance matrix of the two-stage estimates is very complicated and will not be attempted here," (pp.245, 246). We do not attempt it either.

- We also try a more efficient alternative with correct standard errors, derived from Amemiya (1979) and described in detail in the Appendix: first, estimate the first-stage relationship in (3a) and (3b) as described above; second, estimate the reduced form obtained from substituting the determinants of y_{ji}*, as laid out in (3a) and (3b), into the second-stage relationship in (8); third, estimate the structural parameters of the impact of bargaining power based on the resulting parameter restrictions.
- Lastly, we try a non-structural alternative that controls for the raw answers on decision-making power. This approach does not rely on the functional form represented by (1)-(2b) that we assumed in the first stage, but it revives the difficulty of extracting information from the discrete and sometimes conflicting answers of spouses.

Using either of the structural approaches, we now face an additional constraint because $\hat{y}_{ji}$ * is a linear function of the explanatory variables X which also appear linearly in (8). Therefore, we must exclude one or more elements of X so that we can identify the impact $\gamma$of y_i* on z.[16] To this end, we will argue that total household earnings should affect outcomes z that we analyze, but that the split between husband's and wife's earnings should not, except through their influence on bargaining power.

V. WHAT INFLUENCES BARGAINING POWER?

In this section, we analyze the empirical determinants of decision-making power. We estimate bivariate ordered probits on both spouses' answers y_{ji} about decision-making power, coded as {1,0,-1} = {husband has final say, about equal, wife has final say}. We hypothesize that labor market opportunities of each spouse affects threat points and in turn bargaining power. To test this, we explore the impact of current and past earnings and other labor market variables.[17]

The HRS offers a great deal of information to control for other factors that may affect both threat points and decision making. For example, a spouse who is "savvier" than the other may be more likely to work *and* make major decisions, inducing a spurious correlation. To deal

[16] If we observed the continuous values y_{ji}*, then the variation in reported bargaining power that is uncorrelated with X would identify the impact of y* on z.

[17] Pollak (2005) laid out the case that the wage, rather than earnings, is the appropriate proxy for the bargaining threat point, as hours of work may differ across bargaining equilibria. Measuring the marginal wage accurately for this age group proved difficult, though, as salaried jobs are the norm. Moreover, total earnings might better proxy the threat point in this case, since hours adjustments are difficult at this age; for example, a non-working spouse may find it difficult at this age to exercise what earlier was a legitimate threat to earn a high wage by returning to work.

with this, we control for each spouse's human capital as reflected by education, cognition, and health.[18] Cultural background and social norms may be correlated with both threat points and decision-making power, so we control for numerous background variables – race, hispanic ethnicity, immigrant status, religious background, and father and mother's education. We find that many of these variables have statistically significant effects on decision-making power, although ethnic variables also have the strongest effects on disagreements.

A. The impact of husband's and wife's earnings

We show estimation results for various specifications of labor market variables (including current earnings, earnings histories, and others) in bivariate ordered probits estimated jointly on both spouses' responses. Throughout these specifications, we obtain a positive, significant correlation coefficient of around 0.45.[19] Thus, conditioning on observables, both spouses agree about who has decision-making power on average, but not perfectly.

After reviewing various specifications, we will decompose the parameter estimates from some preferred specifications into the "true" and the "disagreement" or "bias" effects that result from imposing (4). Then, we will discuss the magnitude of the estimated effects on the distribution of decision-making power. In the meantime, recall that the estimated effect $\hat{\alpha}$ of a variable on true decision-making power equals the average of its estimated effects $\hat{b}_h$ and $\hat{b}_w$ on husbands' and wives' reports, which we discuss next. Also, the importance of any particular variable can be gauged by comparing its coefficient to the estimated threshold values $\hat{\mu}_0$ and $\hat{\mu}_1$, based on (10).

Current earnings *(Table 3-A).* We generally find that earnings have a significant effect on decision-making power. In our first set of results, a wife's current annual earnings significantly lower both spouses' reports of the husband's decision-making power (with the impact on her husband's and her own report shown in columns (1) and (2), respectively). A husband's earnings also significantly raise his wife's report of his decision-making power.

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[18] We use two of three measures of cognition reported in the HRS. The first, V5105, began, "Next, I'll read a set of 20 words and ask you to recall as many as you can. We have purposely made the list long so that it will be difficult for anyone to recall all the words – most people recall just a few." We use the number that was answered correctly. We also used V5113, which adds together the number of fully or partially correct answers to a series of seven questions. A third variable, V5126, had little explanatory power in our estimates. For missing observations on cognition, we used hot-deck imputation with income and education as explanatory variables.

[19] This exceeds the raw correlation coefficient of 0.36. We used univariate coefficient estimates as starting values, and they consistently yielded a higher log likelihood than did many alternatives that we tried. Most parameter estimates, including those on earnings, were very similar across the univariate and bivariate specifications.

Interestingly, a wife's earnings matter several times more than a husband's in explaining both reports, while earnings of both spouses affect the wife's report by about twice as much as the husband's.[20]

We can also attribute pension income to each spouse. Though the estimates are not statistically significant, each spouse's pension income from earlier jobs and pension participation in a current job affect reported decision-making power with the same signs as earnings in almost all cases. Once again a wife's pension has a much greater effect than a husband's.

Earnings histories *(Table 3-B).* The HRS provides restricted information about earnings histories reported by the Social Security Administration for 1951 to 1991. We computed the average annualized present value of past annual earnings over this period and substituted it in place of current earnings on the right-hand side. We have this data for 77% of the couples in our original estimation sample.[21]

We find that average past earnings in column (2) have a substantially greater impact on decision-making power than current earnings in (1) do. The estimated effect of husbands' earnings roughly doubles, though it is statistically insignificant, while the effect of wives' earnings triples and is highly significant. In column (3), we seek to distinguish the effect of current earnings and a measure of human capital, as indicated by average earnings over the ages of 22-45. In this specification, wives' current and average earnings affect her report, while wives' current earnings affects his report.

Other human capital variables *(Table 3-A).* There are two ways that skill- and work-related variables might affect decision-making power. First, they may capture information about threat points that is not reflected in current earnings, in which case we should consider the effects of these variables alongside that of earnings. Second, these variables may reflect other characteristics about the individual which are related to decision-making – for example, assertiveness, that is also associated with self-employment. In that case, it would be important to control for them in order to isolate the effect of earnings.

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[20] If we limit the sample only to couples whose reports agree (which involves a different set of identifying assumptions, as we mentioned earlier), then the estimated earnings coefficients rise by about 1/3. The biggest gains in parameter estimates occur in those categories – race, ethnicity, national origin – that cause the most disagreement.

[21] We do not have data for respondents who refused to provide their Social Security number or who provided a number that could not be matched. We imputed earnings that were topcoded at the Social Security payroll tax limit. If we run the earlier specifications from Table 3-A on the limited sample from Table 3-B, the estimated effects of current earnings are very similar.

In fact, in later specifications that omit work-related variables, we find very little change in the earnings estimates, so neither possibility seems like a major concern. In the specification in Table 3-A, we find that the effect of skill on bargaining power, as measured by occupation and education, is sometimes statistically significant and generally monotonic, raising own and reducing a spouse's decision-making power. The differential effect of being in the highest versus the lowest skilled occupation is similar in magnitude to the differential effect of having attended college versus not having completed high school.

Being self-employed also has strong effects on one's reported decision-making power. If the husband is self-employed, it raises his reported power by over one-third more than the difference between low and high skill does. It raises his wife's report of his power, but by less. A wife's self-employment reduces the husband's power, but the effects are considerably smaller. Lastly, other human capital variables – cognition, health, parents' education – have minor effects on bargaining power.

Additional labor market variables *(Table 3-C).* We explored additional specifications with different combinations of earnings and other work variables. These estimates reinforce our results about the impact of earnings on bargaining power.

By including controls for weekly hours of work in column (1), the coefficients on earnings can be thought of as isolating the effect of wages on decision-making power.[22] The estimated effects of a wife's labor market activities are now split between hours of work and earnings (which represents wages, when controlling for hours), and both are statistically significant. Finding an effect of hours of work indicates that wives may "exercise" their threat to some extent by working, which raises their decision-making power.

As we mentioned earlier, it is difficult to know how to interpret the occupation and self-employment variables in the main specification – they may help measure threat points or they may capture omitted characteristics correlated with decision-making power. Thus, it is interesting to note that including simple work dummies in (2) instead of occupation and self-employment had little effect on the earnings estimates. If we, instead, exclude all other human capital and cultural variables and control only for work-related variables in (3), the estimated effects of earnings are a little smaller. This reduces concerns that wives' earnings are correlated with cultural variables in ways that undermines conclusions about the effect of earnings.

[22] As we noted earlier, measuring the marginal wage accurately for this age group is difficult, as salaried jobs are the norm.

The last two specifications use transformations of the earnings variables, since we do not know exactly how earnings affect threat points. Including the log instead of level of earnings in (4) yields estimated magnitudes of the effects of earnings that are similar. The specification in (5) indicates that relative as well as absolute earnings influence threat points. The ratio of earnings is now significant, while the level of earnings remains statistically significant for the wife's reported power. These results show that shifting a wife from having 25% to 75% of total earnings reduces husband's reported bargaining power by as much as increasing the wife's earnings by $25,000.

B. Understanding the estimated effect of earnings

In this subsection, we discuss the magnitude of the estimated impact of earnings and other work variables. First, in Table 4 we present estimates and standard errors (based on the delta method) of the true effects of all of the covariates on decision-making power, as well as the reporting bias induced by each covariates, based on our identifying assumption in (4).

In Table 3-A, the estimated coefficient of wives' current earnings/10,000 was -0.0356 (0.0149) for husbands' reports and -0.0753 (0.0149) for wives' reports. The resulting estimate of the true effect is the average, -0.0555 (0.0126), while the reporting bias is 0.0198 (0.0160) on husbands' reports (and -0.0198 on wives' reports). Similarly, the true effect of wives' average past earnings (at the bottom of Table 4) is -0.01756 (0.0337) and the reporting bias on husbands' reports is 0.0650 (0.0570).

Next, we analyze the magnitude of these estimated effects in Table 5. We do this by simulating the effect on the distribution of decision-making power of altering husbands' and wives' earnings and work status. We compare the results to a set of baseline predictions that use the estimated coefficients together with everyone's actual earnings, and another set that assigns average earnings by gender to parallel the simulations. Because the interpretation of the occupation and self-employment variables is ambiguous – it is unclear whether they reflect threat points or individual characteristics – we use similar estimates in which a simple work dummy substitutes for occupation and self-employment (as in column (2) of Table 3-C).[23]

For example, if we switch average current earnings of men and women, then the predicted percentage of husbands having the final say falls from 31.0 to 28.2%, according to

[23] In Table 5 we use the estimated coefficients rather than the estimated "true effects" to give a complete sense of the data that does not rely on our identification assumption. If we used the estimated true effects, the predictions would lie approximately in the middle of those based on the husbands' and on the wives' answers.

husbands' reports, and from 32.3 to 26.6%, according to wives' reports.[24] If we do the same but switch average past earnings, then the declines are double in magnitude – from 31.5% to 19.7%, according to wives' reports. If we compare all husbands and no wives working to all wives and no husbands working (with the working spouse earning the conditional average by gender), then the percentage of husbands having the final say, as reported by wives, swings from 37.5% to 27.3%, and the percentage of wives having the final say rises from 11.5% to 18.0%.

Overall, we characterize these effects as moderate. They show a clear, but not large, effect of earnings on bargaining power that should be kept in mind when considering tests of income pooling that are common in the literature. Moreover, further research may shed light on the extent to which bargaining in the HRS cohort may differ from later cohorts that have experienced major changes in divorce rates, fertility, women's labor supply and earnings, etc.

C. The impact of other control variables

We included a large set of variables reflecting ethnic and cultural background. Coefficient estimates appear in Table 3-A, and the decomposition into true effects and reporting bias appear in Table 4. Some of these have significant effects on bargaining power, which is interesting for three reasons. First, these background factors may be correlated with the labor supply of each spouse. Second, cultural factors may affect threat points. For example, cultural norms may influence the willingness of a spouse to consider divorce by reducing utility outside of marriage. Alternatively, they may reflect the degree to which the community favors one spouse over the other in the event of conflict. Third, some of the background variables lead to considerable disagreement between the spouses' reports about decision-making power.

Race, national origin, and ethnicity have some significant effects on reported decision-making power in Table 3-A in roughly descending order in terms of magnitude, although the significance of the true effects is reduced in Table 4. If both spouses are black, it has little net effect on the husband's report of decision-making power, while reducing the wife's report of the husband's power. Similar results, though somewhat smaller are found for foreign born couples.[25]

Religion also has strong effects on reported decision-making power, and with much less disagreement. In Protestant and especially fundamentalist or evangelical Protestant couples

[24] Average earnings of husbands and wives in our sample are $38,348 and $11,897, including nonworkers.
[25] As these variables generate considerable disagreement, we find substantial increases in their coefficient estimates if we limit the sample only to couples whose reports agree.

husbands have significantly more decision-making power. In Catholic and non-religious couples the effects are the reverse, though smaller, while couples reporting different religions have a significant disagreement.[26] Moreover, regular church attendance by either spouse significantly raises husbands' decision-making power.

It is interesting to find that having kids, especially if they are under the age of 18, reduces a husband's reported bargaining power considerably.[27] While it has much less influence on wives' reports in the main specification, both effects are greater in specification 3-B (2) with average past, rather than current, earnings. The true effect of having children under the age of 18 in this specification is negative and statistically significant at the 90% confidence level.

In addition, increased age of both spouses (or else cohort effects) reduces a husband's reported bargaining power a little. Lastly, we find little effect of controls for information about individuals' time horizon and risk preferences, which we include because they shape some of the household decisions which we investigate later.

VI. WHAT DOES BARGAINING POWER INFLUENCE?

In this section, we demonstrate that decision-making power influences important household decisions. As examples, we focus on two financial outcomes that are well-measured in the HRS: total wealth accumulation and stock market investment. Both sets of estimated effects are important in magnitude, though somewhat sensitive to the specification.

Our findings about wealth accumulation diverge in an interesting way from standard life cycle predictions: household assets rise with the husband's age when husbands are in charge and with the wife's age when wives are in charge. Thus, it appears that the spouse with the final say may be making decisions based primarily on their own life-cycle prospects. We show that this difference is only partly explained by our other main result: when husbands are in charge, the household take on more risk by investing more of the household portfolio in equities. While we do not elaborate on underlying life cycle models that may be associated with these patterns, they suggest important directions for future research.

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[26] We define religious differences based on these broad categories, which are aggregated over many denominations.

[27] In theory, kids might shift bargaining power in either direction (increasing the wife's power if she has disproportionate influence over kids' emotional well-being or increasing the husband's if he has disproportionate influence over their material well-being). We cannot explain why perceptions about the impact of kids might differ across spouses.

A. Estimation approach

We use three methods to estimate the impact of bargaining power. We maintain the assumption throughout that total earnings in the household may be related to these financial outcomes, but the split between spouses' earnings is not, except through its influence on bargaining power.[28] As we noted earlier, this is necessary in the structural models because we do not observe continuously measured bargaining power but instead use variables that influence bargaining power to, in effect, impute a continuous measure.[29] Besides that, we include all non-income related control variables used earlier to explain decision-making power, and we add self-reported information on each spouse's life expectancy, which influences their time horizons.

The first two methods that we use yield structural estimates of equation (6), relating the impact of decision-making power γ to an outcome z. We will highlight the more efficient approach, described in the Appendix and based on Amemiya (1979), which uses reduced form and first-stage estimates to obtain the structural parameters of the second stage. We compare that to a standard two-stage approach that substitutes into (6) an estimate of $\hat{\gamma}$ obtained from our earlier specifications. Here, we can control for the log rather than level of total household earnings, but the estimates are less efficient and have incorrect standard errors. Controlling for the log of income is preferred on a priori grounds (especially when utility is CRRA) and is typical in regressions involving financial behavior. Typically, the estimated effect of decision-making power loses some explanatory power under the efficient estimation approach but remains statistically significant.

With either structural method, the results are somewhat sensitive to the choice of which first-stage estimates to use. We try the specifications with current earnings (from Table 3-A), average past earnings (Table 3-B 2, for a smaller sample), and the ratio of earnings (Table 3-C 5). When we use the last specification, we can control for the log rather than level of total household earnings in the first estimation approach for reasons that are detailed in the Appendix.

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[28] While earnings and other work-related variables may be endogenous, they are typically included in financial regressions and play a major role in explaining the observed variation (Miniaci and Weber 2002). One motivation is that, while wealth and portfolio allocations vary substantially by income, they also vary substantially within income groups, and it is this variation that the other control variables seek to explain. This approach also addresses concerns that omitting earnings might bias the estimated effect of predicted bargaining power. In any case, excluding income and work-related variables typically has little impact on the estimated effect of bargaining power.

[29] We were interested in analyzing life insurance holdings as well because of the potential link between bargaining power during marriage and the poverty of widows, but the exclusion restriction was unreasonable in that case since the decision to insure a spouse's life should depend directly on that spouse's earnings. Another difficulty is that the HRS does not report whose life is insured, but rather which spouse owns the policies.

Lastly, we find similar effects of decision-making power in our third approach, which is a non-structural alternative to (6) that controls for the discrete answers about decision-making power. This approach does not rely on the functional form represented by (1)-(2b) that we assumed in the first stage, but it revives the original difficulty of extracting information from the discrete and sometimes conflicting answers of spouses. On the other hand, it allows us to control for the log rather than level of household earnings and even to include spouses' earnings separately, which has little effect on the estimated results.

B. Wealth and age

Background. As long as households expect to retire at some point, then life cycle models predict that wealth will rise with age until retirement. Moreover, households appear to do most of their life cycle saving in their 40s and 50s (Gourinchas and Parker 2002), which coincides well with the HRS. However, bargaining within the household may be particularly salient here since husbands, with shorter lifespans and younger wives on average, should have shorter time horizons than their wives (Browning 2000). Wives should prefer to accumulate more life cycle saving than husbands, yet widows have higher poverty rates than the population average.

Our results about the role of bargaining power can help resolve this puzzle. We find that, when men are in charge, households with older husbands have significantly higher wealth and households with older wives have significantly lower wealth; and when wives are in charge, the results are reversed. Thus, it appears that the spouse with the final say makes decisions based on their own life-cycle prospects.

We regressed log household wealth on decision-making power and interacted it with each spouse's age, and also included total household earnings, other controls used in our earlier regressions, and the subjective life expectancy of each spouse. We show a small subset of coefficient estimates in Table 6, the key ones being the interaction of decision-making power with each spouse's age. The top panel shows the efficient estimation approach, the middle panel shows the standard two-stage approach, and the bottom panel shows the non-structural approach with the raw answers on decision-making power.

It is worth noting at the outset that the coefficients estimated for the main age effects are quite similar in size to those estimated for the decision-making/age interactions. The age

coefficients generally range between 0.02 and 0.04, indicating an annual percentage increase in wealth of 2-4% as each spouse ages.

The additional impact on wealth of the decision-making/age interactions depends on the magnitude of the decision-making power variable. For this purpose, consider the estimated threshold values $\hat{\mu}_0$ and $\hat{\mu}_1$ reported in Table 3-A. They indicate the values at which the latent continuous variable $\gamma$is predicted to shift, first, from the wife having the final say to power being about equal and, next, from being about equal to the husband having the final say. The estimated difference between these values – typically about 1.7 – crosses the full range over which decision-making power is "about equal", and we will use that to gauge the magnitude of the effects in which we are interested.

Two-stage estimation. As a baseline, the middle panel of Table 6 reports the two-stage estimates from each of three different first-stage specifications, with incorrect standard errors but with the log rather than level of household earnings as a covariate. The estimated effects of decision-making power when it is interacted with each spouse's age is stable across the three sets of results, taking values around 0.045 for the husband's age and -0.040 for the wife's age.

Efficient estimation. When we use the efficient estimation approach in the top panel, the bargaining power-age interaction effects are smaller. We will focus on the specification with the first-stage estimates that use the ratio of earnings, which worked well in Table 3-C 5 and allows us to control for the log of earnings; and we focus on the log of average past earnings, since it explains more of the variation in wealth than do current earnings. The resulting pair of estimated coefficients on the bargaining power-age interaction lies in the middle of the range in this set of results, at 0.0253 for the husbands' age and -0.0319 for the wife's age. The first coefficient falls just short of 90% significance and the second coefficient exceeds 95% significance.

Now, we will consider the implications of these estimates. Recall that if decision-making power shifts from the threshold of the wife to the husband having the final say, then the latent continuous variable γchanges by about 1.7. If such a shift occurs, then household wealth will be 4.20% higher (the estimated coefficient 0.0253 times the estimated difference in threshold values 1.6593) than it would have been otherwise for each year that the husband is older. Additionally, with such a shift in decision-making power towards the husband, wealth is 5.29% *lower* (-0.0319*1.6593) for each year that the wife is older. If the reverse takes place, with the household shifting from the threshold of the husband to the wife having the final say, then the

effects are reversed: wealth is 5.29% higher for each year that the wife is older and 4.20% lower for each year that the husband is older.

To understand the nature of this cross-sectional comparative static, consider a household in which decision-making power is split equally (taking a value of zero). Wealth will be about the same whether the husband is 65 and the wife is 55, or the ages are reversed and the wife is 65 and the husband is 55. That does not hold when decision-making power is unequal. When the husband just barely has the final say, then the first household (husband 65, wife 55) will have accumulated 50.8% more wealth (1.0420^{10}-1) than it would have if the wife just barely had the final say. Moreover, the second household (wife 65, husband 55) will have accumulated 67.5% *less* wealth (1.0529^{10}-1) than if the wife had the final say.

Non-structural estimation. Table 6 also shows alternative estimates that include the raw responses about decision-making power as dummy variables. The age-related patterns are similar, while highlighting the difficulties in interpretation of moving away from the framework laid out in Section III.

When husbands report that they have the final say, household wealth is 4.07% higher for each year that the husband is older and 3.00% lower for each year that the wife is older, compared to when husbands report that wives have the final say. These results are statistically significant. When husbands report "about equal", the results are significantly smaller, at 3.18% higher and 1.39% lower, respectively, and the first result is statistically significant. The values are similar when we use wives' instead of husbands' reports. Lastly, in estimates that are not shown, we do not reject equality of the coefficients on each spouse's earnings included separately, and doing so has little effect on the other results.

C. The riskiness of the household portfolio.

Background. Men in the HRS report somewhat greater risk tolerance than women (Barsky et al 1997). Moreover, other research suggests that men are willing to take on more risk, with single men investing a greater share of their wealth in the stock market than single women (Jianakoplos and Bernasek 1996), men purchasing auto insurance policies that provide less coverage (Cohen and Einav 2004) and men even taking more risks in mundane choices involving seat belt use and preventative dental care (Hersch 1996).

Results in Table 7 reveal the impact of these apparent differences in risk preferences on some important household decisions. We find that, as husbands' power rises, households invest

more in the stock market, and this effect is significant in many of the specifications. We estimated probits on whether households invest in the stock market at all (which 32% in our sample do) and tobits on the share of financial assets invested in the stock market (which is 17% on average).[30] As in the previous section, we controlled for total household earnings, other controls used in our earlier regressions, and subjective life expectancy. The coefficient of interest is the one on the decision-making power and "final say" variables.

Two-stage estimation. As a baseline, the middle panel of Table 7 reports estimates from the two-stage approach with incorrect standard errors, but with the log rather than level of household earnings as a control. When we use the current earnings specification from 3-A in the first stage, the marginal effect of the husband's predicted bargaining power on stock market participation in the probit is 0.1811, and the effect on the desired share of financial assets invested in the stock market in the tobit is 0.2755. The estimated effects are reduced by about one-third when we use the average past earnings specification from 3-B 2 in the first-stage and increased by about one-third when we use the ratio of earnings specification from 3-C 5, whether controlling for the log of current or average past earnings.

Efficient estimation. When we use the efficient estimation approach in the top panel, the estimated effect is smaller for the specifications that control for current earnings (3-A and the first 3-C 5 result) and considerably larger for the specifications that control for average past earnings (3-B 2 and the second 3-C 5 result). Since it is preferable, once again, to control for the log of average past earnings, we will focus on the last specification – though it should be kept in mind that the resulting estimates lie at the high end of the range.

In the preferred specification, the estimated marginal effect of a small change in decision-making power is 0.4262 for the probit, and the estimated coefficient is 0.6874 for the tobit, both of which are highly significant. If decision-making power in a household shifts, as before, from the threshold of the wife having the final say to the husband having the final say, then the probability that the household invests in the stock market rises by a very substantial 50.9 percentage points. The same shift in decision-making power raises the predicted share of

[30] A caveat is that the HRS does not report the investment allocation of Individual Retirement Accounts or of those defined contribution pensions (including 401(k) plans) that do not offer an investment choice. 45% of our sample have IRAs, which we omit entirely from the analysis. 35% have defined contribution pensions, 60% of which can be identified as offering investment choices; for the latter, the HRS reports whether the account was invested mostly in stocks, mostly in bonds, or "split". This information is vague, though, and we chose to focus entirely on financial wealth and did not consider any form pension wealth. These omissions may lead us to underestimate the effect of

financial assets invested in the stock market by 26.0 percentage points.[31] By way of comparison, the estimates for the same first-stage specification but controlling for log current earnings are considerably smaller, at 0.2002 for the probit (statistically significant at a little more than 90%) and 0.3182 for the tobit (statistically significant at a little less than 90%). These estimates imply predicted increases of 29.3 and 13.7 percentage points if decision-making power shifts from the wife to the husband.

Non-structural estimation. In the final panel of Table 6, the results are similar when the raw answers are included as dummy variables. If the husband reports having the final say, then the household is 5.1% more likely to invest in the stock market relative to the wife having the final say and a little greater than that relative to "about equal". The effects are somewhat reduced and not statistically significant based on the wife's reports. As we noted earlier, this specification raises difficulties in reconciling the discrete and sometimes conflicting answers of both spouses.

Lastly, we find some suggestive evidence that other preferences of the individual in charge matter more as well. In results that are not shown, when husbands have the final say, then the household invests more in the stock market if the husband is less risk averse, while wives' risk aversion has no affect. When wives are in charge, wives' risk aversion has substantial effects, though they are not statistically significant. We find similar patterns for time preference.

Summary. Taking our two major sets of results together, we note that the difference in portfolio allocations can explain part but not all of the age-related results. In the benchmark calculation discussed above, a shift from the threshold of the wife to the husband having the final say would raise the predicted share of financial assets invested in the stock market by 26.0 percentage points. According to some simple calculations, this could raise wealth at age 65 by 36.1%.[32] Since our earlier benchmark suggested that the same household would accumulate

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bargaining power. For people in our sample whose pensions offer an investment choice, men are significantly more likely than women to invest theirs "mostly or all" in stock.

[31] For the probit, we calculated this as $\Phi(\hat{\gamma}\hat{\mu}_1 + \overline{X}\hat{\delta}) - \Phi(\hat{\gamma}\hat{\mu}_0 + \overline{X}\hat{\delta})$, where notation is based on equations (6) and (10) and μ_j refers to the j^{th} threshold in the first-stage ordered probit. For the tobit, we calculated the change in the expected censored value of the left-hand side variable using the formula from Greene (2000).

[32] In these calculations, we assume that bonds and stocks earn real returns of 2.25% and 7.10%, the respective averages for the period 1926-2004. We further assume that people have the lifetime age-earnings profile of the median HRS individual, excluding those with non-zero earnings; that they save a constant fraction of their salary each year from age 22 until they retire at age 65; and that they rebalance their portfolio annually.

50.8% more if the husband had the final say and 67.5% less wealth if the wife had the final say (both in comparison to decision-making power being exactly equal), the difference in portfolio choices explains only a fraction of the difference in wealth.

VII. CONCLUSIONS

Our analysis takes advantage of unique data on the distribution of decision-making power between spouses. We interpret this question as revealing whose preferences are reflected to a greater degree in household decisions. We find that decision-making power depends on plausible variables like earnings and also influences some important household outcomes. Moreover, the second set of results is much stronger than the first set.

In terms of outcomes of bargaining, we find that, household wealth is significantly higher the older is the husband but not the wife when husbands have the final say, and the older is the wife but not the husband when wives have the final say – an intriguing twist on the life cycle model. We find further that, when husbands have the final say, households invest significantly more in the stock market, though the difference in portfolio allocations can explain only part of the age-related results. Being able to investigate outcomes that are both novel in the household bargaining literature and important is a major contribution of our research.

From a policy perspective, the results suggest that household bargaining can help explain the relatively high rate of poverty among widows. These concerns provide support for proposals to increase Social Security survivor benefits, especially in case of Social Security privatization. A shift away from the current annuitized Social Security benefit towards a lump-sum private account would increase the risk of impoverishment among older widows who were in a weak bargaining position while married. Likewise, the major shift over the last twenty years in the structure of employer-provided pensions from annuitized defined benefits towards lump-sum defined contribution accounts may undermine the well-being of widows.

In terms of determinants of bargaining power, our major result in this paper is somewhat negative, since we remain unable to explain a great deal about the observed distribution of bargaining power. Labor market earnings have significant but moderate effects in our estimation results for this older sample – switching average lifetime earnings of husbands and wives reduces the predicted percentage of men reported to have the final say by their wives from 31.5% to 19.7%. These results are noteworthy because the HRS affords much more detail about the entire

path of earnings than data used in previous "income pooling" tests, yet earnings appear to play a limited role in determining threat points.

Thus, future research may focus greater attention on other factors influencing threat points, perhaps including the role of marriage markets since remarriage has become common as divorce rates have risen over time. In addition, it should be possible to extend this research by estimating formal models of bargaining with the HRS data and by exploiting the entry in subsequent waves of the HRS of younger cohorts who were asked the same questions about who has the final say.

APPENDIX

We now describe the method that we use to estimate the parameters in (6) when we observe discrete measures y and possibly z rather than the true values y^* and z^*. This approach is based on Amemiya (1979) and was elaborated by Maddala (1983, Section 8.9). Although focusing on the simultaneous tobit model, Amemiya (p.175) noted that, "The principles on which our estimators are based can be applied in general whenever structural parameters need to be determined from the estimates of reduced-form parameters."

While we continue to assume the relationship outlined in (1), (2a), (2b), and (6), the details of separately identifying the parameters α, β_h, and β_w in (1)-(2b) are not germane to the estimation procedure, so we will introduce some simplifications. We will first discuss a simple version and then show how we incorporate the sum of earnings as a covariate in (6) when also including earnings separately in the first stage.

Consider the following structural model:

$$\text{(A.1a)} \qquad y^* = X_1\alpha_1 + X\delta_1 + u_1$$

$$\text{(A.1b)} \qquad z^* = \gamma y^* + X_2\alpha_2 + X\delta_2 + u_2 .$$

Equation (A.1a) is the analog to (1), except with α_1 and δ_1 representing $\overline{\alpha}_1$ and $\overline{\delta}_1$ as defined in (5a), while (A.1b) is the analog to (6). X_1 are variables that only appear in the first equation (or, as we call it sometimes, the first stage), X_2 are variables that only appear in the second equation, and X are variables that appear in both. The parameter γ is a scalar, and α_1, α_2, δ_1, and δ_2 may be scalars or vectors. Substitute (A.1a) into (A.1b) to obtain

$$z^* = \gamma X_1\alpha_1 + X_2\alpha_2 + X(\gamma\delta_1 + \delta_2) + \gamma u_1 + u_2 .$$

We can now write the reduced form of the structural equation (A.1b) as

$$\text{(A.2)} \qquad z^* = X_1\pi_1 + X_2\pi_2 + X\pi_3 + e .$$

We can estimate (A.1a) to obtain consistent estimates of $\hat{\alpha}_1$ and $\hat{\delta}_1$ and (A.2) to obtain consistent estimates of $\hat{\pi}_1$, $\hat{\pi}_2$, $\hat{\pi}_3$, and the covariance matrix $\hat{\Omega}_e$. Note that y^* and z^* may be either continuous or discrete; in our case, (A.1a) is an ordered probit and (A.2) takes the form of, variously, probit, tobit, and OLS.

The relationship between the structural and reduced form parameters is

(A.3a) $\pi_1 = \gamma\alpha_1$

(A.3b) $\pi_2 = \alpha_2$

(A.3c) $\pi_3 = \gamma\delta_1 + \delta_2$.

(A.3b) identifies the structural parameters α_2. In regards to the rest, Amemiya proposes using the consistent estimates of $\hat{\pi}_1$, $\hat{\pi}_3$, $\hat{\alpha}_1$, and $\hat{\delta}_1$ in order to estimate $\hat{\gamma}$ and $\hat{\delta}_2$ by generalized least squares (GLS), with $\hat{\Omega}_e$ as the weighting matrix. He shows that this approach is more efficient than the two-stage estimator proposed by Nelson and Olsen (1977) and elaborated by Maddala (1983, Section 8.8).

Now, we will discuss how to incorporate the sum of household earnings as a covariate in (A.1b) when each spouse's earnings are covariates in (A.1a). We will rewrite the equations as

(A.1a′) $y^* = X_1^1\alpha_1^1 + X_1^2\alpha_1^2 + X_1^o\alpha_1^o + X\delta_1 + u_1$

(A.1b′) $z^* = \gamma y^* + (X_1^1 + X_1^2)\delta_3 + X_2\alpha_2 + X\delta_2 + u_2$.

We have now decomposed X_1 into X_1^1 and X_1^2 (which will represent the husband's and the wife's earnings) and X_1^o (other variables that will only appear in the first equation). Moreover, the sum $X_1^1 + X_1^2$ (total household earnings) now appears in the second equation. Once again, we can substitute to obtain

$$z^* = X_1^1(\gamma\alpha_1^1 + \delta_3) + X_1^2(\gamma\alpha_1^2 + \delta_3) + \gamma X_1^o\alpha_1^o + X_2\alpha_2 + X(\gamma\delta_1 + \delta_2) + \gamma u_1 + u_2$$

and then write the reduced form of the structural equation (A.1b′) as

(A.2′) $z^* = X_1^1\pi_1^1 + X_1^2\pi_1^2 + X_1^o\pi_1^o + X_2\pi_2 + X\pi_3 + e$.

The relationship between the structural and reduced form parameters is now

(A.4a) $\pi_1^1 = \gamma\alpha_1^1 + \delta_3$

(A.4b) $\pi_1^2 = \gamma\alpha_1^2 + \delta_3$

(A.4c) $\pi_1^o = \gamma\alpha_1^o$

(A.4d) $\pi_2 = \alpha_2$

(A.4e) $\pi_3 = \gamma\delta_1 + \delta_2$.

We can proceed in the same way as before. We estimate (A.1a′) to obtain $\hat{\alpha}_1^1$, $\hat{\alpha}_1^2$, and $\hat{\alpha}_1^o$. We estimate (A.2′) to obtain $\hat{\pi}_1^1$, $\hat{\pi}_1^2$, $\hat{\pi}_1^o$, $\hat{\pi}_2$, $\hat{\pi}_3$, and $\hat{\Omega}_e$. Lastly, we estimate the system (A.4a), (A.4b), (A.4c), and (A.4e) using GLS to obtain the remaining structural parameters in (A.1b′).

To sum up, we use the methods that we outlined earlier in the Appendix to estimate the parameters reported in Table 7, with (A.1b) taking the form of a probit or tobit. We estimate a yet more generalized version of (A.1b′) for Table 6, adding additional terms that interact y^* with elements of X – specifically, the husband's age and wife's age. As a consequence of these interactions, (A.2′) involves terms that interact age with the error term e, so we use the Huber-White method to estimate the covariance matrix $\hat{\Omega}_e$.

For the results in both tables, we also try different specifications of the first-stage equation (A.1a). When we use specifications that include each spouse's current or average past earnings in the first stage, then we include the sum of earnings in the second stage. While we would prefer the log of the sum of earnings, including this non-linear transformation of first-stage covariates is not possible using the method we have outlined above. As an alternative, we consider a first-stage specification of (A.1a) with the ratio of spouses' earnings, and then we can use the log of the sum of earnings as a covariate in the second stage.

REFERENCES

Amemiya, Takeshi. 1979. "The Estimation of a Simultaneous-Equation Tobit Model." *International Economic Review* 20 (1): 169-181.

Barsky, Robert, F. Thomas Juster, Miles Kimball, and Matthew Shapiro. 1997. "Preference Parameters and Behavioral Heterogeneity: An Experimental Approach in the Health and Retirement Study." *Quarterly Journal of Economics* 112 (2): 537-579.

Behrman, Jere. 1995. "Intrahousehold Distribution and the Family," in M.Rosenzweig and O.Stark, eds., *Handbook of Population and Family Economics*. Amsterdam: North-Holland, pp.

Bergstrom, Theodore. 1995. "A Survey of Theories of the Family," in M.Rosenzweig and O.Stark, eds., *Handbook of Population and Family Economics*. Amsterdam: North-Holland, pp.

Bergstrom, Theodore. 1996. "Economics in a Family Way." *Journal of Economic Literature* 34 (4): 1903-1934.

Browning, Martin. 2000. "The Saving Behaviour of a Two-Person Household." *Scandinavian Journal of Economics* 102 (2): 235-251.

Browning, Martin, Francois Bourguignon, Pierre-André Chiappori, and Valérie Lechene. 1994. "Income and Outcomes: A Structural Model of Intrahousehold Allocation." *Journal of Political Economy*. 102 (6): 1067-96.

Browning, Martin, and Pierre-André Chiappori. 1998. "Efficient Intra-Household Allocations: A General Characterisation and Empirical Tests." *Econometrica*. 66 (6): 1241-1278.

Bureau of Labor Statistics. 2004. "American Time-Use Survey Summary." Press release, September 14, http://www.bls.gov/news.release/atus.nr0.htm.

Duflo, Esther. 2003. "Grandmothers and Granddaughters: Old Age Pension and Intra-Household Allocation in South Africa." *World Bank Economic Review* 17 (1): 1-25.

Duflo, Esther, and Christopher Udry. 2004. "Intrahousehold Resource Allocation in Côte d'Ivoire: Social Norms, Separate Accounts and Consumption Choices." National Bureau of Economics Research Working Paper No. 10498.

Flinn, Christopher. Forthcoming. "Minimum Wage Effects on Labor Market Outcomes under Search, Bargaining, and Endogenous Contact Rates." *Econometrica*.

Friedberg, Leora, and Steven Stern. 2005. "Marriage, Divorce, and Asymmetric Information." Draft, University of Virginia.

Gourinchas, Pierre-Olivier, and Jonathan Parker. 2002. "Consumption Over The Life Cycle." *Econometrica* 70 (1): 47-89.

Greene, William. 2000. *Econometric Analysis*, Fourth edition. Upper Saddle River, NJ: Prentice-Hall, Inc.

Haddad Lawrence, and John Hoddinott. 1994. "Women's Income and Boy-Girl Anthropometric Status in the Cóte d'Ivoire." *World Development* 22 (4): 543-553.

Hersch, Joni. 1996. "Smoking, Seat Belts and Other Risky Consumer Decisions: Differences by Gender and Race." *Managerial and Decision Economics* 17 (5): 471-481.

Hoddinott, John and Lawrence Haddad. 1995. "Does Female Income Share Influence Household Expenditures? Evidence from Cóte d'Ivoire." *Oxford Bulletin of Economics and Statistics* 57(1): 77-96.

Jianakoplos, Nancy, and Alexandra Bernasek. 1998. "Are Women More Risk Averse?" *Economic Inquiry* 36 (4): 620-630.

Lundberg, Shelley, and Robert Pollak. 1996. "Bargaining and Distribution in Marriage." *Journal of Economic Perspectives* 10 (4): 139-158.

Lundberg, Shelley, Robert Pollak, and Terence Wales. 1997. "Do Husbands and Wives Pool Resources: Evidence from the UK Child Benefit." *Journal of Human Resources* 32 (3): 463-480.

Lundberg, Shelley, Richard Starz, and Steven Stillman. 2003. "The Retirement Consumption Puzzle: A Marital Bargaining Approach." *Journal of Public Economics* 87 (5-6): 1119-1218.

Lyons, Angela, and Tansel Yilmazer. 2004. "How Does Marriage Affect the Allocation of Assets in Women's Defined Contribution Plans?" Center for Retirement Research at Boston College, CRR Working Paper 2004-28, November.

Maddala, G.S. 1983. *Limited-Dependent and Qualitative Variables in Econometrics*. Cambridge: Cambridge University Press.

Manser, Marilyn, and Murray Brown. 1980. "Marriage and Household Decision Making: A Bargaining Analysis." *International Economic Review* 21: 31-44.

McElroy, Marjorie and Mary Horney. 1981. "Nash-Bargained Decisions: Toward a Generalization of the Theory of Demand." *International Economic Review* 22: 333-349.

McElroy, Marjorie. 1981. "Appendix: Empirical Results from Estimates of Joint Labor Supply Functions of Husbands and Wives," in R.Ehrenberg, ed., *Research in Labor Economics*, Volume 4, pp. 53-64. Greenwich, CT: JAI Press.

National Economic Council. 1998. "Women and Retirement Security." Prepared by the Interagency Working Group on Social Security, http://www.ssa.gov/history/pdf/sswomen.pdf.
Nelson, F., and L. Olson. 1977. "Specification and Estimation of a Simultaneous-Equation Model with Limited Dependent Variables." Social Science Working Paper No. 149, California Institute of Technology.

Phipps, Shelley, and Peter Burton. 1998. "What's Mine is Yours? The Influence of Male and Female Incomes on Patterns of Household Expenditure." *Economica* 65: 599-613.

President's Commission to Strengthen Social Security. 2001. "Strengthening Social Security and Creating Private Wealth for All Americans: Report of the President's Commission." Washington, December 21, http://csss.gov/reports/Final_report.pdf.

Rose, Elaina. 1999. "Consumption Smoothing and Excess Female Mortality in Rural India." *Review of Economics and Statistics* 81 (1): 41-49.

Schultz, T. Paul. 1990. "Testing the Neoclassical Model of Family Labor Supply and Fertility." *Journal of Human Resources* 25 (4): 599-634.

Thomas, Duncan. 1990. "Intra-Household Resource Allocation: An Inferential Approach." *Journal of Human Resources* 25 (4): 635-664.

Thomas, Duncan. 1994. "Like Father, Like Son, Like Mother, Like Daughter: Parental Resources and Child Height." *Journal of Human Resources* 29 (4): 950-988.

Ward-Batts, Jennifer. 2003. "Out of the Wallet and into the Purse: Using Micro Data to Test Income Pooling." Claremont Colleges Working Paper No. 2003-10.

TABLE 1
Distribution of decision making power in the HRS sample

"When it comes to making major family decisions, who has the final say?"

	Husband reports … has more say: husband	about equal	wife	Total [N]
Wife reports …				
husband	18.1%	11.5	2.3	31.9 [1350]
about equal	8.8	40.1	3.9	52.8 [2235]
wife	3.3	6.5	5.5	15.3 [652]
Total [N]	30.2 [1278]	58.1 [2460]	11.7 [499]	100% [4237]

"Does … have a lot more say, somewhat more, or only a little more?"

	Husband reports … has … say: husband – a lot more	husband – somewhat /a little more	about equal	wife – somewhat / a little more	wife – a lot more	Total
Wife reports …						
husband – a lot more	2.3	3.3	2.4	0.3	0.3	8.6
husband – somewhat/ a little more	2.0	10.4	9.0	1.1	0.5	23.0
about equal	1.7	7.1	40.2	2.8	1.1	52.9
wife – somewhat/ a little more	0.3	1.9	3.9	2.0	0.8	8.9
wife – a lot more	0.3	0.9	2.7	1.5	1.2	6.6
Total	6.6	23.6	58.2	7.7	3.9	100%

Data: Health and Retirement Study, Wave 1, 1992.
Sample: N = 4237. See text for more details.

TABLE 2
Characteristics of the sample, based on who has more say

	Who has more say?			
	Husband	Wife	About equal	Disagree
Income, work variables:				
both spouses work	42.1	39.4	46.4	43.9
only husband works	29.1	22.0	24.6	25.7
only wife works	9.1	22.0	13.3	15.4
neither spouse works	19.7	16.6	15.9	15.0
husband's weekly hours	44.0	44.0	44.2	45.0
wife's weekly hours	34.2	39.4	37.3	36.8
husband's earnings	31,100	25,000	32,000	30,000
wife's earnings	12,000	19,000	17,000	15,000
Other variables:				
income	45,700	41,216	49,200	46,360
net worth	121,700	65,700	132,000	117,500
financial assets (median/mean)	8,000/ 43,500	3,000/ 22,676	10,500/ 50,451	8,900/ 49.850
% of financial assets invested in equity (median/mean)	0.0/17.9	0.0/10.4	0.0/18.3	0.0/17.2

Data: Health and Retirement Study, Wave 1, 1992.
Sample: N = 4237. See text for more details.

TABLE 3-A

Determinants of decision making power
Estimation results from bivariate ordered probits

Dependent variable: ***Respondent*** reports *husband* has final say ($Y_i = 1$), it's about equal ($Y_i = 0$), *wife* has final say ($Y_i = -1$)

	Husband is respondent		*Wife* is respondent	
Log likelihood (LL/N)	- 1.801			
Rho	0.4545*** (0.0257)			
Threshold value μ_0	-1.2745***	(0.1864)	-1.1504***	(0.1929)
Threshold value μ_1	0.4921***	(0.1887)	0.3966**	(0.1924)
Income variables				
husband's earnings/10,000	0.0072	(0.0053)	0.0150***	(0.0054)
wife's earnings/10,000	-0.0356**	(0.0149)	-0.0753***	(0.0149)
husband's pension income/10,000	0.0360	(0.0312)	0.0435	(0.0289)
wife's pension income/10,000	-0.1072	(0.1118)	-0.1212	(0.0986)
husband has pension in current job	0.0123	(0.0511)	0.0196	(0.0518)
wife has pension in current job	-0.0595	(0.0526)	0.0365	(0.0538)
	Characteristics of:		Characteristics of:	
Other work variables	husband	wife	husband	wife
occupation: professional, tech	0.1352*	-0.0641	0.1039	-0.0693
	(0.0726)	(0.0726)	(0.0728)	(0.0723)
sales, clerical	0.0998	-0.0228	0.0067	0.0306
	(0.0816)	(0.0613)	(0.0821)	(0.0620)
services	0.0357	-0.0241	-0.1288	-0.0727
	(0.0877)	(0.0674)	(0.0922)	(0.0716)
skilled blue collar	-0.0982	0.1744	-0.1333*	-0.0448
	(0.0714)	(0.1658)	(0.0731)	(0.1658)
unskilled blue collar	-0.1085	0.0547	-0.1519**	-0.0740
	(0.0707)	(0.0897)	(0.0727)	(0.0947)
self-employed	0.3442***	-0.1153*	0.2133***	-0.0425
	(0.0603)	(0.0683)	(0.0627)	(0.0716)
Human capital variables				
cognition: score #1	0.0032	-0.0025	0.0120	-0.0077
	(0.0079)	(0.0073)	(0.0080)	(0.0075)
score #2	0.0159**	-0.0115	0.0015	0.0016
	(0.0073)	(0.0076)	(0.0074)	(0.0077)
education: no high school diploma	-0.1529***	0.0740	-0.1466***	0.1374**
	(0.0503)	(0.0510)	(0.0524)	(0.0542)
at least some college	0.0806*	-0.0780	0.0074	-0.0571
	(0.0487)	(0.0481)	(0.0491)	(0.0494)
health is fair or poor	0.0087	-0.0197	0.0228	0.0167
	(0.0475)	(0.0507)	(0.0507)	(0.0525)
both parents: no high school dipl	-0.0114	0.0121	0.0402	0.0294
	(0.0373)	(0.0386)	(0.0383)	(0.0394)
at least some college	-0.1646*	-0.1454*	-0.0679	-0.1065
	(0.0909)	(0.0837)	(0.0948)	(0.0814)

Cultural background variables				
national origin: born outside U.S.	0.1896**	-0.2288***	0.0157	-0.1025
	(0.0891)	(0.0817)	(0.0902)	(0.0854)
race: black	0.4748**	-0.3932*	0.0404	-0.3176
	(0.2000)	(0.2017)	(0.2280)	(0.2308)
ethnicity: hispanic	0.1077	0.1617	-0.0517	0.0685
	(0.1193)	(0.1169)	(0.1250)	(0.1228)
religion: attend church ≥ twice/mth	0.0804*	0.0918**	0.0873*	0.0529
	(0.0454)	(0.0452)	(0.0469)	(0.0468)
both are Protestant	0.2295***	(0.0740)	0.2060***	(0.0807)
both are Evangelical	0.3746**	(0.1535)	0.5177***	(0.1583)
both are Catholic	-0.1126**	(0.0499)	-0.1722***	(0.0501)
both are Jewish	0.1874	(0.1331)	-0.0454	(0.1353)
both report no religion	-0.2177	(0.1746)	-0.0974	(0.1634)
religion differs	0.0515	(0.0487)	-0.1220***	(0.0500)
Other variables				
risk averse	0.0279*	0.0014	-0.0099	-0.0010
	(0.0165)	(0.0170)	(0.0170)	(0.0175)
long time horizon	-0.0247	0.0305	-0.0157	0.0411
	(0.037)	(0.0378)	(0.0378)	(0.0390)
age-50	-0.0079**	-0.0081**	-0.0013	-0.0015
	(0.0040)	(0.0039)	(0.0042)	(0.0041)
has kids: over age 18 only	-0.1109	(0.1033)	-0.0010	(0.1035)
age 18 & under only	-0.2466	(0.1601)	-0.1616	(0.1615)
over and under age 18	-0.1878*	(0.1131)	0.0548	(0.1133)

Data: Health and Retirement Study, 1992.
Sample: N = 4237. Statistical significant at the 90% (*), 95% (**), and 99% (***) level is noted. See text for more details.

TABLE 3-B
Determinants of decision making power
Variations on specification of earnings variable

Dependent variable: ***Respondent*** reports *husband* has final say ($Y_i = 1$), it's about equal ($Y_i = 0$), *wife* has final say ($Y_i = -1$)

	(1) current earnings (from Table 3-A)	(2) average past earnings	(3) current, average past earnings
Log likelihood/N	-1.801	-1.790	-1.792
		Husband is respondent	
Threshold value μ_0	-1.2745 (0.1864)	-1.1133 (0.2230)	-1.1515 (0.2242)
Threshold value μ_1	0.4921 (0.1887)	0.6658 (0.2255)	0.6218 (0.2264)
Earnings variables			
current earnings/10,000			
husband	0.0072 (0.0053)	-	0.0053 (0.0065)
wife	-0.0356** (0.0149)	-	-0.0301* (0.0178)
average past earnings/10,000		*1951-1991*	*age 22-45*
husband	-	0.0114 (0.0244)	-0.0011 (0.0297)
wife	-	-0.1106*** (0.0440)	-0.0173 (0.0318)
		Wife is respondent	
Threshold value μ_0	-1.1504 (0.1929)	-1.1235 (0.2345)	-1.0600 (02443)
Threshold value μ_1	0.3966 (0.1924)	0.4428 (0.2345)	0.5245 (0.2458)
Earnings variables			
current earnings/10,000			
husband	0.0150*** (0.0054)	-	0.0098 (0.0064)
wife	-0.0753*** (0.0149)	-	-0.0678*** (0.0181)
average past earnings/10,000		*1951-1991*	*age 22-45*
husband	-	0.0200 (0.0247)	-0.0048 (0.0305)
wife	-	-0.2405*** (0.0442)	-0.0797*** (0.0312)

Data: Health and Retirement Study, Wave 1, 1992.
Sample: N = 3087 in columns (2), (3). All specifications include on the right-hand side all of the other variables shown in Table 3-A. See text for more details.

TABLE 3-C: Determinants of decision making power
Variations on specification of work variables

Dependent variable: ***Respondent*** reports *husband* has final say ($Y_i = 1$), it's about equal ($Y_i = 0$), *wife* has final say ($Y_i = -1$)

	(1) weekly work hours	(2) work (no occ dummies)	(3) only work variables	(4) log of earnings	(5) ratio of earnings
Log likelihood (LL/N)	-1.799	-1.810	-1.830	-1.803	-1.799
Selected work variables		***Husband*** is respondent			
husband's earnings/10,000	0.0064	0.0116**	0.0111	0.0094	0.0036
	(0.0054)	(0.0052)	(0.0051)	(0.0060)	(0.0058)
wife's earnings/10,000	-0.0256*	-0.0364***	-0.0342**	-0.0205***	-0.0133
	(0.0153)	(0.0145)	(0.0145)	(0.0063)	(0.0169)
wife's earnings / husband's+wife's earnings	-	-	-	-	-0.2402***
					(0.0923)
husband's+wife's earnings = 0	-	-	-	-	0.0358
					(0.0776)
husband works	-	0.1388***	-	-	-
		(0.0498)			
wife works	-	-0.0365	-	-	-
		(0.0461)			
husband's weekly hours	-0.0007	-	-	-	-
	(0.0014)				
wife's weekly hours	-0.0042***	-	-	-	-
	(0.0016)				
		Wife is respondent			
husband's earnings	0.0136	0.0204***	0.0129	0.0275	0.0117
	(0.0054)	(0.0053)	(0.0052)	(0.0369)	(0.0058)
wife's earnings	-0.0613*	-0.0762***	-0.0856**	-0.0340***	-0.0526***
	(0.0155)	(0.0146)	(0.0148)	(0.0377)	(0.0168)
wife's earnings / husband's+wife's earnings	-	-	-	-	-0.2412***
					(0.0945)
husband's+wife's earnings = 0	-	-	-	-	0.0450
					(0.0785)
husband works	-	-0.0455	-	-	-
		(0.0515)			
wife works	-	-0.0299	-	-	-
		(0.0476)			
husband's weekly hours	0.0001	-	-	-	-
	(0.0015)				
wife's weekly hours	-0.0065***	-	-	-	-
	(0.0018)				
Also includes:occ,self-empl	yes	no	yes	yes	yes
other control variables	yes	yes	no	yes	yes

Data: Health and Retirement Study, Wave 1, 1992. Sample: N = 4237. Except as noted, all specifications include on the right-hand side all of the other variables shown in Table 3-A. See text for more details.

TABLE 4
Decomposition of estimated determinants of decision making power
Estimation results from Table 3-A

Dependent variable: ***Respondent*** reports *husband* has final say ($Y_i = 1$), it's about equal ($Y_i = 0$), *wife* has final say ($Y_i = -1$)

	True effect		*Husband's* reporting bias	
Income variables	***Current earnings*** specification			
husband's earnings/10,000	0.0111***	(0.0044)	-0.0039	(0.0060)
wife's earnings/10,000	-0.0555***	(0.0126)	0.0198	(0.0160)
husband's pension income/10,000	0.0397	(0.0246)	-0.0038	(0.0345)
wife's pension income/10,000	-0.1142	(0.0866)	0.0070	(0.1201)
husband has pension in current job	0.0160	(0.0430)	-0.0037	(0.0565)
wife has pension in current job	-0.0115	(0.0447)	-0.0480	(0.0577)
	Characteristics of husband:		Characteristics of wife:	
Other work variables	True	Bias	True	Bias
occupation: professional, technical	0.1196**	0.0156	-0.0667	0.0026
sales, clerical	0.0532	0.0466	0.0039	-0.0267
services	-0.0465	0.0756	-0.0484	0.0243
skilled blue collar	-0.1158**	0.0176	0.0648	0.1096**
unskilled blue collar	-0.1302**	0.0217	-0.0096	0.0644
self-employed	0.2788***	0.0654	-0.0789	-0.0364
Human capital: cognition score #1	0.0076	-0.0044	-0.0051	0.0026
score #2	0.0087	0.0072	-0.0049	-0.0066
education: no high school diploma	-0.1497***	-0.0032	0.1057***	-0.0317
at least some college	0.0440	0.0366	-0.0676*	-0.0104
health is fair or poor	0.0157	-0.0071	-0.0015	-0.0182
both parents: no high sch diploma	0.0144	-0.0258	0.0207	-0.0087
at least some college	-0.1163	-0.0483	-0.1259*	-0.0195
Cultural: born outside U.S.	0.1027	0.0869	-0.1656***	-0.0631
race: black	0.2576	0.2172	-0.3554*	-0.0378
ethnicity: hispanic	0.0280	0.0797	0.1151	0.0466
religion: attend church ≥ twice/mth	0.0839**	-0.0034	0.0724*	0.0195
both are Protestant	0.2178***		0.0117	
both are Evang'l/Fundamentalist	0.4462**		-0.0716	
both are Catholic	-0.1424***		0.0298	
both are Jewish	0.0710		0.1164	
both report no religion	-0.1576		-0.0601	
religion differs	-0.0353		0.0868*	
Other variables: risk averse	0.0090	0.0189	0.0002	0.0012
long time horizon	-0.0202	-0.0045	0.0358	-0.0053
age-50	-0.0046	-0.0033	-0.0049	-0.0033
has kids: over age 18 only	-0.0560		-0.0549	
age 18 & under only	-0.2041		-0.0425	
over and under age 18	-0.0665		-0.1213	

Selected results	***Average past earnings*** specification 3-B(2)			
husband's earnings/10,000	0.0157	(0.0205)	-0.0043	(0.0270)
wife's earnings/10,000	-0.1756***	(0.0370)	0.0650	(0.0479)

Data: Health and Retirement Study, Wave 1, 1992.
Sample: N = 4237. See text for more details.

TABLE 5
Simulations of predicted decision making power

	Husband reports … has more say			Wife reports … has more say		
	husband	about equal	wife	husband	about equal	wife
	Based on specifications that control for current earnings, work status (as in Table 3-C 2)					
Actual values	0.302	0.580	0.118	0.319	0.527	0.154
Baseline predictions						
using own values of earnings, work status	0.311	0.576	0.113	0.325	0.525	0.150
using average values of earnings, work status	0.310	0.579	0.111	0.323	0.530	0.147
Predictions if …						
switch average earnings	0.282	0.590	0.128	0.266	0.545	0.189
switch earnings, work	0.275	0.593	0.132	0.263	0.546	0.191
husbands work, wives don't	0.350	0.558	0.092	0.372	0.509	0.117
wives work, husbands don't	0.253	0.600	0.147	0.270	0.545	0.185
	Based on specifications that control for lifetime earnings, work status (adapted from those in Table 3-B 2)					
Baseline predictions						
using own values of earnings, work status	0.298	0.582	0.120	0.318	0.530	0.153
using average values of earnings, work status	0.298	0.584	0.119	0.315	0.535	0.149
Predictions if …						
switch average earnings	0.243	0.602	0.155	0.197	0.551	0.253
switch earnings, work	0.236	0.604	0.160	0.193	0.550	0.258
husbands work, wives don't	0.330	0.568	0.101	0.375	0.510	0.115
wives work, husbands don't	0.250	0.602	0.148	0.273	0.547	0.180

Predicted probabilities, averaged over the estimation sample, based on the bivariate ordered probit estimates reported in Table 3.

TABLE 6
Consequences of decision making power
Impact on wealth

	Dependent variable: Log household wealth	
	Characteristics of husband:	Characteristics of wife:
A. Use continuous information on true decision-making power *y**		
	(1) Efficient estimation (correct standard errors)	
	Based on current earnings specification (3-A)	
husband's decision-making power	-0.0971 (0.2471)	
age	0.0284*** (0.0061)	0.0383*** (0.0064)
husband's power*age	0.0236 (0.0155)	-0.0234* (0.0134)
current household earnings	0.0622*** (0.0061)	
long time horizon	0.0973*** (0.0368)	0.1295*** (0.0379)
risk averse	0.0311* (0.0179)	0.0038 (0.0183)
	Based on average past earnings specification (3-B 2)	
husband's decision-making power	0.8217*** (0.2281)	
age	0.0185*** (0.0063)	0.0404*** (0.0069)
husband's power*age	0.0324** (0.0133)	-0.0345** (0.0136)
average household earnings	0.3162*** (0.0203)	
	Based on ratio of earnings specification (3-C 5) with control for current earnings	
husband's decision-making power	0.2927 (0.3111)	
age	0.0288*** (0.0061)	0.0400*** (0.0061)
husband's power*age	0.0097 (0.0158)	-0.0189 (0.0144)
log(current household earnings)	0.3296*** (0.0357)	
	with control for average past earnings	
husband's decision-making power	0.5442 (0.3504)	
Age	0.0256*** (0.0068)	0.0360*** (0.0070)
husband's power*age	0.0253 (0.0166)	-0.0319** (0.0165)
log(average household earnings)	0.3555*** (0.0493)	
	(2) Two-stage estimation (incorrect standard errors)	
Selected variables:	*Based on current earnings specification (3-A)*	
husband's decision-making power	0.1528 (0.2550)	
age	0.0320*** (0.0072)	0.0372*** (0.0078)
husband's power*age	0.0478** (0.0193)	-0.0415* (0.0161)
log(current household earnings)	0.0256*** (0.0090)	
long time horizon	0.1168*** (0.0399)	0.1313*** (0.0409)
risk averse	0.0279 (0.0194)	-0.0096 (0.0202)
	Based on average past earnings specification (3-B 2)	
husband's decision-making power	-0.0663 (0.2615)	
age	0.0206*** (0.0079)	0.0380*** (0.0090)
husband's power*age	0.0440** (0.0175)	-0.0359** (0.0165)
log(average household earnings)	0.3741*** (0.0514)	

	Based on ratio of earnings specification (3-C 5) with control for current earnings
husband's decision-making power	0.4064* (0.2342)
age	0.0338*** (0.0073)
husband's power*age	0.0430** (0.0181)
log(current household earnings)	0.0374*** (0.0078)
	-0.0390** (0.0159)
	0.0325*** (0.0093)
	with control for average past earnings
husband's decision-making power	0.2092 (0.2671)
age	0.0263*** (0.0083)
husband's power*age	0.0414** (0.0194)
log(average household earnings)	0.0344*** (0.0090)
	-0.0362* (0.0187)
	0.3698*** (0.0493)

B. Use discrete information on reported decision-making power y^h, y^w

	(1) Information reported by husband	
husband reports: he has final say	-0.0408	(0.1239)
"about equal"	-0.1118	(0.1129)
age-50	-0.0026 (0.0131)	0.0540*** (0.0142)
husband has final say *age	0.0407*** (0.0150)	-0.0300** (0.0151)
"about equal"*age	0.0318** (0.0135)	-0.0139 (0.0149)
	(2) Information reported by wife	
wife reports: he has final say	0.0047	(0.1113)
"about equal"	0.0436	(0.1032)
age-50	0.0032 (0.0126)	0.0512*** (0.0122)
husband has final say *age	0.0412*** (0.0137)	-0.0294** (0.0130)
"about equal"*age	0.0186 (0.0127)	-0.0102 (0.0122)

Data: Health and Retirement Study, 1992.
Sample: N = 4077 when current earnings are included or 2983 when average past earnings are included. Other control variables besides earnings are those reported in Table 3-A , along with subjective life expectancy. See text for more details.

TABLE 7
Consequences of decision making power
Impact on stock market investments

Dependent variable: Household investment in equities

	Probit Invests in equities (1, 0) [marginal effect in brackets]	*Tobit* Share of financial assets invested in equities
Mean value	0.32	0.17
A. Use continuous information on true decision-making power *y**		
	(1) Efficient estimation (correct standard errors)	
	Based on current earnings specification (3-A) Restrict effect of sum of current earnings	
husband's decision-making power	0.3689 (0.2567) [0.1232]	0.0774 (0.1390)
age-50: husband	0.0097 (0.0080) [0.0032]	0.0031 (0.0046)
wife	0.0262*** (0.0086) [0.0087]	0.0122*** (0.0050)
current household earnings	0.0490*** (0.0069) [0.0163]	0.0202*** (0.0031)
long time horizon: husband	0.1329*** (0.0464) [0.0444]	0.0651*** (0.0265)
wife	0.1397*** (0.0475) [0.0466]	0.0628*** (0.0271)
risk averse: husband	-0.0172 (0.0212) [-0.0058]	-0.0042 (0.0121)
wife	0.0166 (0.0220) [0.0056]	0.0059 (0.0126)
	Based on average past earnings specification (3-B 2) Restrict effect of sum of average earnings	
husband's decision-making power	1.1700**** (0.2926) [0.3981]	0.6626*** (0.1537)
average household earnings	0.2926*** (0.0271) [0.0996]	0.1619*** (0.0148)
	Based on ratio of earnings specification (3-C 5) with control for current earnings	
husband's decision-making power	0.5998* (0.3558) [0.2002]	0.3182 (0.2001)
log(current household earnings)	0.1656*** (0.0329) [0.0553]	0.0878*** (0.0187)
	with control for average past earnings	
husband's decision-making power	1.2523*** (0.4088) [0.4262]	0.6874*** (0.2198)
log(average household earnings)	0.3555*** (0.0493) [0.1174]	0.1966*** (0.0256)
	(2) Two-stage estimation (incorrect standard errors)	
Selected variables:	*Based on current earnings specification (3-A)*	
husband's decision-making power	0.5425** (0.2556) [0.1811]	0.3080** (0.1414)
age-50: husband	0.0035 (0.0081) [0.0012]	0.0009 (0.0047)
wife	0.0273*** (0.0086) [0.0091]	0.0137*** (0.0050)
log(current household earnings)	0.0171** (0.0087) [0.0057]	0.0113** (0.0050)
long time horizon: husband	0.1330*** (0.0461) [0.0447]	0.0651** (0.0267)
wife	0.1186*** (0.0473) [0.0399]	0.0479* (0.0272)
risk averse: husband	-0.0306 (0.0212) [-0.0102]	-0.0121 (0.0122)
wife	0.0065 (0.0219) [0.0022]	0.0019 (0.0127)
	Based on average past earnings specification (3-B 2)	
husband's decision-making power	0.3963 (0.2881) [0.1349]	0.2705* (0.1537)

log(average household earnings)	0.3615*** (0.0480) [0.1230]	0.2138*** (0.0270)
	Based on ratio of earnings specification (3-C 5) with control for current earnings	
husband's decision-making power	0.7521*** (0.2218) [0.2510]	0.4098*** (0.1248)
log(current household earnings)	0.0246*** (0.0090) [0.0082]	0.0154*** (0.0052)
	with control for average past earnings	
husband's decision-making power	0.7928*** (0.2532) [0.2698]	0.4100*** (0.1365)
log(average household earnings)	0.3443*** (0.0459) [0.1172]	0.2004*** (0.0257)

B. Use discrete information on reported decision-making power y^h, y^w

	(1) Information reported by husband	
husband reports: he has final say	0.1490* (0.0827) [0.0505]	0.1137** (0.0473)
"about equal"	-0.0400 (0.0765) [-0.0133]	0.0069 (0.0442)
	(2) Information reported by wife	
wife reports: he has final say	0.0791 (0.0727) [0.0266]	0.0473 (0.0424)
"about equal"	0.0150 (0.0675) [0.0050]	0.0017 (0.0397)

Data: Health and Retirement Study, 1992.
Sample: N = 4237 when current earnings are included or 3087 when average past earnings are included. Other control variables besides earnings are those reported in Table 3-A , along with subjective life expectancy. See text for more details.

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Efficiency in Marriage*

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Abstract. Economists usually assume that bargaining in marriage leads to efficient outcomes. The most convincing rationale for this assumption is the belief that efficient allocations are likely to emerge from repeated interactions in stationary environments, and that marriage provides such an environment. This paper argues that when a current decision affects future bargaining power, inefficient outcomes are plausible. If the spouses could make binding commitments—in effect, commitments to refrain from exploiting the future bargaining advantage—then the inefficiency would disappear. But spouses seldom can make binding commitments regarding allocation within marriage.

To investigate the efficiency of bargaining within marriage when choices affect future bargaining power, we consider the location decisions of two-earner couples. Initial location decisions are transparent and analytically tractable examples of choices likely to affect future bargaining power, but the logic of our analysis applies to many other decisions. For example, decisions about education, fertility, and labor force participation are also potential sources of inefficiency.

Keywords: marriage, migration, efficiency, household bargaining, limited committment

JEL Classification: D10, J12, J61

Do married couples allocate family resources efficiently? Recent work on bargaining and other non-unitary models of marriage has abandoned the assumption that spouses act as if they possess a single, well-defined set of preferences, and instead analyzes the interactions of spouses with separate preferences.[1] In this paper we argue that one of the casualties of this paradigm shift from unitary to non-unitary models is the presumption that families are efficient. That is, the pursuit of private gains by husbands and wives, combined with limits on their ability to contract over future behavior, can lead to decisions that fail to achieve Pareto optimality.

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Most economic models of family behavior assume an efficient allocation of resources, either by treating the married couple as a single agent or, as in cooperative game theory, by imposing efficiency as an axiom of the collective choice process. The use of cooperative game theory is plausible when players can make binding, costless enforceable agreements, but the mechanism by which such agreements are enforced within families is not obvious. The most convincing rationale for employing cooperative game theory is the belief that efficient allocations are likely to emerge from repeated interactions between sufficiently patient players in stationary environments, and that marriage often provides such an environment.[2] This belief, however, goes beyond the conclusion of the folk theorem that asserts that efficient solutions are subgame perfect Nash equilibria of repeated games, but does not assert that they are the only such equilibria or that efficient equilibria are more likely to be selected than inefficient equilibria. Finally—and this is our focus—the environment in which marital bargaining takes place is sometimes nonstationary.

Some decisions change the environment in which future bargaining takes place, advantaging one spouse relative to the other. To model such decisions, we must treat marriage not as a repeated game but as a nonstationary, multistage game. In the absence of a commitment mechanism, equilibria in such games need not be efficient. We focus on location decisions of two-earner couples because they are transparent and analytically tractable examples of choices likely to affect future bargaining power. The logic of our analysis, however, implies that other decisions that affect future bargaining strength—for example, decisions about education, fertility, labor force participation, and retirement—are also potential sources of inefficiency.

Using a simple two-stage model of a married couple's location decision, we show that marital decisions involving the future need not be efficient unless individuals can make binding agreements regarding their future actions, or unless they are able to make efficiency-inducing asset transfers. Since neither of these conditions is likely to hold in modern marriages, location decisions are potential sources of inefficiency.

1. Individual investments, intra-family allocation, and efficiency

In the ordinary course of married life, men and women make many choices that affect the opportunities they will face in the future. Earning a degree, rearing a child, accepting or rejecting a job offer, retiring from a career position—each of these decisions will affect the relative returns to home and market time in future periods, and thus the allocation of time by husbands and wives. In the traditional unitary model of the household in which family members pool their resources and maximize a single utility function, bargaining power is irrelevant and investment decisions during marriage have no strategic implications. Not surprisingly, in the unitary model, investment decisions are dynamically efficient. In bargaining models, however, an individual's share of family resources depends upon relative bargaining power and, therefore, on the individual's control of resources inside and outside the

marriage. For example, a mother's interruption of employment to stay home with a young child will reduce her potential earnings and the value of her "threat point," and may limit her claims to family resources in the future. Can such dynamic bargaining effects lead to inefficiency—in this case by discouraging efficient specialization and division of labor between parents? Or do families' incentive structures ensure dynamic efficiency?

We show that efficiency in dynamic marital bargaining requires binding agreements that may not be feasible in modern marriages. Although we do not rely on a particular bargaining model or sharing rule, we do assume that individuals' earnings affect allocation and distribution within marriage. As an example, we consider the problem of a two-earner couple choosing a city of residence. We assume that the location, once chosen, will advantage one spouse relative to the other in future bargaining, and that this is perfectly foreseen. In the first stage, the location is determined; in the second, resources are allocated within marriage. Recognizing that the allocation in the second stage depends upon the location determined in the first, each spouse prefers the location that offers him or her the better outcome in the second-stage game. Even if the second-stage allocation is characterized by conditional efficiency (i.e., is efficient conditional on the location choice), the solution to the two-stage game may not be efficient in an unconditional sense—that is, there may be technically feasible allocations at the other location that would make both spouses better off. This inefficiency might be avoided in one of two ways: the couple could enter into a binding agreement concerning the second-stage allocation, or the advantaged spouse could make an efficiency-inducing asset transfer. In fact, neither of these mechanisms is available to most married couples. Contracts regarding within-marriage distribution of resources are not legally binding or enforceable by the courts, and asset transfers are unlikely to be feasible for couples without substantial wealth.[3]

Other papers that explore the implications of limited commitment in dynamic bargaining models of the family include Ethan Ligon (2002) and Kaushik Basu (2001). Ligon explores the implications of adding an "individual rationality" axiom to the Nash bargaining problem. This requires that neither agent can be made strictly worse off by continuing the bargaining relationship than by discontinuing it. The new set of "constrained Pareto optimality" axioms is satisfied by a class of solutions in which agents efficiently divide any surplus from the relationship according to an invariant sharing rule unless using this rule would make one agent worse off than she would be on her own. The division of surplus will then change so as to make this agent just indifferent between remaining in the relationship and leaving. This formulation allows limited commitment of a very specific sort—efficient renegotiation of the sharing rule occurs only when one partner would be better off outside the relationship.[4]

Basu examines a set of models in which the household balance of power is endogenously determined and there is no intertemporal commitment. If the household maximizes a weighted average of husband's and wife's utility, and the outcomes in one period (e.g., wife's labor supply) affect the bargaining weights in the future,

then strategic considerations can lead to inefficient outcomes. Basu constructs some interesting illustrative models, showing how endogenous bargaining power can influence the evolution of women's labor supply and the prevalence of child labor.

2. The two-earner couple's location problem

To illustrate the inefficiencies that may arise in dynamic bargaining, we consider a simple two-stage model of marriage and migration.[5] At each location, the spouses receive utility payoffs that depend on a conditionally efficient sharing rule. Pierre-Andre Chiappori (1988) introduced "efficient sharing rules" to analyze single-stage allocation decisions; we assume efficient sharing in the second stage of our two-stage model.

We assume that the sharing rule depends on earnings and interpret this as a reflection of bargaining power, but we do not explicitly model the bargaining that takes place at the second stage (i.e., after the location has been determined). Nash bargaining in the second stage is a special case within this general framework.

The couple begins with jobs together in location 0. One spouse receives a job offer in location 1 with higher earnings than in location 0: we call him the leading spouse, or L. His partner also receives a job offer in location 1, but with lower earnings than at location 0—call her the trailing spouse, or T.[6]

In the first-stage game, husband and wife each decide on a location, choosing between two alternative moves, Stay (S) and Go (G). If both choose S or both choose G, then the couple remains married; if they make inconsistent choices, then the marriage ends in divorce. We assume that the first-stage game is non-cooperative, and consider both sequential move and simultaneous move versions. In the second stage, if the couple remains married, the sharing rule allocates resources efficiently, conditional on location. All consumption takes place in the second stage and we assume that all consumption is private, ignoring household public goods and all forms of interdependent preferences.[7] Each spouse derives utility from the marriage and, because of the assumed absence of household public goods and interdependent preferences, this utility bonus is the only source of gains to marriage.

The utility function of spouse i depends upon both marital status and location and is assumed to be linear in consumption for ease of exposition.[8] So $U^i_{Dj} = c^i_{Dj}$, where c^i_{Dj} is the consumption of individual i in location j when divorced and $U^i_{Mj} = c^i_{Mj} + M^i$, where c^i_{Mj} is the consumption of individual i in location j when married and M^i is the utility bonus individual i derives from the marriage.

Total household consumption is equal to total household earnings. The earnings of spouse i in location j are denoted Y^i_j, where $Y^L_1 = Y^L_0 + g^L$ and $Y^T_1 = Y^T_0 + g^T$, where g^i is the gain in earnings associated with moving to the new location. By assumption, $g^L > 0$ and $g^T < 0$, so that if both spouses move to the new location, the leading spouse's earnings increase and the trailing spouse's earnings decrease. Hence,

if the spouses remain married in location 0, their utility possibility frontier has a slope of -1 and is given by:

$$V^L + V^T = U^L_{M0} + U^T_{M0} = Y^L_0 + Y^T_0 + M^L + M^T = R_0 \tag{2}$$

Because the utility bonuses individuals derive from marriage cannot be transferred from one spouse to the other, the utility possibility frontier corresponds to the segment satisfying $V^L \geq M^L$ and $V^T \geq M^T$. Unless otherwise noted, we assume that all solutions lie on this segment.[9] If the spouses remain married in location 1, their utility possibility frontier is given by:

$$V^L + V^T = U^L_{M1} + U^T_{M1} = Y^L_1 + Y^T_1 + M^L + M^T = R_1. \tag{3}$$

If the individuals choose different locations, the result is divorce and the utilities are equal to individual earnings.

If $g^L + g^T \geq 0$, then the frontier corresponding to location 1 lies outside the frontier corresponding to location 0 and the efficient solution to the first-stage game is either divorce or moving to the new location: every point on the inner frontier is Pareto dominated by some point on the outer frontier. After location has been determined, the husband and wife share total resources (R_j), where the sharing rule depends upon his earnings and her earnings. Given linearity, this is equivalent to sharing total utility. The leading spouse receives a share $s_j = s(Y^L_j, Y^T_j)$ of total utility in city j, and the trailing spouse receives $(1 - s_j)$. Therefore, the utility of the leading spouse of marriage in location j will be:

$$U^L_{Mj} = c^L_{Mj} + M^L = s_j R_j = s_j(Y^L_j + Y^T_j + M^L + M^T),$$

while the utility of being single in location j is $U^L_{Dj} = c^L_{Dj} = Y^L_j$. We assume that each individual's share of total utility is increasing in own earnings, so that $s_1 > s_0$. (This assumption is consistent with both divorce-threat and separate spheres bargaining.) The normal (i.e., strategic) form of the game maps the strategies S and G into utility payoffs, giving the payoff matrix:

	Trailing spouse	
Leading spouse	Stay	Go
Stay	$(U^L_{M0}, U^T_{M0}) = (s_0 R_0, (1 - s_0)R_0)$	$(U^L_{D0}, U^T_{D1}) = (Y^L_0, Y^T_1)$
Go	$(U^L_{D1}, U^T_{D0}) = (Y^L_1, Y^T_0)$	$(U^L_{M1}, U^T_{M1}) = (s_1 R_1, (1 - s_1)R_1)$

The crucial feature of this example is that the couple cannot enter into a binding contract at the first stage to transfer earnings, alter the second-stage game, or alter the second-stage sharing rule. Thus, the location determines not only the couple's utility possibility frontier but also, because the sharing rule depends on earnings,

a particular point on the frontier. The trailing spouse will receive a greater share of total utility in the initial location, but total utility will be greater if they move to the new location. If the increase in total utility is sufficiently large that the trailing spouse would rather receive a smaller slice of a bigger pie, then there will be no conflict, and the strategy choices {G, G} will result in an outcome Pareto-superior to {S, S}. If, however, the trailing spouse would rather receive a larger slice of the smaller pie, then there are two ways in which the equilibrium location choice might be inefficient. First, if the leading and trailing spouses both decide to stay in the initial location, then the equilibrium will be on the inner frontier, Pareto-dominated by points on the frontier corresponding to the new location. Second, if the leading spouse decides to go and the trailing spouse decides to stay, then the result is divorce and the loss of the utility bonus that the spouses derive from the marriage, $M^L + M^T$. This divorce equilibrium may be Pareto-dominated by points on the frontier corresponding to the new location or, alternatively, the divorce equilibrium may be Pareto-efficient (i.e., the gains to each member of the couple at his or her best labor market location may exceed the lost marital bonus).

The first-stage location decision will depend upon each spouse's preference ordering of the four possible outcomes. The locational choices, S and G, uniquely determine the outcome, and we can translate preferences over outcomes to preferences over strategy pairs. For example, GS denotes the case in which the leading spouse chooses Go and the trailing spouse chooses Stay and leads to the utilities associated with divorce, while GG denotes the case in which both spouses choose the new location and leads to the utilities determined by the sharing rule at the new location.

With strict preference orderings among the four outcomes, there are $4! = 24$ possible preference orderings for each spouse and, hence, $24 \times 24 = 576$ possible preference profiles for each couple. Our assumptions about earnings gains and losses from moving and utility gains from marriage allow us to rule out most of these. The leading spouse prefers to remain married and relocate (and thus prefers GG to the three other first-stage outcomes) while the trailing spouse prefers to remain married and not relocate (and thus prefers SS to the three other first-stage outcomes). Conditional on divorce, the leading spouse prefers the new location (and thus prefers GS to SG), while the trailing spouse prefers the current location (and thus prefers SG to GS).[10] This implies that the leading spouse has preferences of the form (GG, GS, SS, SG) or (GG, SS, GS, SG), while the trailing spouse has preferences of the form (SS, GS, GG, SG) or (SS, GG, GS, SG). For each spouse, the only degree of freedom is the ranking of the second and third place alternatives: being divorced at the better location, and remaining married at the worse location. Hence, of the 576 possible preference profiles, we can restrict our attention to 4:

Case 1. {(GG, GS, ...), (SS, GG, ...)}.
Case 2. {(GG, SS, ...), (SS, GS, ...)}.
Case 3. {(GG, GS, ...), (SS, GS, ...)}.
Case 4. {(GG, SS, ...), (SS, GG, ...)}.

We consider three alternative specifications of the noncooperative first-stage game: two sequential games in which either the trailing or leading spouse moves first, and a simultaneous move game.

Case 1: Preference profile: {(GG, GS, ...), (SS, GG, ...)}. *Outcome: Unambiguous* {G, G}. If the leading spouse prefers moving to the new job without his partner to staying in the current location with her, (GG, GS, ...), while the trailing spouse prefers moving and accepting a reduction in earnings to staying behind and divorcing, (SS, GG, ...), then {G, G} is the equilibrium in all three games (i.e., the simultaneous move game, the sequential game in which the leading spouse is first mover, and the sequential game in which the trailing spouse is first mover). The utility possibility frontiers and the values of the possible outcomes are shown in Figure 1. The couple relocates to the new city, which is efficient in the sense that it corresponds to the outer utility possibility frontiers, but the move makes the leading spouse better off and the trailing spouse, whose bargaining position has deteriorated, worse off.

Case 2: Preference profile: {(GG, SS, ...), (SS, GS, ...)}. *Outcome: Unambiguous* {S, S}. If the leading spouse prefers staying at the current location with his spouse to moving without her, (GG, SS, ...), but the trailing spouse prefers divorce to relocating and remaining married, (SS, GS, ...), then {S, S} is the equilibrium in all

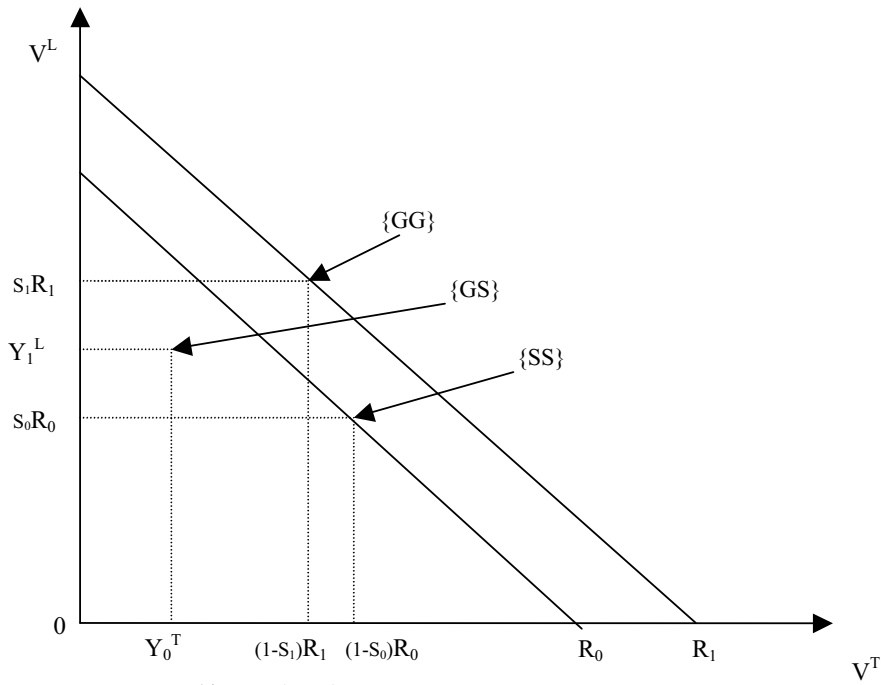

Figure 1. Case 1: Unambiguous {G, G}.

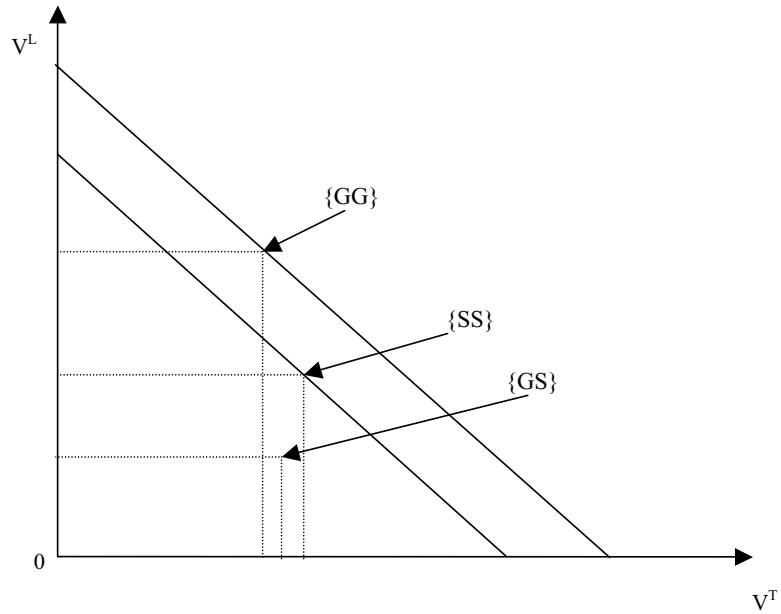

Figure 2. Case 2: Unambiguous {S, S}.

three games (see Figure 2). This equilibrium is inefficient; each equilibrium on the frontier corresponding to the current location is Pareto-dominated by some point on the relocation frontier. But unless the trailing spouse can be compensated for the loss she would suffer by relocating, either through a transfer conditional on relocating or a contract regarding second-stage allocations, the couple will be unable to attain an allocation in the new location that both would prefer to the *status quo*.[11] The Figure 2 illustrates this case.

Case 3: Preference profile: {(GG, GS, ...), (SS, GS, ...)}. *Outcome: Unambiguous* {G, S} (*i.e.*, *Divorce*). If the leading spouse prefers moving to the new job without his partner to staying in the current location with her, (GG, GS, ...), while the trailing spouse would rather divorce and stay than remain married and go, (SS, GS, ...), then the equilibrium in all three games is {G, S}. Divorce is the dominant strategy equilibrium in Case 3, and it may be efficient or inefficient, as shown in Figure 3. If the utility bonuses one or both spouses derive from the marriage are small and the earnings differences between locations (for one or both spouses) are large, then divorce is the efficient outcome. But divorce and the loss of the marital utility bonuses can also be the equilibrium when divorce yields utilities that are interior to the frontier corresponding to the new location. Under these circumstances, the couple's inability to contract regarding the second-stage outcome prevents them from attaining an outcome that both would prefer to divorce.

Some calculations clarify the boundary between efficient and inefficient divorce. If the couple remains married and relocates, the utility possibility frontier is defined

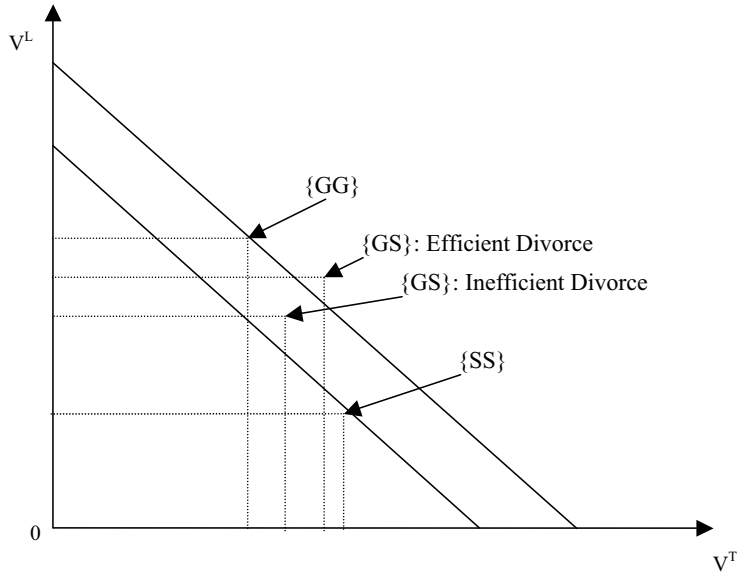

Figure 3. Case 3: Unambiguous {G, S}. Divorce.

by $R_1 = Y_1^T + Y_1^L + M^T + M^L = Y_0^T + g^T + Y_0^L + g^L + M^T + M^L$. If the couple divorces, then the frontier is given by $R_D = Y_0^T + Y_1^L = Y_0^T + Y_0^L + g^L$, because each chooses the location that maximizes his or her individual earnings. If $R_D > R_1$, or equivalently if $-g^T > M^T + M^L$, then the divorce point lies above the utility possibility frontier in the new location, and divorce is the efficient outcome.[12]

But the conditions for efficient divorce are not the conditions for divorce. The couple will divorce if (a) the second-stage division, if they relocate, fails to give the trailing spouse enough to remain in the marriage and (b) the second-stage division, if they remain in the current location, fails to give the leading spouse enough to remain in the marriage. In our notation, divorce occurs if, for the trailing spouse $Y_0^T > (1 - s_1)R_1$ and for the leading spouse $Y_1^L > s_0 R_0$. For example, if the second-stage division is determined by Nash bargaining, which divides the sum of the utility bonuses equally between the spouses, then divorce will be the outcome when $-g^T > \frac{1}{2}(M^T + M^L)$ and $g^L > \frac{1}{2}(M^T + M^L)$. If the earnings loss the trailing spouse would experience by relocating lies in the range $\frac{1}{2}(M^T + M^L) < -g^T < (M^T + M^L)$ and the earnings gain the leading spouse would experience by relocating is greater than $\frac{1}{2}$ the marital surplus, $g^L > \frac{1}{2}(M^T + M^L)$, then an inefficient divorce will be the dominant strategy equilibrium.[13]

Case 4: Preference profile: {(GG, SS, ...), (SS, GG, ...)}. *Outcome: The "Battle of the sexes" (indeterminate).* Figure 4 illustrates the case in which each spouse prefers remaining married at the less-favored location to divorce. With these preferences, the solution to the first stage game depends on the rules of the game and the solution concept employed. In a sequential game, the first mover now has an advantage: if the

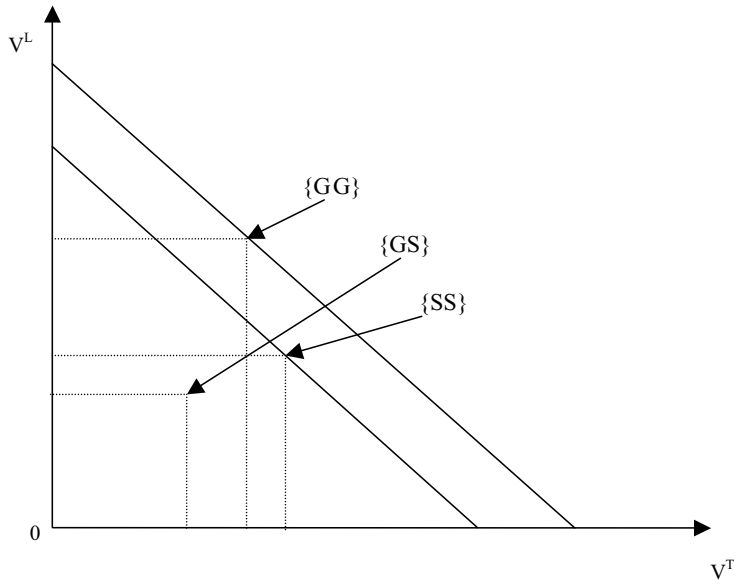

Figure 4. Case 4: Indeterminate: "Battle of the sexes."

leading spouse is first mover, the equilibrium is $\{G, G\}$, while if the trailing spouse is first mover, the equilibrium is $\{S, S\}$. The simultaneous move game is equivalent to the classic "battle of the sexes" game, in which both parties prefer remaining married regardless of location to being divorced, but prefer different marital locations.[14] This coordination game has two pure strategy equilibria, $\{G, G\}$ and $\{S, S\}$; under our assumptions, $\{G, G\}$ is efficient and $\{S, S\}$ is inefficient. Without resolving the equilibrium selection problem, we cannot say which pure strategy equilibrium will emerge and, hence, we cannot address the efficiency of equilibria in the simultaneous move game.[15]

What are the lessons of our simple two-stage location games? First, each game must be analyzed to see whether its equilibria are efficient and the equilibria may not be independent of the rules of the game. Second, potentially Pareto-improving moves will not necessarily take place: in multistage household bargaining without a commitment mechanism, there is no presumption of dynamic efficiency.

3. Inducing efficiency: commitments, transfers, and social norms

We can modify our two-stage game to ensure efficiency by reformulating it as a one-stage cooperative game or as a noncooperative game all of whose equilibria are efficient. Cooperative versions include the Nash bargaining games in which the threat point is either divorce or the equilibrium of our two-stage noncooperative

game. An example of a noncooperative reformulation would be the altruist model in which one spouse—the altruist—can at the outset confront the other spouse with a take-it-or-leave-it offer. The equilibrium of this single-stage game maximizes the altruist's utility subject to the constraint that the other spouse receives enough to remain in the marriage.

All three reformulations of the location game require the assumption that at least one spouse can make binding commitments. The required assumptions about commitments, however, differ in the cooperative and the noncooperative versions. In the cooperative reformulations, or at least in the informal stories that are usually told to motivate cooperative game theoretic models, the ability of the players to make binding agreements and forego the possibility of renegotiation is crucial. In the noncooperative model, one spouse—the altruist—has the ability to threaten the other spouse with divorce. Commitment is required because the altruist would not want to carry out the threat if called upon to do so—or, to restate the point in terms of our two-stage game, the altruist's threat to divorce is not credible. Noncooperative games based on other unilateral threats or promises, including threats of violence, are also of interest, but they also require that one spouse have the ability to make unilateral commitments.

Under what conditions can up-front asset transfers induce efficiency in two-earner couple location decisions? Becker (1991, Chapter 4) considers an analogous question in marriage markets. Becker notes that the efficient matching of men and women may not be achieved if rigidities in the socially acceptable distributions within marriage prevent prospective spouses from achieving a division of the marital surplus consistent with clearing the marriage market. Becker interprets dowry and bride price as lump-sum inducements to marry and argues that they are capable of providing the necessary adjustment mechanism when the appropriate *ex post* division cannot be guaranteed *ex ante*. Even if we accept Becker's interpretation and analysis of dowry and bride price, however, we see no analogous asset transfer mechanisms currently in use in developed countries.[16]

The threshold issue for upfront asset transfers is feasibility: do spouses have sufficient wealth to offset the losses that the disadvantaged spouse would experience by relocating or failing to relocate? Or, if the spouses lack sufficient wealth, can they borrow? The lack of wealth, together with borrowing constraints, rule out *ex ante* asset transfers for less affluent couples. Furthermore, even couples with sufficient wealth may find it difficult to make legally binding asset transfers (e.g., in community property states).[17]

For couples with sufficient assets who can overcome the legal obstacles, under what conditions will asset transfers ensure efficiency? First, the asset transfer must be conditional on location, just as dowry and bride price are conditional on marriage. For example, in Case 3, where the equilibrium outcome is divorce, the leading spouse might transfer assets to the trailing spouse in return for an agreement by the trailing spouse to relocate; but the trailing spouse must be able to commit to relocating in exchange for the transfer: she cannot take the money and refuse to relocate. Thus, we require not only the ability of the spouses to transfer assets but also the ability to

make binding agreements about location, if not the distribution of resources conditional on location.

Finally, the distinctions among agreements to transfers assets, agreements to transfer earnings, and agreements regarding the allocation of consumption in the second-stage game are tenuous. The proper generalization of our model to include assets as well as earnings requires reinterpreting the *Y*s in the sharing rule as the sum of the flow of income from assets and income from earnings. More precisely, if assets generate flows of income that continue forever and if earnings are flows that continue forever, then transferring claims to assets and transferring claims to earnings are essentially equivalent not only in their effects but also in the commitment assumptions required to implement them. Thus, the assumption that in the first-stage game the spouses can make binding agreements regarding asset transfers is very close to the assumption that they can make binding agreements regarding earnings transfers and very close to contradicting the assumption that they cannot make binding agreements regarding future consumption.

Norms and social institutions may mitigate some of the dynamic inefficiencies in family life, but norms and institutions are rather blunt instruments. Kenneth J. Arrow (1974) argues that professional norms or ethics mitigate the inefficiencies created by asymmetric information in the dealings of lawyers with clients and physicians with patients. Social norms may play a similar role in regulating behavior within marriage, although norms may be most effective in traditional societies both because informal sanctions used to enforce norms are likely to be most effective in such societies and because differences across couples are relatively small. In nontraditional societies, on the other hand, the potential gains and losses to migration and other dynamic investment decisions are too heterogeneous across couples to admit of across-the-board remedies that rely on rigid social norms or legal rules. For example, if child-rearing disadvantages most women in future marital bargaining, the negative effect on fertility incentives might be offset by changes in custody and support standards that increase maternal bargaining power in marriage. As the labor force participation behavior of mothers becomes more variable across married couples, however, the balance between the strategic losses and gains due to child-rearing will differ from one couple to another. Furthermore, long-run marriage market effects might offset the short-run effects of changes intended to affect bargaining power within marriage.[18]

4. Conclusion

Dynamic models of strategic interactions between and among family members allow us to investigate possible inefficiencies in the lifetime allocation of resources within families. In non-unitary models of allocation within marriage, the equilibrium allocation typically depends upon the spouses' alternatives outside marriage (e.g., the "divorce threat") or their alternatives within marriage (e.g., "separate spheres"). Because investments that increase one partner's market earnings relative to those of

his or her spouse will affect future bargaining power, strategic considerations will affect investment decisions.

Strategic marital inefficiencies are not limited to migration, but arise in a broad range of decisions that affect spouses' market earnings or other determinants of bargaining power. Three examples illustrate their generality.

1. Individuals may overinvest in education *ex ante* to improve their bargaining position in subsequent family interactions. Using a two-stage model, Kai A. Konrad and Kjell Erik Lommerud (2000) demonstrate that family members who bargain cooperatively in the second stage will overinvest in education in the first stage in an attempt to improve their bargaining positions. The resulting equilibrium is not a first-best optimum, and a simultaneous reduction in all education levels would be Pareto-improving.
2. If children have asymmetric effects on the bargaining power of their mothers and fathers, then fertility decisions will have complex strategic implications involving market earnings, the value of home production, and custody and support arrangements in case of divorce.
3. Labor supply decisions, including market participation, job changes, and retirement, affect individual bargaining power as well as family resources. The timing of retirement may affect an individual's share of family consumption and, hence, may be affected by the anticipated loss of bargaining power when market earnings fall.[19]

The location decision of a married couple provides a very simple example of our basic assertion—that in a dynamic model of decision-making by a multi-person household, efficient solutions can be guaranteed only if household members are able to make binding commitments concerning future allocations. We show that, in the absence of a commitment mechanism that prevents a spouse advantaged by a move from renegotiating the intrahousehold distribution of resources, two kinds of inefficient outcome are possible: the couple stays in a location that is Pareto-dominated by some feasible post-move allocations, and the couple divorces so that one spouse can stay while the other moves. This result focuses our attention on mechanisms that may facilitate intertemporal commitments by family members, including social norms and upfront transfers, but suggests that the presumption that family decisions are efficient should not survive the rejection of unitary family preferences.

Notes

1. For a survey, see Shelly Lundberg and Robert A. Pollak (1996).
2. A negative rationale is provided by the desire to avoid specifying a non-cooperative bargaining game in terms of its rules, moves, and information structure. Martin Shubik (1989, p. 103) expresses skepticism about the usefulness of noncooperative game theory for analyzing "complex, loosely structured social interaction," a category that surely includes marriage.

3. We show in Section 3 that asset transfers, even when they are feasible, induce efficiency only under stringent conditions.
4. This result is similar to the subgame–perfect equilibrium in Kenneth G. Binmore's (1985) extension of Ariel Rubinstein's (1982) bargaining model to agents with access to an outside option. The application of the Binmore–Rubinstein model to married couples with a (possibly) credible divorce threat is discussed in Theodore C. Bergstrom (1996).
5. Jacob Mincer (1978), the seminal paper on family migration, assumes a unitary model. Dora L. Costa and Matthew E. Kahn (2000) show that highly educated two-earner couples ("power couples") tend to be located in large cities and attribute this to their co-location problem.
6. For ease of exposition, we adopt the traditional version of this problem in which the husband is the leading spouse, but recognize that for many couples this gender classification will be reversed. Although the language we use to describe our model identifies one location as the *status quo*, this asymmetry plays no role in our analysis. Hence, we could use the model to analyze a fully symmetric situation in which, after receiving their JDs, MDs, or PhDs at location l^* both spouses receive offers at locations 0 and 1; the wife receives her better offer at location 0 and the husband receives his better offer at location 1.
7. This assumption implies that each spouse cares only about his or her own consumption and rules out what Gary S. Becker calls "altruism" and Robert A. Pollak (2003) calls "deferential preferences."
8. No important results depend upon this linearity.
9. Alternatively, we can view married couples as cooperating to produce output ("marital surplus") that they allocate between them, in the spirit of Gary S. Becker's (1991, Chapter 4) household production specification. Becker's transferable output specification and our nontransferable utility bonus specification coincide provided the equilibrium in our model lies on the segment satisfying $V^L \geq M^L$ and $V^T \geq M^T$.
10. If the spouses care whether they both live in the same city after divorce (e.g., to facilitate maintaining contact with their children), then we must distinguish among four divorce outcomes, each specifying the location of both spouses. We ignore this possibility.
11. The frontier corresponding to the new location lies outside the frontier corresponding to the initial location only because we have assumed it does. The efficiency results are reversed in the mirror image case in which relocation is assumed to be inefficient, but in which relocation is the equilibrium outcome.
12. $R_D > R_1$ implies $R_D > R_1$ because of our assumption that $g^L > g^T$.
13. It is interesting to compare this result with the inefficient divorces that occur in the H. Elizabeth Peters (1986) model when asymmetric information about opportunities outside the marriage prevents *ex post* bargaining over the marital surplus.
14. The canonical battle of the sexes story relies heavily on gender stereotypes. Both the husband and wife want to spend the evening together, but the husband wants to go to a sporting event (e.g., a prize fight) and the wife to a cultural event (e.g., a ballet). The story is used to motivate a noncooperative nonzero sum game in which the Pareto optimal outcomes correspond to successful coordination (i.e., both go to the prize fight or both go to the ballet) and are Nash equilibria.
15. Focal points may be crucial in equilibrium selection and the *status quo* provides a "natural" focal point. In the symmetric case in which the spouses must leave their current location (e.g., the Garden of Eden) and move to one of two new locations, neither alternative corresponds to the *status quo*.
16. Junsen Zhang and William Chan (1999) argue that dowry and bride price differ fundamentally because dowry goes to the new couple, while bride price goes to their parents' generation.
17. In a dynamic model of a married couple's consumption and investment choices, Saku Aura (2002) shows that a community property regime is unlikely to result in efficiency, while a stylized common-law regime leads to a fully efficient outcome.
18. Lundberg and Pollak (1993) show how the short-run effect of a change in government policy might be offset in the long run by the marriage market.
19. Shelly Lundberg, Richard Startz, and Steven Stillman (2003) present evidence that the husband's relative power in the marriage does fall with retirement.

References

Arrow, Kenneth J. (1974). *The Limits of Organization*. New York: W. W. Norton.

Aura, Saku. (2002, October). "Uncommitted Couples: Some Efficiency and Policy Implications of Marital Bargaining." CESifo Working Paper No. 801.

Basu, Kaushik. (2001). "Gender and Say: A Model of Household Behavior with Endogenously-determined Balance of Power." Working Paper, Cornell University.

Becker, Gary S. (1991/1981). *Treatise on the Family*, Enlarged edition. Cambridge: Harvard University Press.

Bergstrom, Theodore C. (1996, December). "Economics in a Family Way." *Journal of Economics Literature* 34(4), 1903–1934.

Binmore, Kenneth G. (1985). "Bargaining and Coalitions." In Alvin Roth (ed.), *Game-Theoretic Models of Bargaining*. Cambridge: Cambridge University Press, pp. 259–304.

Chiappori, Pierre-Andre. (1988, January). "Rational Household Labor Supply." *Econometrica* 56(1), 63–89.

Costa, Dora L. and Matthew E. Kahn. (2000, November). "Power Couples: Changes in the Locational Choice of the College Educated, 1940–1990." *Quarterly Journal of Economics* 115(4), 1287–1315.

Konrad, Kai A. and Kjell Erik Lommerud. (2000, May). "The Bargaining Family Revisited." *Canadian Journal of Economics* 33(2), 471–487.

Ligon, Ethan. (2002). "Dynamic Bargaining in Households (With an Application to Bangladesh)." Working Paper, University of California, Berkeley.

Lundberg, Shelly and Robert A. Pollak. (1993, December). "Separate Spheres Bargaining and the Marriage Market." *Journal of Political Economy* 101(6), 988–1010.

Lundberg, Shelly and Robert A. Pollak. (1996, Fall). "Bargaining and Distribution in Marriage." *Journal of Economic Perspectives* 10(4), 139–158.

Lundberg, Shelly, Richard Startz, and Steven Stillman. (2003, May). "The Retirement-Consumption Puzzle: A Marital Bargaining Approach." *Journal of Public Economics* 87(5–6), 1199–1218.

Mincer, Jacob. (1978, October). "Family Migration Decisions." *Journal of Political Economy* 86(5), 749–773.

Peters, H. Elizabeth. (1986, June) "Marriage and Divorce: Informational Constraints and Private Contracting." *American Economic Review* 76(3), 437–454.

Pollak, Robert A. (2003, January–April). "Gary Becker's Contribution to Family and Household Economics." *Review of Economics of the Household* 1(1–2), 111–141.

Rubinstein, Ariel. (1982, January). "Perfect Equilibrium in a Bargaining Model." *Econometrica* 50(1), 97–109.

Shubik, Martin. (1989). "Cooperative Games." In John Eatwell, Murray Milgate, and Peter Newman (eds.), *The New Palgrave, Game Theory*. New York: W.W. Norton, pp. 103–107.

Zhang, Junsen and William Chan. (1999, August). "Dowry and Wife's Welfare: A Theoretical and Empirical Analysis." *Journal of Political Economy* 107(4), 786–808.

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http://www.aeaweb.org/articles.php?doi=10.1257/aer.99.4.1245

Spousal Control and Intra-Household Decision Making: An Experimental Study in the Philippines

By Nava Ashraf*

I elicit causal effects of spousal observability and communication on financial choices of married individuals in the Philippines. When choices are private, men put money into their personal accounts. When choices are observable, men commit money to consumption for their own benefit. When required to communicate, men put money into their wives' account. These strong treatment effects on men, but not women, appear related more to control than to gender: men whose wives control household savings respond more strongly to the treatment and women whose husbands control savings exhibit the same response. Changes in information and communication interact with underlying control to produce mutable gender-specific outcomes. (*JEL* D13, D14, J12, J16, O15)

Household outcomes depend on decisions made by spouses who may often disagree. Given these potential differences in preferences, the particular conditions under which intra-household decisions are taken may matter a great deal for household outcomes. A large and growing literature in economics provides evidence from several countries that household savings and investment are significantly affected by how decision-making power is allocated between women and men. In particular, when intra-household financial decisions are made by women, savings and investment are often greater and repayment of debt is more likely.[1]

Theoretical and empirical work in economics has generally overlooked the range of factors that influence intra-household decisions. Most models of household decisions have either treated the household as an individual decision maker—ignoring intra-household decisions completely—or modeled household decisions as a bargaining process between agents who are able to make

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[1] For example, income given to women is more likely to be used for investments in education, children's nutrition, and housing than income in the hands of men (Duncan Thomas 1990, 1994; John Hoddinott and Lawrence Haddad 1995; Esther Duflo 2003). Beatriz Armendariz de Aghion and Jonathan Murdoch (2004) review findings that microfinance loans made to women are significantly more likely to be repaid. Martin Browning (2000) provides an interesting model for how difference in savings outcomes can arise within one household.

binding commitments, have full information, and are able to communicate.[2] These models, all of which predict that outcomes will be Pareto optimal, are contradicted by empirical evidence against Pareto optimality (Christopher R. Udry 1996)[3] and complete information (Jan M. Pahl 1983; Markus P. Goldstein and Udry 1999; Michael A. Boozer and Goldstein 2003). More realistic assumptions, such as the possibility of private information and limited communication between spouses, may be needed. Indeed, more recent theoretical work has modeled households in which commitment between members is not assumed and is often limited; efficiency is not always attained (Ethan Ligon 2002; Maurizio Mazzocco 2004, 2007).

Empirical work on intra-household bargaining has increasingly used exogenous shocks to one spouse's income to identify its effect on household outcomes and to infer individual preferences.[4] However, who receives the income is only one factor that may affect the household outcome. There is a substantial sociological literature on the processes of intra-household decision making which emphasizes the importance of financial management structures in the family and the role that information and communication can play in making decisions within a marriage (see, for example, Daisy H. Dwyer and Judith Bruce 1988; Viviana A. Zelizer 2005). Nonetheless, factors like privacy of information have not been widely incorporated into household models of decision making;[5] even within these models, it is not clear how information asymmetries affect outcomes, beyond a standard prediction of decreasing efficiency. Understanding how spouses adjust strategically when information about their income and subsequent financial decisions is private, or when elements of the bargaining process (such as communication) change, is important to understanding household decision outcomes— but requires exogenous variation to identify.

In order to identify how information and communication affect intra-household decisions, I use an experimental approach. I observe intra-household financial decisions in a randomized field study. These experiments were explicitly designed not to treat households as a unit, but to allow for as much individual decision making as possible while varying the degree of privacy of information and ability to bargain.

Experiments have recently emerged as a method for getting inside the household.[6] These experimental papers have focused on testing predictions of existing (usually unitary) models of the household, similar to the empirical work in economics cited above. I use experiments, rather, as a method to tell us what existing economic models might be missing, by exogenously varying factors in household decision making—private information and communication—that are difficult to measure or vary empirically. Using experiments to understand decision making within the household can be challenging: subjects have an ongoing relationship with each other, so behavior within the experiments can often be undone when spouses leave the experiment. I thus design outcomes that are difficult to undo, like time-limited, person-specific gift certificates. In addition, and similar to challenges facing experiments in other applications, one worries about subjects behaving differently under the "artificial" conditions of the laboratory. To overcome this, I ran the experiments in a familiar setting to all subjects (a local bank with which they

[2] See, for example, Marilyn E. Manser and Murray Brown (1980), Marjorie B. McElroy and Mary Jean Horney (1981) and Shelly Lundberg and Robert A. Pollak (1994). Pierre-Andre Chiappori (1992) and Browning and Chiappori (1998) do not make assumptions about the specific bargaining process or structure, but assume that the bargaining outcome will be efficient.

[3] Richard Akresh (2005) finds evidence in support of Pareto efficiency for other parts of Cote d'Ivoire using an alternative nationally representative dataset. He cites other work that has found some evidence of inefficiency using survey data from Cameroon (Christine Jones 1986), Cote d'Ivoire (Duflo and Udry 2004), and Mexico (Habiba Djebbari 2005).

[4] See, as examples in a growing literature, Duflo (2003), Duflo and Udry (2004), and Marcos A. Rangel (2006).

[5] Exceptions include Ligon (1998) and Pierre Dubois and Ligon (2004).

[6] See, for example, Elizabeth A. Peters et al. (2004); Ian Bateman and Alistair Munro (2004); and Vegard Iversen et al. (2006).

had contact) and designed treatment conditions that mimic real world conditions under which couples made decisions. These conditions were decided upon through focus groups on couple decision making, where private information and communicating with one's spouse before decision making emerged as key variable situations; in debriefing, subjects talked about how much the treatment condition to which they were assigned reminded them of situations in which they had to make decisions.

In the experiments reported in this paper, subjects were given a sum of money, approximately a day's wage, and asked either to deposit the money directly or take consumption in the form of committed consumption or cash. The experiments were carried out with a sample of existing or previous clients—and their spouses—of a rural bank in the Philippines. Each subject was randomly assigned, along with his or her spouse, to one of three settings that had different limitations placed on the privacy of information and the possibility of spousal communication.

In the first condition, private information without pre-play communication (denoted "Private"), subjects are separated from their spouses at the onset of the experiment. They do not know what the spouse is doing, whether the spouse has received any income, what decisions the spouse is making, or what outcomes he/she receives; as much information as is possible is kept private from the spouse. In the second condition, public information without pre-play communication ("Public"), subjects and their spouses enter the room together. They learn about their own and each other's payoffs and choice sets, and make simultaneous decisions; however, they cannot communicate or see the decisions the other is making until after their decisions have been made. In the third condition, public information with pre-play communication ("Negotiation"), subjects and their spouses follow the same procedure as Public, but they communicate before making their decisions, and their decisions are immediately observable to each other.[7] Due to random assignment, the distribution of individual and household characteristics is approximately the same across all treatment conditions. Any significant difference in outcomes, therefore, can be attributed to the difference in treatment condition.

I find that men are more likely to deposit the money into their own account in Private and commit it to consumption in Public, and that this effect is mainly driven by men whose wives make the savings decisions in the household. Although initially it does not appear that women exhibit such behavior, women whose husbands control the savings decisions in the household behave as the men whose wives control the savings decisions. Finally, men are more likely to turn their money over to their spouse's account in the Negotiation condition, an effect that is greater for men who do not control the savings decisions in their household. Women whose husbands control the savings decisions in their household are also more likely to turn money over to their spouse's account.

Underlying the effect of information and communication appears to be the mechanism of monitoring; in my sample, women monitor the behavior of their husbands. This is consistent with the cultural setting of these experiments; in the Philippines, most men are expected to turn their earnings over to their wives for budgeting and allocation, but women often complain that their husbands do not turn over all their income. The pattern of women as financial managers who

[7] This combination of private-public information, and communication, suggests a fourth treatment: private information with pre-play communication. This treatment condition did not form part of the experiment because it was ultimately difficult to ensure privacy of information when there is also pre-play communication. The pre-play communication in the third treatment condition takes the form of expressing one's preferences for allocating the income shock to one's spouse: doing this before the Private condition (in order to maintain the same structure of communication) would mean that spouses would have to know about the income shocks and about the choices available—which would leave very little to remain private in the first condition. In future experiments, private with pre-play communication would be an interesting condition to implement, to determine if making the decisions in separate rooms—even having expressed one's preferences before—could in itself have a significant effect.

monitor their husband's use of income is found in many developing countries and in low-income US and UK households.[8] Such a financial management system can be seen as a contract, agreed to at the time of marriage, which the wife is expected to enforce.

I propose a framework of income monitoring within the household, where observability of income and communication at the time of decision making make a significant difference in the monitor's ability to enforce a contract. This implies that limited commitment and imperfect contractibility are more realistic assumptions in household decision-making models. My results suggest that husbands and wives respond strategically to changes in information and communication, but what initially looks like differences in response by gender appears to be driven by underlying household control structures that create incentives to change behavior in face of changes in monitoring; the implications of this for program design are discussed in the conclusion.

The remainder of the paper is organized as follows. Section I describes the conceptual framework that guides the experimental design. Section II describes the experimental design: the setting, outcomes, and conditions. Section III describes the empirical analysis and results, followed by a discussion of implications. Section IV concludes.

I. Conceptual Framework: Designing the Experiment

The experiments were designed in accordance with a model of the household in which husbands and wives develop a contract about financial management of the household at the beginning of marriage. Such a contract can take many forms; in this paper, I study a prevalent form of informal marital contracting in the Philippines, whereby women are the financial managers of the household who do the majority of the budgeting and, to varying degrees, control the spending and allocation decisions (A. Timothy Church 1986; Jeanne F. Illo 1989; Belen T. G. Medina 1991; Mina M. Ramirez 1984). "Cultural norms dictate that the husband turn over his earnings to his wife to receive in return a daily allowance for his daily expenses such as transportation, cigarettes and the like … the decisions to save, how much to save, and when to repay loans are more of the wife's independent decision" (Illo 1989, 45).[9] How such a contract arose is outside of the scope of this paper; survey self-reports across many countries in Asia suggest that men have traditionally viewed women as being better budgeters and having greater self-control (Villia Jefremovas 2000; Suzanne A. Brenner 1995). In my surveys, the majority of men, when asked why it is that their wife holds the income in the family, responded that they would spend it if they held the money.[10] The husband can thus benefit by deferring the responsibility of controlling

[8] In 70 percent of British low-income families, and in only 25 percent of higher-income families, Pahl (1990) found that wives manage the finances in the family; husbands are expected to turn over their income to their wives to manage. In 70.5 percent of Indonesian couples, the wife decided all money matters (Hanna Papanek and Laurel Schwede 1988). In supplementary surveys of my subjects in the Philippines, I find that 80 percent of households have the wife hold the income and do the budgeting; in 49 percent of households the wife also makes the major decisions about saving or spending money. This is not necessarily a source of rents in the household: budgeting and deciding about saving can be an onerous task when money is short.

[9] The following quote, from a homemaker in Mauswagon, Philippines, illustrates the degree to which financial management and turning over income can be part of a marriage contract, particularly in cultural settings like the Philippines: "I give him his daily allowance. His cigarette and liquor consumption is part of our budget because he buys them on credit at the store. I am the one in-charge of paying our debts every payday. I believe that husbands should turn over their earnings to their wives. At the marriage ceremony the coins are turned over by the groom to the bride. What is the significance of the marriage rights if husbands won't turn over their earnings to their wives?" (Chona Echavez 1996).

[10] Representative responses from the husbands include: "It's not safe if I hold the money, I might spend it for my vices"; "I'm very impulsive when it comes to spending my money. That's why I give all my income to my wife"; "I believe that it is a regulation in the family that the wife will hold the money." In very rare cases, the husband had to take over handling the money, despite cultural norms, because his wife "just wasn't good with money." This is consistent

the spending and lending of money earned.[11] In a model of intra-household specialization, Gary S. Becker (1981) shows that even small initial differences in comparative advantage or cost can result in large effects when such differences lead spouses to take on different roles in the household, due to increasing returns from investment in activity-specific human capital.

This deferral of responsibility, or intra-household specialization in financial management, can allow the financial manager of the household to make everyday allocational decisions closer to her preferences than his. Thus, at any given moment, the husband may be tempted to cheat. In particular, he may withhold money and not turn all of it over. "While women devote all their wages to the household budget, men withhold some of theirs at the outset to spend on so-called vices" (Illo and Rona C. Lee 1991). This behavior is so widespread that there is a word in the Tagalog language that is applied to men not handing over all of their income to their wives: *kupit*. *Kupit* literally means to pilfer, to filch, to steal in small quantities.[12] Colloquially, it is applied to husbands and wives in the following way: "It is like an unwritten agreement that the husband will turn over his earnings to the wife, but he will make *kupit* by declaring "ghost" expenses/deductions. In some cases, this will be in the form of not declaring unexpected income like bonus, incentive or loyalty pay, or only declaring a portion of what he receives."[13]

In particular, when the husband receives extra money at work, he faces a decision of whether to turn it all over to his wife as the cultural norm/contract dictates, and have the amount he has earned be taxed/used on an allocation that is closer to her preferences ("Turn Over"), or whether to "shield" it from her in some way by hiding it ("Hide") or committing it to consumption ("Commit"). Committing it to consumption is akin to spending it immediately on something enjoyable (like at the bar on the way home) to avoid it being taxed when it is turned over. In a situation where she cannot observe his actions, there is some probability that she will find out if he hides it. There is a possibly greater probability (still less than one) that she will find out if he commits it to consumption because it may be harder to hide a commodity bought or used (such as a new outfit or alcohol-infused breath) than it is to hide money.

If she finds out, she immediately expropriates what she can, in keeping with her role as the financial manager: if the money was hidden, she takes it all as if he had turned it over. If the money has already been committed/spent, she tries to undo it in subsequent budget allocations. In both cases, in addition to trying to take back the money that was spent, she enacts a (likely nonmonetary) punishment to show him her displeasure.[14] This displeasure is greater if she feels that he willfully and explicitly defied her, rather than possibly made a mistake in interpreting her preferences.

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with a more formal analysis of my data, where "husband controls savings" is significantly predicted by a self-report that "spouse is more impulsive than I am."

[11] Illo (1989) writes of an additional benefit of deferring this responsibility: "Because the wife generally keeps the cash, the man can and does avoid lending cash by referring the matter to the woman. More than the husband, the woman can convincingly explain to the would-be debtor why she cannot lend them money, especially if the family's financial position is so tight that moneylending can force the family to do without basic things."

[12] Tagalog-English Dictionary (1986).

[13] Chona Echavez, personal correspondence. In addition, Erlinda Burton (Research Institute for Mindanao Culture (RIMCU) at Xavier University) writes: "The definition of '*kupit*' refers to a practice of stealthily or secretly taking a very small amount from an amount of cash for whatever purpose it is to be used. For example, a husband would make '*kupit*' of a small amount from his salary before giving it to his wife or an employee who would take a little amount from the office's coffers."

[14] As one respondent said when asked what happened when she and her husband got into a conflict over money, "I was so angry with him that I didn't do his laundry for three weeks!" I assume that the wife is somewhat limited in the degree to which she can punish, both by cultural norms and because many types of nonmonetary punishment (like forcing the husband to sleep on the couch) can be costly to the punisher; she chooses the maximal level of punishment she can, given the implied guilt of the husband. I argue that explicit defiance increases the maximal allowable punishment level.

Thus, the payoff if he Turns Over is simply the allowance he gets, along with the ordinary household expenditure allocation, and no punishment. The payoff from hiding is the full sum of money he receives if she does not find out; if she does find out, he receives his ordinary allowance and some punishment (which is greater if she feels that he explicitly defied her by putting the money away somewhere else).[15] The payoff from committing to consumption if she does not find out is less than that from hiding (since the money had to be committed immediately and is less fungible) but greater than if he had just received his allowance and the standard expenditure allocation; if she does find out, he receives some punishment, as above, and she tries to expropriate the already spent funds as much as she can—that is, she reallocates subsequent budgets to decrease his allowance, for example, but she can't reallocate the budget fully, particularly if the amount he spent is more than several months of his entertainment/luxury allowance. It is thus more difficult to undo consumption that has already been committed.[16]

Even in a case where all information is public and she will inevitably find out what decisions her husband made, the intention behind the decision can matter greatly for the degree of punishment a husband might receive. In particular, I argue that she is more likely to punish him if she knows for sure that he explicitly defied her: i.e., she had an opportunity to tell him clearly what her preferences are in the moment he made the decision. Of course, communication in the context of bargaining could have many effects.[17] The anthropology literature focuses on the role of communication in providing an opportunity for the woman to show her displeasure for his choices as a way to try to influence his actions.[18] This clear stating (or restating) of preferences can change expected punishment; in particular, communication prior to decision making can invoke greater punishment if the spouse goes against a clearly stated preference, since now he will have acted in explicit defiance (rather than tacit defiance when a preference has not been explicitly stated in the moment). In a condition of full information, but one without communication at the moment of decision making and thus without full certainty about the spouse's preferences or willingness to punish, the husband could plausibly deny guilt about knowingly breaking the contract.[19]

Changing opportunities for privacy of information and communication before decision making can clearly serve to change monitoring possibilities for the original marital financial contract, and thus change the payoffs for each choice. In a case where there is private information, with a limited probability of detection, the payoff to hiding a shock to income would be greatest; in the case of full information—where hiding and spending will be fully detected afterward—committing to consumption could yield an outcome closer to one's preferences than either hiding or turning over (since hidden money will be discovered and turned over to be taxed by the manager); this depends on the tax rate and the maximal punishment for tacit defiance. However, when communication occurs right before decision making, both hiding and committing to consumption may invoke stronger punishments due to being in explicit defiance of the spouse's wishes. Thus, turning money over may be more likely in this case.

[15] For a situation in which this is not the case, imagine the man pleading that he was actually putting the money away to buy her a present.

[16] This could be the case because the money she has allocated for his allowance is much smaller than the money he has just spent on one good: it may be very difficult to take that (small) allowance away regularly for a long period of time. In addition, if budget cuts have to be made over many months, subsequent cuts could be heavily discounted over present consumption, depending on discount rates and functions. For individuals with great impatience or with present-biased time inconsistency, the value of present consumption over future budget cuts would be even more extreme.

[17] See Kathleen L. McGinn and Rachel Croson (2004) for an excellent overview of the role of communication and communication media in enhancing "social awareness" in bargaining situations.

[18] "When the woman feels that the husband's decision is not a fair or good one, she can continue to show her displeasure either by nagging him about the matter or by shutting him out" (Illo 1977).

[19] In addition, the punisher may have an aversion to punishing when guilt is not certain.

In the next section I will describe how I designed the experimental treatments and outcomes to mimic these real-world settings.

II. Experimental Design

A. *Experimental Setting*

The experiments were run with 146 married couples in the conference rooms of Green Bank, a rural private bank in Mindanao, the Philippines. The subject pool was drawn from former and existing clients of Green Bank and their spouses. Recruiters went door to door and invited subjects and their spouses to a study for which they would each receive a 40-peso fee to show up and the opportunity to earn more money.[20] Some members of the subject pool who were approached to take part in the experiment came from a group of individuals who had been involved in a large-scale randomized field experiment (Ashraf, Dean Karlan, and Wesley Yin 2006) and who were in communities near the bank's location; this provides me with baseline data to study selection on take-up of the invitation to the experiment. Using these data, I find that subjects from this pool who accepted the invitation to participate were not significantly different in most characteristics from those who did not (Appendix Table A1). In addition, men and women did not appear to select into the experiment based on decision-making power in the household.[21]

Once the couples were recruited, they arrived at the laboratory at a prearranged time for the experimental sessions, which were randomly assigned across days and times.[22] After the experiment was completed, individual-level surveys were conducted either directly after the experiment was finished in the lab or in the subsequent two to three days in the homes of the subjects. These surveys were conducted with each spouse separately and privately. The questions included levels of education, occupation, income variability, immediate money needs, how income is received, and how much, if any, is given to the spouse. Additional questions were asked about decision making and conflict in the household, including perceptions of patience, impulsiveness, and responsibility of one's spouse and problems with liquor and gambling.[23]

Table 1 provides summary statistics of the sample from both of the individual-level surveys. This was a broad sample of married couples, with substantial heterogeneity: subjects range from newlyweds to couples married for more than 50 years, from relatively poor for this region to relatively well off, from having completed only one year of education to those having graduated from college. Not all subjects were bank clients: only 38 percent of the men and 51 percent of the women have accounts at Green Bank.[24] In the majority of cases, both husband and wife work (approximately 70 percent); in 60 percent of all couples the husband brings in more income than the wife. Consistent with the sociology literature cited in Section I, the wife is the one who holds the income in the family and does the budgeting in more than 80 percent of these cases. Half of all couples respond "wife" or "jointly" (with wife's decision being a tie-breaker) when asked who

[20] Fifty pesos equals approximately $1US. Recruiters did not specify the amount of additional money that could be earned.

[21] In the final sample, 118 households come from this subgroup of 201 individuals approached to bring their spouse (Appendix Table A1 describes determinants of take-up); 28 remaining couples were drawn from invitations to 50 prior and current Green Bank clients in the surrounding area.

[22] Recruiters did not know what this schedule was.

[23] Surveys were conducted after the experiment so the survey questions would not prime subjects. There is no evidence that the reverse happened: survey responses to questions about conflict in the household or decision making did not differ significantly by treatment condition.

[24] Although I also asked subjects about their bank account status at Green Bank, I used objective data from Green Bank archives on the subject's bank account status, as this variable could be misreported by treatment condition if a subject wanted to hide bank account status from his or her spouse.

Table 1—Summary Statistics

	Experimental data 2004		CLHNS 1998		ISSP 2002	
	Males	Females	Males	Females	Males	Females
Variable	($N = 291$)		($N = 1{,}746$)		($N = 416$)	($N = 456$)
Age	44.62	42.15	44.08	41.72	44.33	38.37
	(11.52)	(10.90)	(6.93)	(6.05)	(12.89)	(12.01)
Number of children	3.77[a]	3.74	4.45		2.54	2.61
	(2.17)	(2.14)	(2.06)		(1.50)	(1.57)
Highest grade completed	10.32	11.44	7.66	7.33	9.33	9.47
	(3.22)	(3.38)	(3.92)	(3.81)	(3.48)	(3.29)
Daily wage	370.68	401.99	253.24	146.97	382.7	284.94
	(1,010.05)	(1,509.51)	(336.13)	(214.41)	(820.74)	(523.75)
Both husband and wife work	0.74	0.72	0.71		0.35	0.34
	(0.44)	(0.45)	(0.45)		(0.48)	(0.47)
Husband makes more income than wife	0.62	0.61	0.67		0.65	0.82
	(0.49)	(0.49)	(0.47)		(0.48)	(0.39)
Husband turns over all income to wife*	0.61	0.61	0.68		0.54	0.59
	(0.49)	(0.49)	(0.47)		(0.50)	(0.49)
Husband turns over some (but not all) income to wife*	0.28	0.28	0.30		NA	
	(0.45)	(0.45)	(0.46)			
Work outside the home	0.96	0.77	0.86	0.76	0.80	0.38
	(0.20)	(0.43)	(0.35)	(0.45)	(0.40)	(0.49)
Years married	19.18	19.02	20.77		NA	
	(11.25)	(10.94)	(5.82)			
Wife does budgeting	0.80	0.72	NA		NA	
	(0.40)	(0.45)				
Wife controls savings decisions	0.25	0.28	NA		NA	
	(0.43)	(0.45)				
Husband controls savings decisions	0.18	0.13	NA		NA	
	(0.38)	(0.34)				
Couple has conflicts over money	0.36	0.39	NA		NA	
	(0.48)	(0.49)				
Has an account at Green Bank	0.38[a]	0.51	N/A		NA	
	(0.49)	(0.50)				
Spouse has account at Green Bank	0.42	0.30	N/A		NA	
	(0.50)	(0.46)				
Couple has joint bank account	0.07	0.07	N/A		NA	
	(0.21)	(0.21)				

Notes: Column 1 of this table presents summary statistics from the experimental sample, collected during the experiment and in individual surveys conducted after the survey separately with husbands and wives, based on their own reports. One woman could not be located after the experiment, and thus survey variables are available for only 145 out of the 146 experimental sample couples (291 individuals). Data on years married were collected from only 132 couples. Columns 2 and 3 present similar variables collected on other datasets across the Philippines, for comparison purposes. The CLHNS (the Cebu Longitudinal Health and Nutrition Survey) surveyed Filipino women who gave birth between May 1, 1983, and April 30, 1984, and conducted follow-up surveys in 1991–1992, 1994, and 1998. CLHNS couples for this table are based on household roster information from the most recent data. The ISSP (International Social Survey Programme) 2002, Module on Family and Changing Gender Roles in the Philippines, was a nationally representative sample of voting-age adults (18 years and older) in 2002. Since ISSP does not select couples, the sample for the table is not restricted to couples.

* All variables were collected separately for husbands and wives, except for "Husband turns over all income" and "Husband turns over some income," which were asked only of the husbands in the sample. These questions are included here for comparison purposes with similar questions asked in other household decision-making surveys in the Philippines.

makes the savings decisions in the household; approximately 25 percent respond "only wife," which I code as "Wife controls savings decisions," and approximately 15 percent respond "only husband," which I code as "husband controls savings."[25] Finally, almost 40 percent of couples in the sample reported having conflict over money issues in the household. Appendix Table A2 shows these summary statistics by treatment condition and by gender, with pairwise *t* tests for significance; all but two variable means are statistically indistinguishable across conditions, one at 10 percent significance.[26] Table 1 also shows similar variables for comparison from two major surveys conducted in the Philippines, the Cebu Longitudinal Health and Nutrition Survey, which was representative of the nearby region of Cebu, and the International Social Survey Programme, Module on Family and Changing Gender Roles in the Family, which was nationally representative. Although the experimental sample was not selected to be representative, the respondents do not appear substantially different from regional or national norms with respect to most variables.

B. *Experimental Conditions*

Subjects, upon arriving at the laboratory with their spouses, were randomly assigned to one of three conditions under which they made decisions about saving or spending an endowment. These conditions were designed to mimic the real-world circumstances under which households were making decisions. Figure 1 provides a schematic diagram of the experimental design.

In the first condition, Private subjects were separated from their spouses upon arrival and told that the women were to be in one room and the men in another. Once the subjects were settled, they were registered and told about how much money they were getting and which decisions they were going to be asked to make. Subjects were explicitly told at the beginning of the experiment that their spouse did not know whether they received any income or what choices they had, that their choices would be kept private, and that they would be paid based on their choices before reuniting with their spouses.[27] Designing a perfectly private condition for married couples is challenging, particularly since spouses could always attempt to learn the information from each other when they went home. I designed the Private condition to occlude as much information as possible, in order to allow the subject to maintain "plausible deniability" in front of his or her spouse when the subject exited the experiment. Upon entering the experiment, spouses were taken into separate rooms when told that they would be receiving 200 pesos with which to make allocational decisions (in excess of the 40 pesos show-up fee), as well as what choices they had

[25] Husbands and wives were separately and privately asked about who controls the savings decisions; as the summary statistics by gender show, there was a small discrepancy between who each person reported controlled the savings decisions in the household. In the analysis, I use their own reports about who controls in the household, since what is important for the theoretical framework is personal perception of who controls the finances in the household. None of these variables was significantly differently reported across treatment conditions, nor did differences in reports between husbands and wives differ significantly among treatments. Although the questions were asked after the experiment, the answers were not affected by the experiment itself.

[26] "Education" and "Spouse has bank account" are significantly different across treatment conditions; subjects in Negotiation have, on average, two years less education than subjects in the Private or Public conditions. Subjects in Negotiation are also slightly more likely to have a spouse that has a bank account at Green Bank. Appendix Table A2 reports these specifications.

[27] One possible threat to maintaining privacy of information is that subjects may have heard from their neighbors about the experiments and what occurred therein. When subjects came in for the experiment, they were asked individually how they heard about the experiment, to check whether they had heard from anyone other than the recruiter who came to their house. All subjects answered that they had learned from the recruiter. In addition, subjects were more casually asked in debriefing whether any friends or neighbors had mentioned being part of this study at Green Bank or had told them what had happened when they had come to Green Bank. They responded that people were unlikely to talk about this with their friends, because it is not common to discuss financial matters with friends or neighbors—in part because as soon as one reveals that one has just received some money, one might be asked to share it.

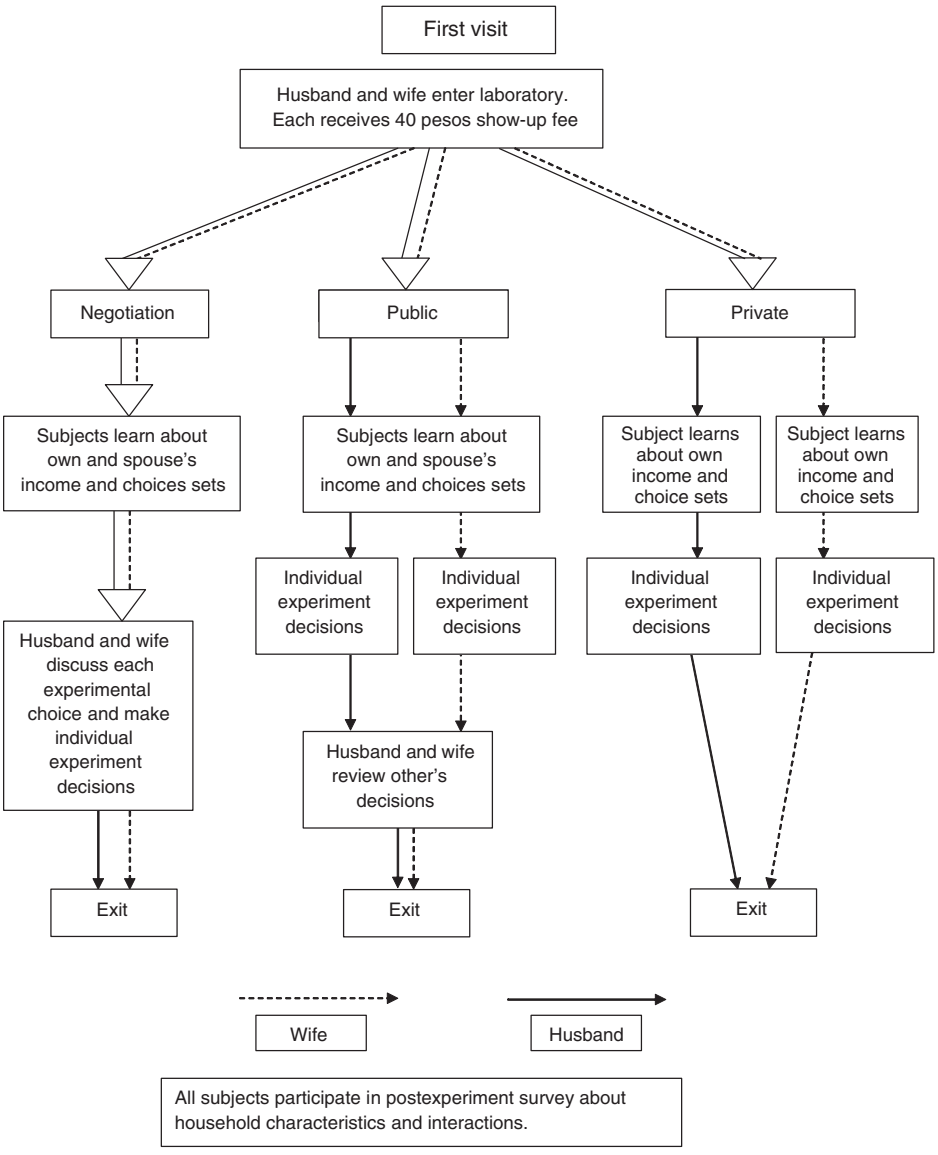

FIGURE 1. DIAGRAM OF EXPERIMENTAL DESIGN

available to them; it is plausible that subjects had some probability distribution over whether their spouse was simply filling out a questionnaire or was getting the same amount of money (if any) as they were and whether they were facing the same choices. This is in comparison to the Public and Negotiation conditions, in which they knew *for certain* that their spouses were facing the same income shocks and same choices as they were.

In addition, the Private condition obscured both outcomes and the choices leading to those outcomes through a luck-of-the-draw mechanism. Under all treatment conditions in the experiment, subjects made several decisions about how to allocate their 200 pesos. They were told that at the end of the experiment, one of these decisions would be randomly chosen. In addition, there was

a chance that none of the decisions would be realized and instead one would get the luck of the draw, which could be any one of the outcomes possible in the experiment (as well as nothing).[28] The probability of receiving "luck of the draw" was the same across all three treatment conditions. However, the luck of the draw created plausible deniability only in the Private condition, since it obscured the link between choices and outcomes. (In the other two conditions spouses saw each other's entire range of choices and could perfectly map choices to outcomes.) Thus, even if a spouse were able to find out what outcome one received after walking out of the experiment in the Private condition, the subject could always claim that he got that outcome through bad luck and not through any choice of his own.[29]

Moving from Public to Private can therefore tell us the net effect of obscuring information about spouse's income and choices, but cannot tell us definitively which aspect of the information was most important. The obscuring of information involved obscuring the possibility of income shocks and the choices available, and providing plausible deniability for responsibility for any outcome received. This is in comparison to the Public condition, in which all information about income and available choices was publicly revealed and outcomes were both fully verifiable and the choices that led to those outcomes were perfectly observable.

In the second condition, Public, subjects and their spouses enter the room together, and each subject sits at a different table from his/her spouse in the same room. They both learn about their own and each other's payoffs and choice sets, and make simultaneous decisions; however, they cannot communicate or see the decisions the other is making until all decisions have been made. They know that their choices will be fully revealed to their spouse once the experiment is over. At the end of the decision-making process, subjects meet with their spouse, show each other all the decisions they made, and discuss. They are not allowed to change any decision at this point. When the couple returns together to compare responses, local researchers fill out a form detailing each subject's decision and their response to the spouse's decision, as well as any discussion or conflict between the spouses that ensued. This condition is analogous to the real-world situation in which one spouse has received extra income at work or elsewhere and can put it aside or spend it—but with the foreknowledge that the spouse will find out what he or she did with it.[30]

In the third condition, Negotiation, subjects and their spouses follow the same procedure as "Public," but they are required to communicate before making their decisions, and their decisions are immediately observable to each other. Couples are instructed to tell each other what they would like to do for each decision, discuss what would be best to do, and then to make a final (individual) decision.[31] This condition is analogous to standard cooperative or collective household models where couples with full information decide together what would be best. Although couples were not required to come to agreement after talking, evidence suggests that

[28] As described in more detail in the subsection below, the subjects made eight main decisions about allocating their 200 pesos. After each subject had filled out his/her choices, the experiment rolled a nine-sided die to determine which choice would be enacted for the subject. If the die rolled on one to eight, one of the subject's own choices would be realized. If the die rolled on nine, the subject would receive what was called "luck-of-the-draw," which meant that he/she picked an outcome out of a hat. The hat included all possible outcomes in the experiment, including the outcome of receiving nothing. The subjects were told this in advance.

[29] Please see the Web Appendix for the Experimental Instruction Forms for each treatment condition (available at http://www.aeaweb.org/articles.php?doi=10.1257/aer.99.4.1245).

[30] One subject compared it to going to the bar on the way home from work: his wife would know that he spent his money on drink, but by then it would be too late and he would already be drunk.

[31] A qualitative supplement for each couple is coded by local researchers for each decision, including a measure of which spouse appeared to dominate the negotiation process, and arguments used for persuasion. Analysis on these measures shows that the person who dominates the majority of decisions in the negotiation is significantly correlated (at 5 percent) with the one who is older (corr coefficient = 0.21) and who has more education (0.23). These supplements were gathered discreetly; experimental assistants were instructed to be available to help translate individually for any couple who asked, but otherwise kept to their own table on the side.

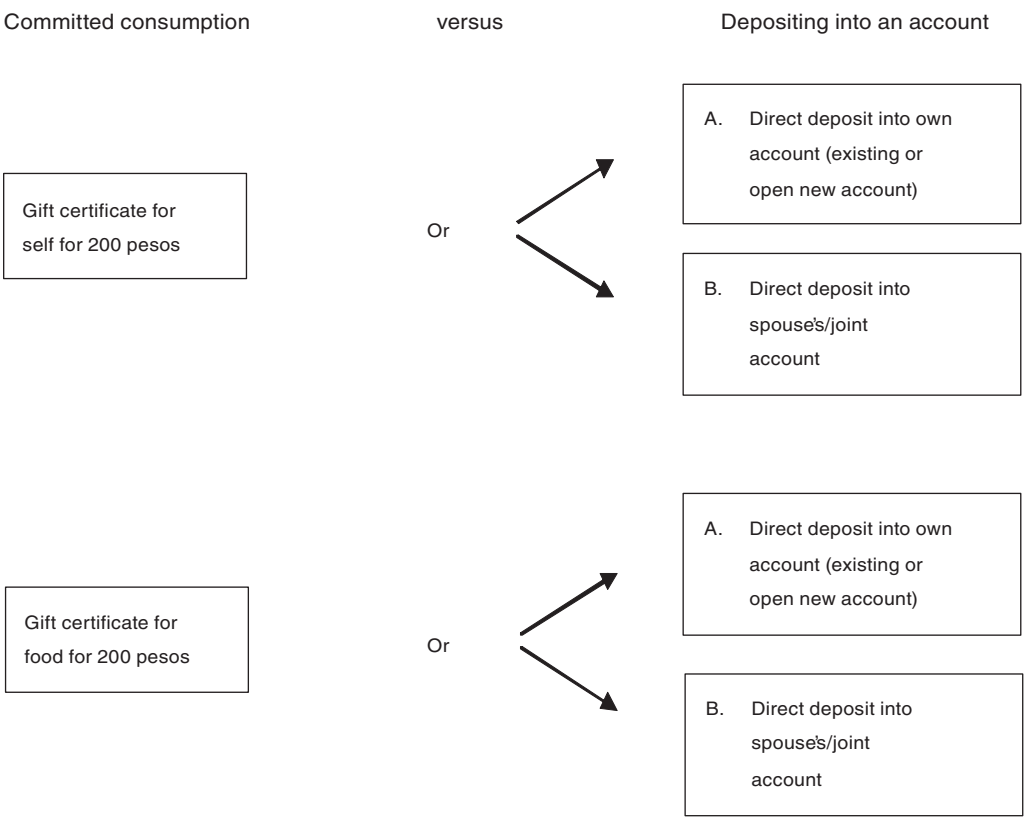

FIGURE 2A. EXPERIMENTAL CHOICES

subjects saw this condition as a coordination exercise: correlation among spouses' choices was significantly higher in this condition.

C. *Experimental Outcomes*

In addition to a 40 peso show-up fee, subjects earned the equivalent of a day's wages (200 pesos, or $4), which they received at the end of the experiment.[32] They were informed about their payment only after they entered their particular experimental condition. During the experiment, subjects were asked to make several decisions in advance about what they would like to do with both earnings. One of these decisions is randomly chosen to be implemented at the end of the experiment.

As shown in Figure 2A, subjects could choose to deposit the money into their own account (or, if they did not have an account, into a new account in their name) or their spouse's/joint account. Outcome measures not related to direct deposit are reported in Appendix Table A6 but are not the focus of this paper.[33] Comparing these two types of choices—direct deposit and committed

[32] All subjects also received another 200 pesos in 3 months' time, given to them in the form of a postdated check, as part of choices measuring time preference (for long-term horizon) and time inconsistency.

[33] A number of choices were elicited in the experiment that did not have to do with direct deposit but were collected for other purposes. These other choices, reported in the Appendix, were: cash against different values of gift certificates

consumption—allows for outcomes that vary in observability based on the treatment condition: redeemed gift certificates, particularly for apparel, would be more observable, whether they are chosen in Private or Public, whereas money put into a private savings account is more hidden when chosen in Private, but not when it is chosen in Public.

Subjects traded off consumption that was precommitted in the form, in one decision, of a gift certificate for a "special good for self"[34] worth 200 pesos against receiving 200 pesos directly deposited into an account of their choosing and, in another decision, of a gift certificate for food worth 200 pesos redeemable at a number of stores against 200 pesos directly deposited into an account of their choosing. Both types of gift certificates expired within 1 to 2 weeks of the experiment, and could be used only by the person whose name was on the certificate; thus, they were a way of committing the income to a particular consumption good.[35]

In order to understand the degree to which subjects valued putting money aside into an account, subjects also traded off receiving 200 pesos in cash against varying amounts put into direct deposit in a savings account of their choosing. This choice is described in Figure 2B. Subjects answered each of the trade-offs (200 cash versus 225 in account, 200 cash versus 200 in account, 200 cash versus 175 in account, 200 cash versus 150 in account, 200 cash versus 125 in account), providing a measure of willingness to pay to deposit into an account of one's choosing.

III. Empirical Analysis and Results

Table 2 describes the main results for direct deposit decisions, by the three treatment conditions, and for men and women separately, comparing means through Fisher's exact tests; subsequent tables present the results controlling for observables and for interaction effects with underlying financial control structure. In the body of the paper, I focus on the results from the decision to commit 200 pesos to consumption in the form of a gift certificate for apparel, which could be used only for oneself (labeled "gift certificate for self"), or to put 200 pesos into one's own account (either existing or new account) or that of one's spouse; the results from decisions for gift certificate for committing to food versus direct deposit is presented in the Appendix tables and exhibit the same patterns. I discuss the results on willingness to pay for direct deposit and its implications for inefficiency in the household after a preliminary discussion of these first results.

I run the following regression:

$$D_{sim} = a + \beta T_{im} + v\mathbf{X}_{im} + e, \tag{1}$$

for self; trade-off of cash against different values of gift certificates for food; cash against saving in accounts in the name of a child; and short and long horizon time preferences which give us a measure of patience, impatience, and time inconsistency (these time preference measures were evaluated using certified bank post-dated checks with transaction costs equalized by requiring all subjects to come back three times to the bank to sign in and receive 20 pesos (more than twice their fare to the bank) when they return: once in two weeks, once in three months, and once in three and a half months). Subjects knew that each decision had a chance of being realized, as outlined in the Experimental Design section. Previous experimental work has found that the collection of additional outcome variables does not dilute incentives (see Susan K. Laury 2000).

[34] This gift certificate is redeemable only in the women's apparel department for female subjects, and in the men's apparel department for male subjects. After several trials using different "private goods," this was what appeared to appeal to the broadest variety of both men and women as special, indulgent goods for themselves.

[35] This was done by ensuring that the gift certificates for self (for a large department store called Gaisano) were produced by the national department store head office and would not be accepted if they were redeemed after the expiration date or if the person using them was not the same person as the name on the certificate (verified through national identification cards and numbers); store employees were trained to handle these transactions. Similarly, the managers of a small number of stores that sold food and foodstuffs consented to be part of the project and produced and monitored the food gift certificates to ensure both that they were not used after expiration and that they were used only by the intended recipient (again verified through national identification cards).

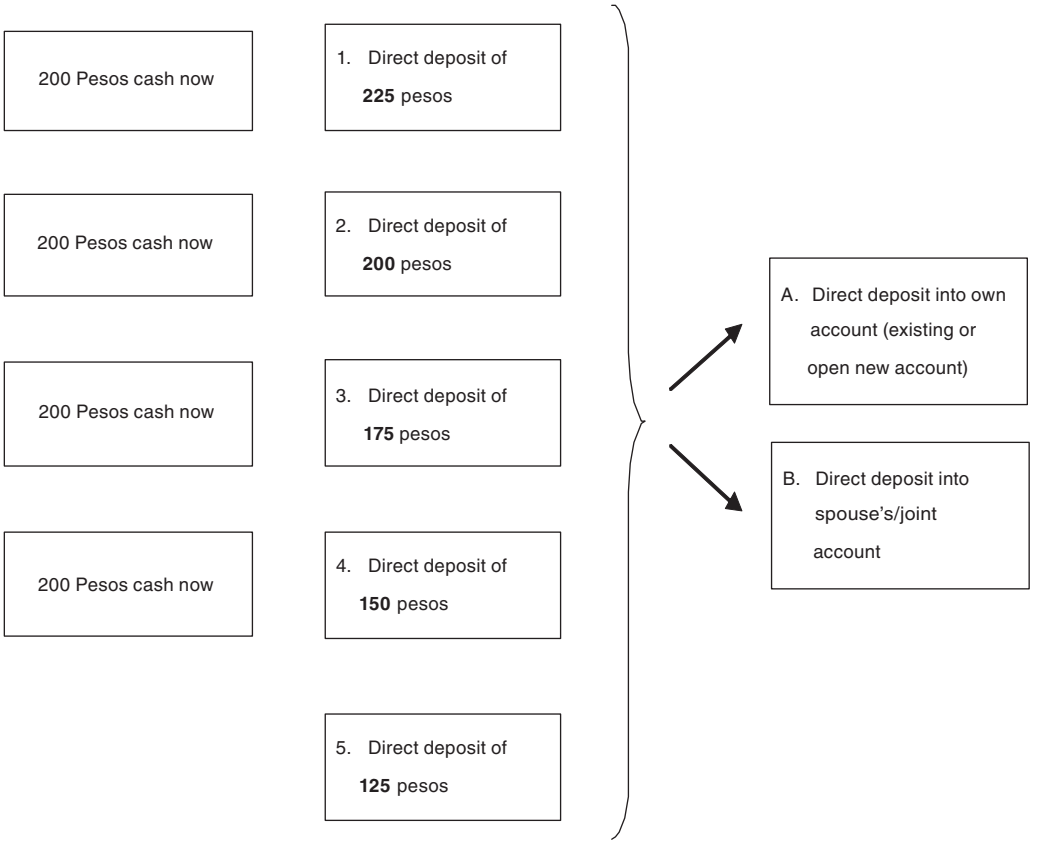

FIGURE 2B. WILLINGNESS TO PAY FOR DEPOSITING INTO AN ACCOUNT

where D_{sim} is the outcome variable of interest which takes on three forms (s): I code each outcome "gift certificate for self"; "direct deposit into own account"; "direct deposit into spouse's account" as a dummy variable (s_1, s_2, s_3) to allow for the most nonparametric analysis using ordinary least squares (OLS) on dummy variables.[36] The treatment variable (Private, Public, or Negotiation) is denoted by T and the vector of controls by $\mathbf{X}$. I run the regressions separately for men (m) and women (w) to allow for heterogeneous responses to treatment; controls include both own and spouse's demographic characteristics and account status. The results, described below, present the response of the financial decision to asymmetric information and communication.

To understand the degree to which this response to asymmetric information and communication may be driven by underlying roles in the household (rather than simply gender), I interact the treatment with the degree to which the spouse controls the savings decisions in the household.

[36] The fact that these dummy variables are coded in relation to each other inherently takes into account that they come from the same variable. The dummies add to one, for each individual; thus, the slope coefficients add to zero. Results from predictions of all three dummies are shown to illustrate both coefficients and standard errors. The coefficients are estimated using OLS estimation, with bootstrapped standard errors (300 repetitions) in parentheses. Running OLS imposes less structure than running a multinomial probit and allows for ease of interpretation of coefficients (Josh Angrist 2001). Since almost all variables in all regression specifications are dummy variables, OLS functions similarly to probit and logistic regression, but imposes the least structure on the data. The results do not change with probit or logistic specifications.

TABLE 2—MAIN EXPERIMENTAL OUTCOMES

	Male			Female		
	Private $N = 48$	Public $N = 48$	Negotiation $N = 50$	Private $N = 48$	Public $N = 48$	Negotiation $N = 50$
Gift certificate for self	0.25	0.58	0.30	0.38	0.40	0.28
Direct deposit in own account	0.52	0.23	0.32	0.54	0.35	0.52
Direct deposit in spouse or joint account	0.23	0.19	0.38	0.08	0.25	0.20
Fisher's exact *p*-value: Private to Public	0.002			0.052		
Fisher's exact *p*-value: Public to Negotiation		0.015			0.246	
Fisher's exact *p*-value: Private-Negotiation			0.112			0.24

Notes: This table shows the distribution of subjects' choices on whether they would prefer 200 pesos in the form of a gift certificate for a "special good for self" worth 200 pesos (redeemable at the local department store), or having the 200 pesos directly deposited into an account of their choosing: their own account (already existing own account or new account that can be opened in their name) or into their spouse's/joint account. The first row presents the fraction of individuals who preferred gift certificates for self over direct deposit of 200 pesos into their own account or 200 pesos deposited into spouse's/joint account. The second row is the fraction of individuals who preferred direct deposit for 200 into their own savings account over either a gift certificate for self worth 200 pesos or over deposit of 200 pesos into their spouse's or a joint savings account over gift certificate for self worth 200 pesos or over deposit of 200 pesos into their own account. The table presents results from Fisher's exact tests for significant differences in the distribution of these choices across the three treatment conditions of Private, Public, and Negotiation. These tests are conducted separately for men and women, to allow for gender interactions in the data. They thus compare men's (women's) responses in one treatment condition to men's (women's) responses in a different treatment condition and do not directly compare men's answers to women's answers within each treatment condition.

This tests the prediction that individuals with less control in the household are more likely to try to shield income shocks through hiding (in Private) or committing to consumption (in Public). I use the variable "Who decides whether to save or spend money" as a proxy for an individual's perception of who controls the allocation decisions in the household. This is a variable that is both pre-existing to the experiment and is subjective: it is based on an individual's perception of the reality within the household. What matters for this prediction is the *perception* that one's spouse controls the financial decisions and that therefore one will get little or no say in the allocation once one turns over the money.[37] Thus, I use each subject's self-reports about who controls the savings decisions in the household. By interacting this variable with the treatment conditions, I test for—and find—heterogeneous treatment effects, which serve to suggest the mechanism underlying the main experimental results.

I find that men are more likely to deposit the money into their own account in Private and commit it to consumption in Public. This effect is mainly driven by men whose wives make the savings decisions in the household. Although initially it does not appear that women exhibit such behavior, women whose husbands control the savings decisions in the household behave as the men whose wives control the savings decisions, consistent with the theoretical framework above.

[37] Since most of the men in my sample have wives who are the financial managers, consistent with the Filipino cultural context, this variable captures only the additional variation that comes from perceiving that one has a spouse who truly controls these decisions (i.e., likely does not give any say in the allocation decision to their partner); the prediction is simply that for this (smaller) subsample results should be stronger.

Finally, men are more likely to turn their money over to their spouse's account in the Negotiation condition, an effect that is greater for men who don't control the savings decisions in their household; this also holds for women whose husbands control the savings decisions in their household (although this treatment interaction loses significance in the full specification).

RESULT 1: *Men prefer to put money away in their own accounts when information is Private, but when information is made Public, they switch to committing money to consumption. Women choose to put money away rather than committing it to consumption regardless of the treatment condition.*

Table 2 presents the effect of obscuring information—in going from the column labeled "Private" to "Public"—using Fisher's exact tests. In the Private condition, 52 percent of men prefer to directly deposit money into their own account (two-thirds opening new accounts in their name) rather than putting it into their spouse's account (23 percent) or committing it to consumption (25 percent). However, when information about the outcomes is made Public, 58 percent of men choose to commit their money to consumption rather than putting the money into their own account (23 percent) or into their spouse's account (19 percent). The change in the distribution of these outcomes in moving from Private to Public is highly statistically significant, with a Fisher's exact p-value of 0.002. The same pattern and significance levels repeat in the decision for the gift certificate for food,[38] described in Appendix Table A5. Women, in contrast, do not vary across treatment conditions in their desire to deposit money into an account rather than to commit it to consumption; they change from depositing into their own accounts in Private to their spouse's account in Public.

Adding controls (in Table 3) shows that, as would be expected, having an account at Green Bank has a positive and significant effect on choosing to deposit into one's own account, and the spouse having an account has a negative effect on depositing into spouse's account, but these controls do not alter the treatment effects. Men are significantly more likely to save in their own accounts in Private, both with or without controls for having an account, whether their spouse has an account, their daily wage and their spouse's daily wage, and their and their spouse's education. Women, in contrast, do not vary across treatment conditions in their desire to save their earnings in an account rather than spend them. However, as regards which account to deposit into, making information private moves women from saving in their spouse's account to saving in their own account, an effect that remains generally robust controlling for account dummies.

RESULT 2: *Both men and women whose spouses control savings decisions are more likely to put money away in Private and commit it to consumption in Public.*

Table 4 describes the interaction between treatment conditions and underlying perceptions of household control over financial decisions. Men whose wives control the savings decisions are 65 percentage points more likely to commit money to consumption in Public rather that putting money away (panel 1, column 1).[39] Women whose husbands make the savings decisions are 60

[38] Although food can be shared, and is thus not a strictly selfish good, it is a highly desirable consumption good among men in the Philippines. Other studies in the Philippines (Dubois and Ligon 2005) have shown the strong degree to which husbands receive better quality, and quantity, of food in the household when their wages increase.

[39] The effect of the Private treatment on men whose wives control savings is the addition of the straight coefficient on Private (-0.201) plus the interaction coefficient on Private*WifeControlsSavings (-0.452), plus the straight coefficient on WifeControlsSavings (0.288), which equals -0.365. To calculate the change for men whose wives control savings in going from public information to making information private, subtract the straight coefficient for the base case of WifeControlsSavings (0.288) from the above, yielding $(-0.365–0.288) = -0.653$. Thus, men are 61 percentage points

TABLE 3—GIFT CERTIFICATE FOR SELF OVER DIRECT DEPOSIT: CONTROLS

	Gift certificate for self over deposit into any account		Own account deposit over gift certificate for self or spouse's account deposit		Spouse's account deposit over own account deposit or gift certificate for self	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel 1. Male						
Private	−0.333***	−0.305***	0.292***	0.305***	0.042	−0.000
	(0.092)	(0.100)	(0.100)	(0.080)	(0.083)	(0.095)
Negotiation	−0.277***	−0.262**	0.097	0.111	0.180*	0.151*
	(0.091)	(0.095)	(0.095)	(0.091)	(0.088)	(0.093)
Husband's age		0.010		−0.001		−0.009
		(0.010)		(0.011)		(0.008)
Wife's age		−0.005		0.001		0.005
		(0.009)		(0.011)		(0.008)
Husband's highest grade completed		−0.013		0.018		−0.005
		(0.014)		(0.015)		(0.015)
Wife's highest grade completed		0.032**		−0.023		0.009
		(0.015)		(0.015)		(0.014)
Husband's daily wage				−0.040		−0.009
				(0.063)		(0.055)
Wife's daily wage				0.014		0.008
				(0.050)		(0.057)
Have account at Green Bank		−0.043		0.244***		−0.202**
		(0.086)		(0.082)		(0.073)
Spouse has account at Green Bank		−0.066		−0.123		0.189**
		(0.088)		(0.086)		(0.084)
Have joint account		0.095		0.068		0.127
		(0.212)		(0.241)		(0.216)
Constant	0.583***	0.180	0.229***	−0.257	0.188***	0.562**
	(0.066)	(0.281)	(0.064)	(0.265)	(0.058)	(0.230)
Observations	145	143	145	143	145	143
R^2	0.09	0.158	0.064	0.201	0.031	0.176

percentage points more likely to commit money to consumption in Public rather that putting money away (panel 2, column 2). Men whose wives control the savings decisions are also 55 percentage points more likely to put money away into their own accounts in Private (panel 1, column 3), and women whose husbands control savings are 72 percentage points more likely to put money away into their own accounts (panel 2, column 4). The same pattern, with even greater significance, holds for food, described in Appendix Table A4.

Thus, what looks like differences in gender in responding to treatment conditions, from Result 1, appears in fact to be driven by differences in underlying household control structure. This is consistent with the conceptual framework above, which predicts that subjects whose spouses control the savings decisions would be more likely to commit money they receive to consumption, or hide it if they are undetected—unless doing so would be in explicit defiance of their spouse's preferences.

less likely to choose committed consumption in Private, or 65 percentage points more likely to choose it in Public. The same procedure is used to calculate the other treatment interaction effects described in Result 2.

TABLE 3—GIFT CERTIFICATE FOR SELF OVER DIRECT DEPOSIT: CONTROLS *(Continued)*

	Gift certificate for self over deposit into any account		Own account deposit over gift certificate for self or spouse's account deposit		Spouse's account deposit over own account deposit or gift certificate for self	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel 2. Female						
Private	−0.008	0.050	0.180*	0.105	−0.172**	−0.155**
	(0.099)	(0.096)	(0.097)	(0.112)	(0.080)	(0.067)
Negotiation	−0.097	−0.070	0.148	0.091	−0.051	−0.021
	(0.097)	(0.097)	(0.098)	(0.099)	(0.088)	(0.086)
Husband's age		0.004		−0.004		0.000
		(0.010)		(0.011)		(0.009)
Wife's age		−0.001		−0.000		0.002
		(0.010)		(0.011)		(0.009)
Husband's highest grade completed		−0.027*		0.009		0.018
		(0.016)		(0.016)		(0.012)
Wife's highest grade completed		0.020		−0.130		−0.007
		(0.015)		(0.017)		(0.013)
Husband's daily wage		0.052		−0.009		−0.043
		(0.096)		(0.091)		(0.063)
Wife's daily wage		−0.027		0.024		0.003
		(0.041)		(0.067)		(0.050)
Have account at Green Bank		−0.214***		0.365***		−0.151**
		(0.084)		(0.082)		(0.068)
Spouse has account at Green Bank		−0.095		−0.052		0.148*
		(0.091)		(0.103)		(0.081)
Have joint account		−0.085		0.111		−0.026
		(0.240)		(0.253)		(0.180)
Constant	0.383***	0.430	0.361***	0.482*	0.255***	0.088
	(0.074)	(0.341)	(0.071)	(0.289)	(0.067)	(0.218)
Observations	144	143	144	143	144	143
R^2	0.009	0.108	0.024	0.172	0.035	0.142

Notes: This table predicts determinants of the choices summarized in Table 2. As described in the Table 2 notes, this choice was between 200 pesos in the form of committed consumption (in a gift certificate for self) versus 200 pesos directly deposited into an account of one's choosing (one's own account versus spouse's/joint account). To facilitate regression analysis and interpretation of the source of the change in distribution, each of these options is coded as a dummy variable; the fact that they are coded in relation to each other inherently takes into account that they come from the same variable. The dummies add to one for each individual; thus, the slope coefficients add to zero. The coefficients from predicting the third dummy could thus be calculated from the coefficients on the first two; however, presenting all three gives us the standard errors as well. The coefficients and standard errors take into account the interrelationship among the three variables, arising essentially from one data point for each subject. The coefficients are estimated using OLS estimation, with bootstrapped standard errors (300 repetitions) in parentheses. This is equivalent to running probit and logit estimates since almost all variables are dummy variables, and imposes less structure on the data (Angrist 2001). Columns 2, 4, and 6 estimate with both own and spouse's control variables. Three observations, two women and one man, are dropped due to missing data on daily wage, leaving a full sample size of 144 women and 145 men. When own and spousal daily wage is included in the regression, this requires dropping the spouse as well from columns 2, 4, and 6, leaving a final sample size of 143.

*** Significant at 1 percent. ** Significant at 5 percent. * Significant at 10 percent.

RESULT 3: *Communicating with their wives at the moment of decision making makes the majority of men put money into their spouse's account, rather than consume or put it into their own account, when compared to a condition of public information.*

TABLE 4—GIFT CERTIFICATE FOR SELF OVER DIRECT DEPOSIT: TREATMENT INTERACTIONS

	Gift certificate for self over deposit into any account		Own account deposit over gift certificate for self or spouse's account deposit		Spouse's account deposit over own account deposit or gift certificate for self	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel 1. Male						
Private	−0.201*	−0.334***	0.230**	0.303	−0.028	0.030
	(0.122)	(0.105)	(0.102)	(0.100)	(0.092)	(0.097)
Negotiation	0.149	−0.262**	0.024	0.099	0.125	0.162*
	(0.117)	(0.106)	(0.111)	(0.091)	(0.095)	(0.095)
Wife controls savings × Private	−0.452**		0.318		0.135	
	(0.195)		(0.203)		(0.200)	
Wife controls savings × Negotiation	−0.521***		0.397*		0.124	
	(0.217)		(0.196)		(0.202)	
Wife controls savings decisions	0.288*		−0.142		−0.146	
	(0.157)		(0.118)		(0.121)	
Husband controls savings × Private		0.176		0.005		−0.180
		(0.309)		(0.326)		(0.209)
Husband controls savings × Negotiation		−0.017		0.074		−0.057
		(0.326)		(0.373)		(0.262)
Husband controls savings decisions		0.004		−0.027		0.023
		(0.235)		(0.272)		(0.170)
Constant	0.222	0.200	0.192	0.256	0.586	0.544**
	(0.299)	(0.293)	(0.267)	(0.274)	(0.243)	(0.245)
Account, education, and wage variables (own and spouse)	Yes	Yes	Yes	Yes	Yes	Yes
Observations	143	143	143	143	143	143
R^2	0.197	0.164	0.229	0.201	0.182	0.181

Table 2 describes outcomes in the Negotiation condition, once husbands and wives are able to bargain and communication is enforced: only 30 percent of men and 28 percent of women now choose the committed consumption. Rather, Negotiation inspired the majority of men to directly deposit into their spouse's account and the majority of women to directly deposit into their own accounts (consistent with the high degree of coordination between couples in choosing which account to deposit into, observed in Negotiation). Table 3 presents this result controlling for own and spouse's demographic and account variables. Women whose husbands control the savings decisions exhibit the same pattern as men in Negotiation; they are 16 percentage points more likely to deposit money into their spouse's account in Negotiation, although this interaction effect is not statistically significant (Table 4, column 6).

A. *Discussion*

The results above are consistent with the monitoring framework in which making information public leads to a larger proportion of men committing income to consumption rather than trying to hide their money or turn it over. These information changes act most strongly on those men whose wives control the savings decisions rather than simply doing the budgeting, for example.

TABLE 4—GIFT CERTIFICATE FOR SELF OVER DIRECT DEPOSIT: TREATMENT INTERACTIONS *(Continued)*

	Gift certificate for self over deposit into any account		Own account deposit over gift certificate for self or spouse's account deposit		Spouse's account deposit over own account deposit or gift certificate for self	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel 2. Female						
Private	−0.075	0.126	0.249**	0.031	−0.174**	−0.157**
	(0.121)	(0.110)	(0.124)	(0.105)	(0.087)	(0.077)
Negotiation	−0.199*	0.002	0.213**	0.042	−0.014	−0.044
	(0.116)	(0.108)	(0.110)	(0.115)	(0.105)	(0.096)
Husband controls savings × Private		−0.726**		0.692**		0.035
		(0.276)		(0.305)		(0.144)
Husband controls savings × Negotiation		−0.597**		0.393		0.203
		(0.254)		(0.280)		(0.227)
Husband controls savings decisions		0.640***		−0. 466*		−0.174*
		(0.141)		(0.213)		(0.109)
Wife controls savings × Private	0.468**		−0.562***		0.093	
	(0.221)		(0.234)		(0.164)	
Wife controls savings × Negotiation	0.504**		−0.504**		0.001	
	(0.223)		(0.230)		(0.175)	
Wife controls savings decisions	−0.280*		0.356**		−0.076	
	(0.150)		(0.164)		(0.124)	
Constant	0.532	0.223	0.362	0.641**	0.106	0.136
	(0.336)	(0.293)	(0.311)	(0.280)	(0.219)	(0.229)
Account, education, and wage variables (own and spouse)	Yes	Yes	Yes	Yes	Yes	Yes
Observations	143	143	143	143	143	143
R^2	0.153	0.160	0.217	0.204	0.015	0.152

Notes: Bootstrapped standard errors (300 repetitions) in parentheses, on OLS estimation. Wife controls savings × Negotiation is the interaction between Wife controls savings decisions and negotiation. Husband controls savings × Negotiation is the interaction between Husband controls savings decisions and Negotiation. Wife controls savings decision: variable = 1 if, in response to the question: "Who decides whether money will be saved or it would be spent on something?" the subject answers "wife." Variable = 0 if subject answers "husband" or "husband and wife together." It is the subject's perception of who controls savings decisions in the household; a longer, more precise label for the variable is "Own perception that wife controls savings decisions." Husband controls savings decisions = 1 if the subject answers "husband" in response to "Who decides whether money will be saved or it would be spent on something?" Variable = 0 if subject answers "wife" or "husband and wife together." It is the subject's perception of who controls savings decision in the household. A longer, more precise label for the variable is "Own perception that husband controls savings decisions." Account, education, and wage variables (own and spouse) consist of all controls from previous table: own age, spouse's age, own highest grade completed, spouse's highest grade completed, own daily wage, spouse's daily wage, have account at Green Bank, spouse has account at Green Bank, and have joint account. Treatment and interaction results are robust to excluding controls. Spousal variables are as reported by the spouse.

*** Significant at 1 percent. ** Significant at 5 percent. * Significant at 10 percent.

The experimental means appear to show little effect on women's behavior of changing privacy of information in taking consumption for themselves, but this masks heterogeneous treatment effects; women whose husbands control the savings decisions do indeed behave very similarly to the men in our sample. This suggests that what initially looks like gender differences in treatment responses in the experiment is really about differences in control in the household.

Under a standard unitary household model, even one in which spouses specialize in different types of labor (including financial management) in the household, one should not see such

differences arising by changing information conditions. If anything, spouses who are not responsible for the financial management should be more likely to turn over their earnings to the other spouse if they don't know what they should do with it, rather than trying to put it into their own account (particularly opening a new account in their name), or committing it to a form of consumption that is difficult to undo.

Similarly, under a nonunitary bargaining model, exogenous bargaining power should matter for the outcomes chosen, but observability of outcomes should not. The fact that putting money away into one's own account versus committing it to consumption appears to take on such different value depending on whether or not it is observable suggests that the decision of what is done with money has possibly as much to do with opportunities and incentives for enacting one's preferences as with one's bargaining power.

Indeed, the apparent preference for putting away the endowment into one's own account in Private but committing it to consumption in Public suggests there is a first stage of bargaining that household models have missed, one in which it is decided how much will be bargained over. Once information is made public, subjects can try to impose preferences on *type* of consumption, but possibly more important is how much is given over.

Simply making information public does not seem to solve the incentive problem; rather than affecting the extensive margin of how much to turn over, it affects the intensive margin of what the money is spent on and what it can be committed to, even if the spouse will find out afterward.

The differences in results between this condition of public information and where spouses have to communicate before deciding is striking. This is consistent with the prediction from the monitoring framework, whereby communication is used to explicitly state preferences and reinforce the contract. Indeed, the supplements on the Negotiation condition revealed strong statements women made to persuade their husbands to turn over their income by saving it in the wife's account, often repeating "remember you have a family" and sometimes saying a child's name repeatedly until the husband made his decision. These tactics, in many cases, appear to have worked: men overwhelmingly chose to deposit the income into their wives' accounts, rather than into their own account or a new account opened in their own name. The negotiation also causes the small proportion of women whose spouses control the savings decision to turn over their money, but communication seems to be a monitoring technology that particularly favored women.

B. *Inefficient Outcomes?*

The treatment effects of information and communication, and the way in which these effects interact with spousal control, have implications for our understanding of household decision making and, specifically, for unitary and nonunitary household models, as discussed above. Nonetheless, it is difficult to argue definitively that choosing to put money away into one's own account or committing it to consumption is necessarily an *inefficient* choice for the household (and therefore strong evidence against collective or cooperative bargaining models which assume or predict efficiency).[40]

However, supporting evidence from a separate outcome in the full experiment suggests that the motivation to rend control back by putting money away in private may lead to inefficiencies. As Figure 3B describes, subjects traded off receiving 200 pesos in cash against varying amounts put into direct deposit in a savings account of their choosing. Subjects answered each of the

[40] In part, this is based on how much one believes that the gift certificates, which were designed to be large in amount, personalized, expire quickly, and committed to a specific good, were difficult to undo and therefore a Pareto dominated choice compared to having more flexible cash in an account.

TABLE 5—WILLINGNESS TO PAY FOR DIRECT DEPOSIT

	Male			Female		
	$N = 48$	$N = 48$	$N = 50$	$N = 48$	$N = 48$	$N = 50$
Cash versus direct deposit	Private	Public	Negotiation	Private	Public	Negotiation
Prefer cash always	0.50	0.66	0.54	0.56	0.50	0.48
Direct deposit in own account	0.33	0.19	0.16	0.39	0.27	0.40
Direct deposit in spouse's or joint account	0.16	0.14	0.30	0.04	0.23	0.12
Fisher's exact *p*-value: private to public	0.198			0.021		
Fisher's exact *p*-value: public to negotiation		0.187			0.245	
Fisher's exact *p*-value: private-negotiation			0.092			0.379
How much cash willing to give up for direct deposit?						
Mean (in pesos)	21.88	9.37**	13.5	11.97	10.93	17.00
(standard deviation)	(32.87)	(25.07)	(28.22)	(26.29)	(24.14)	(31.31)
[minimum, maximum]	[0,75]	[0,75]	[0,75]	[0,75]	[0,75]	[0,75]

Notes: In this decision, subjects traded off receiving 200 pesos in cash against varying amounts put into direct deposit in a savings account of their choice (see Figure 2B). Subjects gave an answer for each of the trade-offs: "Would you prefer 200 cash versus 225 in account, 200 cash versus 200 in account, 200 cash versus 175 in account, 200 cash versus 150 in account, and 200 cash versus 125 in account?" If they chose direct deposit in any of the trade-offs, they designated the account into which the money should be deposited. Prefer cash always is the percentage of subjects who always preferred 200 cash to any amount put into an account. Direct deposit into own account is the percentage of subjects who chose to put the money into an account in any of the trade-offs rather than receive 200 cash, and chose own account as the designated account. Direct deposit into spouse or joint account is the percentage of subjects who chose to put the money into an account in any of the trade-offs rather than receive 200 cash, and chose their spouse's or joint account as the designated account. The first part of the table presents results from Fisher's exact tests for significant differences in the distribution of these choices across the three treatment conditions. Willingness to give up cash for direct deposit: because the subjects gave answers for a range of direct deposit amounts, we are able to measure how they valued direct deposit into an account as compared to 200 pesos cash. Subjects displayed monotonicity in their responses (that is, if they chose 175 pesos in their account over 200 cash, they also chose 200 pesos in their account over 200 cash and 225 pesos in their account over 200 cash). The variable, How much cash willing to give up for direct deposit?, is assigned a value of 0 pesos if subject always chose cash, or chose 225 in account or 200 in account over 200 cash; 25 pesos if subject preferred to receive (minimum) 175 pesos direct deposit over 200 cash; 50 if subject answered (minimum) 150 in account versus 200 cash; and 75 pesos if subject answered (minimum) pesos into account versus 200 cash. Note that this is an underestimate of the actual willingness to give up cash for direct deposit as trade-offs were not asked for below 125 pesos. These amounts are compared using tests across treatment conditions.

*** Significant at 1 percent. ** Significant at 5 percent. * Significant at 10 percent.

trade-offs (200 cash versus 225 in account, 200 cash versus 200 in account, 200 cash versus 175 in account, 200 cash versus 150 in account, 200 cash versus 125 in account), providing a measure of willingness to pay to deposit into an account of one's choosing. As Table 5 shows, men were again more likely to choose to put money away into their own accounts in Private (33 percent in Private, compared to 19 percent in Public). Appendix Table 3 shows the extent to which underlying financial roles in the household can exacerbate this effect of asymmetric information: men whose wives make the savings decisions are significantly more likely to put money into their own accounts in Private (women whose husbands made the savings decisions also followed a similar pattern, although the coefficient is not significant).

However, demonstrating that men are more likely to put money into their own accounts in Private—even when (or especially when) their spouses are the ones making the savings

decisions—is not evidence of inefficiency. The *additional* information that this outcome provides us is the extent to which a subject was willing to pay in order to deposit the money into an account of his/her choosing. Twenty-one percent of subjects were willing to give up some money (i.e., they chose direct deposit amounts below 200 pesos).[41] These subjects were sacrificing money that could not be regained in order to make sure it was deposited into the savings account. In debriefing surveys after the experiments, subjects who responded in this way explained that direct deposit made sure their money was *segurado* (secured); they used the popular Filippino expressions *Inig ang kuarto* (the money is hot) and *paxi, paxi* (the money will get divided) to describe why they felt that once there was cash in hand, they did not trust themselves or their spouse, as the case may be, to deposit the cash into the savings account later on their own. They preferred to have it directly deposited during the experiment even if it meant a lower amount went into their account. Men sacrificed significantly more money in Private to have money deposited into an account (an average of 21 pesos in Private, compared to 9 pesos in Public)—and the account they preferred in Private was their own, often opening an account when their wife already had one.[42]

This suggests a very specific channel through which asymmetric information can create inefficient outcomes in financial decision making: through incentives to hide one's additional income from one's spouse. This is particularly important given the theoretical work showing that efficient risk sharing can increase savings but requires income pooling and joint saving (Mazzocco 2004). Ultimately, the degree to which hiding of income is widespread among households is an empirical question. Growing empirical work suggests hiding of income that occurs among spouses has significant implication for tax reporting and national income calculations (Frances Wooley 2003; Jay L. Zagorsky 2003).[43] Measuring a willingness to pay for one's money to be safely sheltered or put aside, and seeing how that willingness to pay varies when there is asymmetric information or when spouses are forced to communicate, as I have here, is one way of concretely measuring the losses to household efficiency from intra-household frictions.[44]

[41] Subjects displayed monotonicity in their responses (that is, for example, if they chose 175 pesos in their account over 200 cash, they also chose 200 pesos in their account over 200 cash and 225 pesos in their account over 200 cash).

[42] Subjects who always chose cash, or chose 225 in account or 200 in account over 200 cash, were coded as willing to give up zero pesos in order to have money directly deposited into an account. Subjects who preferred to receive (minimum) 175 pesos direct deposit over 200 cash were coded as being willing to give up 25 pesos in cash for direct deposit; 50 pesos if subject answered (minimum) 150 in account versus 200 cash; and 75 pesos if subject answered (minimum) 125 pesos into account versus 200 cash. Since subjects were not asked for trade-offs below 125 pesos, this is may be an underestimate of the actual willingness to give up cash for direct deposit.

[43] I am grateful to Elizabeth Gugl for pointing me to this work. Relatedly, "sheltering" or hiding of income from one's spouse calls into question one of the standard assumptions of household models: income pooling. In recent work, Alexander Gelber (2008) used separate tax records for husbands and wives in Sweden to reject income pooling, finding outcomes that were consistent with a spouse's extra income being unobservable to the other spouse.

[44] Of course, this measure of willingness to pay is both a measure of one's preference for the good (for example, one's desire to have one's money put into a savings account or how much one likes a gift for self) *and* one's preference for having the money committed. I thus asked a willingness-to-pay question, measured in the same way as described above, for the other outcomes collected in the experiment: for a gift for self, for food, and for savings in the name of the child. Table A5 reports the willingness-to-pay measures, along with the other outcomes of the experiment. Both spouses seemed to love putting money into a savings account in the name of the child and were willing to give up a significant amount of money for it; this preference did not vary with asymmetric information or communication. In contrast, the amount of money both spouses were willing to give up to commit for a gift certificate for themselves decreased dramatically as their choices were made public (for women) and couples could communicate prior to decision making (for women). A similar, although less dramatic, effect occurs for money given up for committed consumption of food. In these cases, it did seem that communication eased household frictions and improved efficiency. However, both men and women were still willing to give up a significant amount of money, even after negotiation, for money put into an account; the fact that this mainly went to the wife's/household financial decision-maker's account in negotiation suggests that this was more of a commitment strategy for the couple as a unit.

IV. Conclusion

Using an experimental design, I am able to elicit causal effects of spousal observability and communication on household choices. I find that making information public moves men from putting money away into their own accounts to committing it to consumption. This effect appears to be driven not as much by gender as by control: men whose wives control savings decisions in the household are much more likely to exhibit this treatment effect, consistent with a framework in which information serves a monitoring role in enforcing a contract in which one spouse controls the finances. Although women in the Philippines are traditionally in charge of budgeting, there is heterogeneity among households in degrees of control. Indeed, women whose husbands control the savings decisions exhibit the same type of behavior as the men. This provides further evidence that the effect of privacy of information—and of communication—is heterogeneous, and depends critically on existing household roles. These roles are not just an efficient division of labor, as they have been primarily presented in the intra-household literature in economics, but rather can create a system of incentives that make hiding money desirable and committing it to consumption necessary in order to enforce one's preferences.

My experiment suggests that conditions of asymmetric information interact with underlying household control structures to create greater incentives for hiding, and thus any interventions that change household public information should take into account what the underlying roles are. There are many interventions and policies that can have asymmetric effects on information within the household: making prices of certain goods (that only one spouse sells in a nearby market, for example) public or giving subsidies to the household versus loans only to women without the husbands' knowledge. Migration provides a particularly stark example of altering information asymmetries. Jost de Laat (2005) shows that migrant men in Kenya go to great lengths to monitor the activities of the wives who receive remittances, because of their concern that the wives will take advantage of the asymmetric information created; indeed, in Kenya, a culture that has the opposite gender norms for financial management from the Philippines, many women form "secret savings societies" to keep extra income they earn in the workplace from their husbands.[45] Joyce Chen (2006) finds that migrant-sending households in China respond strongly to the efficacy of monitoring through adjusting intra-household allocation.

De Laat and Chen present frequent visits as a monitoring technology for enforcing contracts in the face of private information. My paper suggests that even when information is public, monitoring technologies make a difference by influencing decision making. In particular, communication at the moment of decision making appears to significantly change men's choices in particular. The theoretical framework I have presented suggests that the effect of communication is due to disincentives for explicit defiance, rather than the tacit defiance that occurs in a condition of full information, but no communication.

I provide evidence for why we may see gender differences when looking at means—differences in preferences that are not immutable, based on gender alone; they are due to the roles the genders have taken on, and the structure of household financial management that has created incentives for strategic behavior. When we observe strong gender differences in outcomes or treatment effects—whether in empirical or experimental data—it is important to know where such differences are coming from, particularly before advancing programs and policies that serve one spouse versus the other because we believe one gender's preferences are more closely aligned with those of the policymaker's. In particular, it is critical to ask what effect this program will have in creating, exacerbating, or mitigating information asymmetries within the households,

[45] Personal correspondence with village bank managers and female clients of K-Rep Development Agency in Kenya.

and what are the existing household management roles that may create incentives for one party to take advantage of the changes in information created through the program.

Previous empirical work which observes household outcomes and changes in members' incomes to draw conclusions about underlying gender preferences should be interpreted with caution: such results are not necessarily reflective of intrinsic or immutable preference differences between women and men. Further emphasis on the bargaining process in which men and women interact—in particular the effects of information and communication—and the way in which this process interacts with underlying control structures in the household, can shed greater light on how individual incomes turn into household outcomes.

Appendix

Table A1—Experiment Sample Selection

	Dependent variable: Take-up of experimental offer					
	Male			Female		
Age	−0.001	−0.001	−0.003	−0.000	0.001	−0.001
	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)
Highest grade completed	−0.036	−0.037	−0.054**	0.012	0.014	0.015
	(0.024)	(0.025)	(0.027)	(0.021)	(0.022)	(0.021)
Total household income	0.071	0.069	0.125	0.262**	0.232**	−0.239
	(0.130)	(0.130)	(0.137)	(0.115)	(0.120)	(0.121)
Total self-reported savings	−0.004	−0.004	−0.003	0.002	0.002	0.002
	(0.007)	(0.007)	(0.007)	(0.009)	(0.009)	(0.009)
Own labor and pension income	−0.129	−0.128		−0.400**	−0.362**	
	(0.180)	(0.182)		(0.173)	(0.177)	
Barangay						
Bading Pob	0.085	0.088	0.143	−0.086	−0.085	−0.072
	(0.176)	(0.178)	(0.172)	(0.145)	(0.147)	(0.151)
San Vincente	0.152	0.155	0.115	−0.002	−0.006	0.004
	(0.135)	(0.142)	(0.144)	(0.129)	(0.130)	(0.132)
Pagatpatan	0.178	0.179	0.109	−0.127	−0.157	−0.145
	(0.146)	(0.147)	(0.161)	(0.274)	(0.271)	(0.276)
Pangabugan	−0.014	−0.012	0.060			
	(0.177)	(0.178)	(0.173)			
Score of female decision-making power		−0.010			0.111	
		(0.400)			(0.285)	
Wife decides about buying expensive items			−0.055			0.040
			(0.077)			(0.070)
Wife decides about large family purchases			−0.125			−0.021
			(0.096)			(0.079)
Wife decides whether she can work outside the house			0.102			−0.040
			(0.091)			(0.067)
Observations	83	83	83	103	103	103
Mean dependent variable	0.66	0.66	0.66	0.53	0.53	0.53

Notes: A barangay is the smallest political unit and defined community, on average comprising 1,000 individuals. Standard errors in parentheses. Individuals were recruited to take part in the experiment from two samples: (1) Green Bank clients who had taken part in a prior field experiment, and on whom there was prior baseline data; and (2) other Green Bank current and prior clients. This table reports a probit regression of take-up of the experiment on subgroup (1): 201 individuals in this subgroup were approached and asked to bring their spouses into the bank for the experiment; 115 of these individuals showed up (57 percent). To the extent that individuals in this subgroup were originally randomly selected out of a larger pool of Green Bank clients, their selection into the experiment would likely be similar to that of subgroup (2). This table shows the results from a probit regression on a dummy variable for showing up to the experiment conditional on being offered to take part. Fifteen individuals were dropped from the regressions because they had missing data for some observations or, in the case of four individuals, Barangay Pangabugan perfectly predicted failure to take up.

TABLE A2—SUMMARY STATISTICS BY GENDER

	Private	*p*-Value private-public	Public	*p*-Value public-negotiation	Negotiation	*p*-Value private-negotiation
Panel 1. Male						
Age	43.617	0.892	43.333	0.157	46.800	0.198
	(10.271)		(10.217)		(13.559)	
Years married	18.403	0.978	18.344	0.337	20.835	0.328
	(9.907)		(10.432)		(13.286)	
Number of children	3.395	0.259	3.895	0.848	3.979	0.194
	(2.209)		(2.106)		(2.193)	
Highest grade completed	11.040	0.809	10.895	0.004**	9.080	0.004**
	(3.215)		(2.667)		(3.403)	
Daily wage	281.052	0.449	398.288	0.892	431.430	0.482
Median daily wage	(450.978)		(941.965)		(1,407.165)	
Both wife and husband work	0.750	0.692	0.770	0.487	0.700	0.258
	(0.437)		(0.424)		(0.462)	
Work outside the home	1.000	0.571	0.937	0.437	0.940	0.816
	(0.000)		(0.244)		(0.239)	
Wife does the budgeting	0.833	0.319	0.750	0.404	0.820	0.863
	(0.376)		(0.437)		(0.388)	
Wife makes more income than husband	0.312	0.829	0.333	0.571	0.280	0.727
	(0.468)		(0.476)		(0.453)	
Husband turns over all money to wife†	0.645	0.652	0.600	0.806	0.574	0.481
	(0.483)		(0.495)		(0.499)	
Husband turns over some money to wife†	0.229	0.864	0.244	0.226	0.361	0.159
	(0.424)		(0.434)		(0.485)	
Wife controls savings decisions	0.270	0.478	0.208	0.551	0.260	0.904
	(0.449)		(0.410)		(0.443)	
Husband controls savings decisions	0.187	1.000	0.187	0.722	0.160	0.722
	(0.394)		(0.394)		(0.370)	
Couple has conflicts over money	0.333	0.299	0.437	0.161	0.300	0.726
	(0.476)		(0.501)		(0.462)	
Has an account at Green Bank	0.333	0.832	0.354	0.346	0.440	0.248
	(0.476)		(0.483)		(0.501)	
Spouse has account at Green Bank	0.395	0.677	0.354	0.100+	0.520	0.221
	(0.494)		(0.483)		(0.504)	
Couple has joint bank account	0.104	0.135	0.020	0.489	0.100	0.459
	(0.308)		(0.144)		(0.303)	

TABLE A2—SUMMARY STATISTICS BY GENDER (*Continued*)

	Private	*p*-Value private-public	Public	*p*-Value public-negotiation	Negotiation	*p*-Value private-negotiation
Panel 2. Female						
Age	40.541	0.788	41.063	0.112	44.740	0.073*
	(9.635)		(9.336)		(12.965)	
Years married	18.447	0.910	18.205	0.365	20.463	0.403
	(9.932)		(10.291)		(12.599)	
Number of children	3.458	0.389	3.833	0.8410	3.920	0.294
	(2.163)		(2.086)		(2.174)	
Highest grade completed	11.583	0.454	12.085	0.037**	10.700	0.223
	(3.607)		(2.850)		(3.535)	
Daily wage	588.646	0.114	180.95	0.377	431.160	0.674
Median daily wage	(1,738.882)		(195.140)		(1,925.509)	
Both wife and husband work	0.750	0.953	0.723	0.543	0.700	0.514
	(0.437)		(0.452)		(0.462)	
Work outside the home	0.791	0.035	0.787	0.437	0.720	0.224
	(0.410)		(0.413)		(0.453)	
Wife does the budgeting	0.687	0.945	0.680	0.275	0.780	0.304
	(0.468)		(0.471)		(0.418)	
Wife makes more income than husband	0.270	0.950	0.276	0.684	0.240	0.729
	(0.449)		(0.452)		(0.431)	
Husband turns over all money to wife†	0.000	0.652	0.000	0.806	0.000	0.481
	(0.000)		(0.000)		(0.000)	
Husband turns over some money to wife†	0.000	0.864	0.000	0.226	0.000	0.159
	(0.000)		(0.000)		(0.000)	
Wife controls savings decisions	0.312	0.274	0.212	0.331	0.300	0.894
	(0.468)		(0.413)		(0.462)	
Husband controls savings decisions	0.125	0.779	0.106	0.444	0.160	0.625
	(0.334)		(0.311)		(0.370)	
Couple has conflicts over money	0.354	0.773	0.382	0.573	0.440	0.390
	(0.483)		(0.491)		(0.501)	
Has an account at Green Bank	0.520	0.223	0.395	0.044**	0.600	0.435
	(0.504)		(0.494)		(0.494)	
Spouse has account at Green Bank	0.229	0.490	0.291	0.360	0.380	0.107
	(0.424)		(0.459)		(0.490)	
Couple has joint bank account	0.104	0.135	0.062	0.489	0.040	0.459
	(0.308)		(0.244)		(0.197)	

Notes: Standard errors in parentheses.

† Reports by husband. All others are individual reports.

*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

TABLE A3—CASH VERSUS DIRECT DEPOSIT INTO SAVINGS ACCOUNT

	Cash over any savings		Own savings over cash or spouse's savings		Spouse's savings over own savings or cash	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel 1. Male						
Private	−0.166*	−0.031	0.146	0.059	0.021	−0.028
	(0.107)	(0.115)	(0.085)	(0.094)	(0.079)	(0.102)
Negotiation	−0.116	−0.031	−0.024	−0.044	0.139	0.076
	(0.100)	(0.124)	(0.073)	(0.102)	(0.082)	(0.100)
Wife controls savings × Private		−0.443*		0.379*		0.065
		(0.227)		(0.217)		(0.176)
Wife controls savings × Negotiation		−0.302		0.099		0.203
		(0.211)		(0.187)		(0.180)
Wife controls savings decisions		0.282**		−0.083		−0.199**
		(0.132)		(0.117)		(0.085)
Constant	0.667***	0.649**	0.190**	0.018	0.146**	0.331
	(0.070)	(0.304)	(0.052)	(0.230)	(0.052)	(0.240)
Account, education and wage variables (Own and Spouse)	No	Yes	No	Yes	No	Yes
Observations	145	143	145	143	145	143
R^2	0.020	0.085	0.032	0.153	0.024	0.099
Panel 2. Female						
Private	0.052	0.146	0.140	0.054	−0.192**	−0.201**
	(0.101)	(0.112)	(0.088)	(0.103)	(0.070)	(0.077)
Negotiation	−0.021	0.059	0.132	0.071	−0.111	−0.131
	(0.108)	(0.120)	(0.095)	(0.113)	(0.081)	(0.086)
Husband controls savings × Private		−0.440		0.249		0.190
		(0.370)		(0.344)		(0.121)
Husband controls savings × Negotiation		−0.290		0.056		0.233
		(0.335)		(0.251)		(0.175)
Husband controls savings decisions		0.402*		−0.150		−0.251
		(0.258)		(0.212)		(0.097)
Constant	0.511***	0.006	0.255***	0.628**	0.234***	0.366**
	(0.076)	(0.321)	(0.061)	(0.310)	(0.060)	(0.178)
Account, education and wage variables (Own and Spouse)	No	Yes	No	Yes	No	Yes
Observations	144	143	144	143	144	143
R^2	0.004	0.111	0.018	0.120	0.054	0.129

Notes: Bootstrapped standard errors (300 repetitions) in parentheses, on OLS estimation. Wife controls savings × Negotiation is the interaction between Wife controls savings decisions and Negotiation. Husband controls savings × Negotiation is the interaction between Husband controls savings decisions and Negotiation. Wife controls savings decision: variable = 1 if, in response to the question: "Who decides whether money will be saved or it would be spent on something?" the subject answers "wife." Variable = 0 if subject answers "husband" or "husband and wife together." It is the subject's perception of who controls savings decisions in the household; a longer, more precise label for the variable is "Own perception that wife controls savings decisions." Husband controls savings decisions = 1 if the subject answers "husband" in response to "Who decides whether money will be saved or it would be spent on something?" Variable = 0 if subject answers "wife" or "husband and wife together." It is the subject's perception of who controls savings decisions in the household. A longer, more precise label for the variable is "Own perception that husband controls savings decisions." Account, education, and wage variables (own and spouse) consist of all controls from Table 3: own age, spouse's age, own highest grade completed, spouse's highest grade completed, own daily wage, spouse's daily wage, have account at Green Bank, spouse has account at Green Bank, and have joint account. Treatment and interaction results are robust to excluding controls. Spousal variables are as reported by the spouse.

*** Significant at 1 percent. ** Significant at 5 percent. * Significant at 10 percent.

TABLE A4—FOOD INTERACT

	Food over any savings		Own savings over food or spouse's savings		Spouse's savings over own savings or gift for food	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel 1. Male						
Private	−0.348***	−0.222*	0.246**	0.108	0.102	0.114
	(0.097)**	(0.119)	(0.089)	(0.102)	(0.072)	(0.093)
Negotiation	−0.275	−0.166	0.054	−0.015	0.221**	0.182*
	(0.099)	(0.109)	(0.079)	(0.098)	(0.078)	(0.100)
Wife controls savings × Private		−0.467**		0.582**		−0.114
		(0.229)		(0.209)		(0.188)
Wife controls savings × Negotiation		−0.323		0.255		0.067
		(0.203)		(0.189)		(0.198)
Wife controls savings decisions		0.105		−0.114		0.008
		(0.155)		(0.117)		(0.112)
Constant	0.745***	0.968**	0.170***	−0.019	0.085**	0.051
	(0.064)	(0.305)	(0.055)	(0.238)	(0.041)	(0.245)
Account, education and wage variables (own and spouse)	No	Yes	No	Yes	No	Yes
Observations	144	142	144	142	144	142
R^2	0.090	0.168	0.056	0.194	0.052	0.108
Panel 2. Female						
Private	−0.116	−0.023	0.245**	0.160	−0.129*	−0.137**
	(0.099)	(0.114)	(0.100)	(0.108)	(0.067)	(0.075)
Negotiation	−0.137	−0.043	0.225**	0.161	−0.087	−0.118
	(0.102)	(0.116)	(0.095)	(0.110)	(0.070)	(−0.086)
Husband controls savings × Private		−0.307		0.180		0.126
		(0.294)		(0.299)		(0.121)
Husband controls savings × Negotiation		−0.305		0.118		0.187
		(0.294)		(0.253)		(0.178)
Husband controls savings decisions		0.467**		−0.290		−0.177*
		(0.148)		(0.149)		(0.085)
Constant	0.595***	0.420	0.212***	0.287	0.191***	0.292
	(0.070)	(0.285)	(0.063)	(0.310)	(0.058)	(0.184)
Account, education and wage variables (own and spouse)	No	Yes	No	Yes	No	Yes
Observations	143	142	143	142	143	142
R^2	0.015	0.150	0.053	0.164	0.027	0.079

Notes: Please see Table A6 for the main experimental outcomes for the choice of gift certificate for food over direct deposit. This table presents controls and interactions with spousal control. Bootstrapped standard errors (300 repetitions) in parentheses, on OLS estimation. Wife controls savings × Negotiation is the interaction between Wife controls savings decisions and Negotiation. Husband controls savings × Negotiation is the interaction between Husband controls savings decisions and Negotiation. Wife controls savings decision: variable = 1 if, in response to the question: "Who decides whether money will be saved or it would be spent on something?" the subject answers "wife." Variable = 0 if subject answers "husband" or "husband and wife together." It is the subject's perception of who controls savings decisions in the household; a longer, more precise label for the variable is "Own perception that wife controls savings decisions." Husband controls savings decisions = 1 if the subject answers "husband" in response to "Who decides whether money will be saved or it would be spent on something?" Variable = 0 if subject answers "wife" or "husband and wife together." It is the subject's perception of who controls savings decision in the household. A longer, more precise label for the variable is "Own perception that husband controls savings decisions" account, education, and wage variables (own and spouse) consist of all controls from Table 3: own age, spouse's age, own highest grade completed, spouse's highest grade completed, own daily wage, spouse's daily wage, have account at Green Bank, spouse has account at Green Bank, and have joint account. Treatment and interaction results are robust to excluding controls. Spousal variables are as reported by the spouse.

*** Significant at 1 percent. ** Significant at 5 percent. * Significant at 10 percent.

TABLE A5— FULL EXPERIMENTAL OUTCOME

	Private		Public		Negotiation	
	Males $N = 48$	Females $N = 48$	Males $N = 48$	Females $N = 48$	Males $N = 50$	Females $N = 50$
Gift certificate for self versus cash						
200 pesos cash always	0.66	0.61	0.72	0.73	0.86**	0.84**
Gift certificate $\geq$ 200 over 200 cash	0.21	0.26	0.19	0.23	0.12	0.14
GC $<$ 200 over 200 pesos cash	0.13	0.13	0.09	0.04	0.02**	0.02**
WTP for gift certificate for self	5.32	5.43	3.70	1.56	1.00*	1.02*
Gift certificate for food						
Cash	0.56	0.42	0.58	0.52	0.61	0.50
Gift certificate $>$ 200	0.31	0.42	0.27	0.44	0.35	0.44
GC $<$ 200 pesos over 200 pesos cash	0.13	0.17	0.15	0.04**	0.04	0.06*
WTP for gift certificate for food	6.25	7.29	6.25	2.08*	2.04	3.00
Child's savings account versus cash						
Cash	0.62	0.43	0.52	0.56	0.58	0.54
Gift certificate $>$ 200	0.13	0.35	0.29*	0.19*	0.24	0.30
GC $<$ 200 pesos for child's saving account over 200 cash	0.26	0.21	0.18	0.25	0.18	0.16
WTP for gift certificate for child's savings	17.5	15.6	12.5	15.6	12.5	11.00
Gift certificate trade offs						
200 pesos gift certificate for food over 200 pesos gift certificate for self	0.77	0.90	0.71	0.92	0.86*	0.88
200 pesos into child's savings account over 200 pesos gift certificate for self	0.53	0.79	0.54	0.69	0.60	0.58**
200 pesos into child's savings account over gift certificate for food	0.54	0.66	0.52	0.56	0.46	0.50
200 pesos child's savings account over 200 pesos into own savings account	0.54	0.73	0.52	0.60	0.46	0.48**
Time preference						
Patient	0.48	0.48	0.42	0.52	0.38	0.44
Impatient	0.06	0.08	0.10	0.04	0.06	0.06
Impatient now, patient later	0.375	0.354	0.375	0.375	0.400	0.320
Time preference for spouse	0.66	0.66	0.66	0.61	0.59	0.56

Notes: This table shows the full set of experimental outcomes, comparing across treatment conditions using tests. Willingness-to-pay (WTP) variables are determined in the following way: the variable WTP for gift certificate for self is assigned a value of 0 pesos if the subject always chose cash, or chose a gift certificate worth 225 or 200 over 200 cash; 25 pesos if subject preferred to receive a gift certificate worth (minimum) 175 pesos over 200 cash; and 50 if subject answered that s/he would prefer a gift certificate worth (minimum) 150 over 200 cash. Note that this is an underestimate of the actual willingness to give up cash for gift certificates for self and food, as trade-offs were not asked for below 150 pesos. Time-preference variables: patient, impatient, impatient now, patient later refer to time preference questions that were asked in near term and in far term. To ensure that subjects trusted that they would receive the money if they waited, we used certified bank postdated checks (with transaction costs equalized by requiring all subjects to come back three more times to the bank to "sign in" and receive 20 pesos (more than twice their fare to the bank) when they return: once in two week, once in three month, and once in three and a half months. Almost 90 percent of subjects returned for these sign-ins and received their additional 20 pesos each time). Those who were willing to wait for a sum larger than 200 pesos in the near term (in 2 weeks versus now) and in far term (in 14 weeks versus 12 weeks) were classified as patient. Those who always opted for the 200 pesos both now, in the near term, and in 12 weeks, in the long term, were classified as impatient. Those willing to wait in the long term, but wanting the 200 pesos now in the near term, were classified as impatient now, patient later. Time preference for spouse: subjects were asked, through a series of discrete choices, what amount of money should the spouse be willing to wait for two weeks, rather than getting the 200 pesos cash today. Subjects were told that if this decision was the one chosen, this choice would actually be implemented for the spouse. This decision, therefore, elicits a combination of the subject's hope for, and their expectations of, their spouse's behavior.

*** Significant at 1 percent. ** Significant at 5 percent. * Significant at 10 percent.

TABLE A6—MAIN EXPERIMENTAL OUTCOMES: FOOD OVER DIRECT DEPOSIT

	Male			Female		
	Private $N = 48$ (1)	Public $N = 47$ (2)	Negotiation $N = 50$ (3)	Private $N = 48$ (4)	Public $N = 48$ (5)	Negotiation $N = 50$ (6)
Gift certificate for food	0.40	0.74	0.46	0.48	0.58	0.45
Direct deposit in own account	0.42	0.17	0.22	0.46	0.23	0.45
Direct deposit in spouse or joint account	0.19	0.09	0.32	0.06	0.19	0.10
Fisher's exact p-value: private to public	0.003			0.027		
Fisher's exact p-value: public to negotiation		0.006			0.068	
Fisher's exact p-value: private-negotiation			0.095			0.865

Notes: This table presents results from Fisher's exact tests for significant differences in the distribution of choices for a gift certificate for food worth 200 pesos versus direct deposit into an account of one's choice, across the three treatment conditions. The first row is the fraction of individuals who preferred a gift certificate for food over direct deposit of 200 pesos into their own account and 200 pesos deposited into the spouse's/joint account. The second row is the fraction that preferred direct deposit for 200 into their own savings account over either a gift certificate for food worth 200 pesos or a deposit of 200 pesos into the spouse's account. The third row is the fraction that preferred direct deposit for 200 into the spouse's or a joint savings account over a gift certificate for food worth 200 pesos and over deposit of 200 pesos into their own account.

REFERENCES

Akresh, Richard. 2005. "Understanding Pareto Inefficient Intrahousehold Allocations." Institute for the Study of Labor Discussion Paper 1858.

Angrist, Joshua. 2001. "Estimation of Limited Dependent Variable Models with Binary Endogenous Regressors: Simple Strategies for Empirical Practice." *Journal of Business and Economic Statistics*, 19(1): 2–16.

Armendariz de Aghion, Beatriz, and Jonathan Morduch. 2004. "Microfinance: Where Do We Stand?" In *Financial Development and Economic Growth: Explaining the Links,* ed. Charles A. E. Goodhart. London: Palgrave Macmillan.

Ashraf, Nava, Dean Karlan, and Wesley Yin. 2006. "Tying Odysseus to the Mast: Evidence from a Commitment Savings Product in the Philippines." *Quarterly Journal of Economics*, 121(2): 635–72.

Bateman, Ian, and Alistair Munro. 2004. "Testing Economic Models of the Household: An Experiment." University of East Anglia CSERGE Working Paper EDM 04–01.

Becker, Gary S. 1991. *A Treatise on the Family.* Cambridge, MA: Harvard University Press.

Boozer, Michael A., and Markus P. Goldstein, P. 2003. "Poverty Measurement and Dynamics." Unpublished.

Brenner, Suzanne A. 1995. "Why Women Rule the Roost: Rethinking Javanese Ideologies of Gender and Self-Control." In *Bewitching Women, Pious Men: Gender and Body Politics in Southeast Asia,* ed. Aihwa Ong and Michael G. Peletz, 19–50. Berkeley, CA: University of California Press.

Browning, Martin. 2000. "The Saving Behaviour of a Two-Person Household." *Scandinavian Journal of Economics*, 102(2): 235–51.

Browning, Martin, and Pierre-André Chiappori. 1998. "Efficient Intra-Household Allocations: A General Characterisation and Empirical Tests." *Econometrica*, 66(6): 1241–78.

Chen, Joyce. 2006. "Identifying Non-Cooperative Behavior among Spouses: Child Outcomes in Migrant-Sending Households." http://www.agecon.ucdavis.edu/research/seminars/files/chen_paper.pdf.

Chiappori, Pierre-André. 1992. "Collective Labor Supply and Welfare." *Journal of Political Economy*, 100(3): 437–67.

Church, A. Timothy. 1986. *Filipino Personality: A Review of Research and Writings.* De La Salle University Press Monograph Series 6.

de Laat, Joost. 2005. "Moral Hazard and Costly Monitoring: The Case of Split Migrants in Kenya." PhD diss. Brown University.

Djebbari, Habiba. 2005. "The Impact on Nutrition of the Intrahousehold Distribution of Power." Institute for the Study of Labor Discussion Paper 1701.

Dubois, Pierre, and Ethan Ligon. 2005. "Incentives and Nutrition for Rotten Kids: Intrahousehold Food Allocation in the Phillipines." http://www.econ.yale.edu/seminars/develop/tdw03/ligon-030915.pdf.

Duflo, Esther. 2003. "Grandmothers and Granddaughters: Old Age Pension and Intra-Household Allocation in South Africa." *World Bank Economic Review*, 17(1): 1–25.

Duflo, Esther and Udry, Christopher R. 2004. "Intrahousehold Resource Allocation in Côte d'Ivoire: Social Norms, Separate Accounts and Consumption Choices." National Bureau of Economic Research Working Paper 10498.

Dwyer, Daisy, and Judith Bruce. 1988. *A Home Divided: Women and Income in the Third World*. Palo Alto, CA: Stanford University Press.

Echavez, Chona R. 1996. "Women and Factory Work: A Case in Cagayan de Oro City, Philippines." PhD diss. The Australian National University.

English, Leo J. 1986. *Tagalog-English Dictionary.* Mandaluyong City: Cacho Hermanos, Inc.

Gelber, Alexander. 2008. "Taxation and Family Labor Supply." Unpublished.

Goldstein, Markus P., and Christopher R. Udry. 1999. "Agricultural Innovation and Resource Management in Ghana." Final Report to the International Food Policy Research Institute under MP17.

Goldstein, Markus P., and Christopher R. Udry. 1999. "Gender and Land Resource Management in Southern Ghana." Unpublished.

Hoddinott, John, and Lawrence Haddad. 1995. "Does Female Income Share Influence Household Expenditures? Evidence from Côte d'Ivoire." *Oxford Bulletin of Economics and Statistics*, 57(1): 77–96.

Illo, Jeanne F. 1977. *Involvement by Choice: The Role of Women in Development*. Quezon City: Ateneo de Manila University.

Illo, Jeanne F. 1989. "Who Heads the Household? Women in Households in the Philippines." In *The Filipino Woman in Focus: A Book of Readings*, ed. Amaryllis T. Torres, 244–66. Bangkok: UNESCO.

Illo, Jeanne F., and Rona C. Lee. 1991. "Women and Men in a Rainfed Farming Systems Project: The Cahabaan Case." In *Gender Analysis Planning*, ed. Jeanne F. Illo, 65–74. Quezon City: Institute of Philippine Culture.

Iversen, Vegard, Cecile Jackson, Bereket Kebede, Alistair Munro, and Arjan Verschoor. 2006. "What's Love Got to Do with It? An Experimental Test of Household Models in East Africa." Royal Holloway University of London Discussion Paper in Economics 06/01.

Jefremovas, Villia. 2000. "Women Are Good With Money: The Impact of Cash Cropping on Class Relations and Gender Ideology in Northern Luzon, Philippines." In *Women Farmers and Commercial Ventures: Increasing Food Security in Developing Countries*, ed. Anita Spring, 131–50. Boulder, CO: Lynne Reinner.

Jones, Christine. 1986. "Intrahousehold Bargaining in Response to the Introduction of New Crops: A Case Study From North Cameroon." In *Understanding Africa's Rural Households and Farming Systems,* ed. Joyce Lewinger Moock. Boulder,CO: Westview Press.

Laury, Susan K. 2006. "Pay One or Pay All: Random Selection of One Choice for Payment." Georgia State University, Economics Center Working Paper Series 2006–24.

Ligon, Ethan. 2002. "Dynamic Bargaining in Households (With an Application to Bangladesh)." Giannini Foundation Working Paper.

Lundberg, Shelly, and Robert A. Pollak. 1994. "Noncooperative Bargaining Models of Marriage." *American Economic Review*, 84(2): 132–37.

Manser, Marilyn E., and Murray Brown. 1980. "Marriage and Household Decision-Making: A Bargaining Analysis." *International Economic Review*, 21(1): 31–44.

Mazzocco, Maurizio. 2004. "Saving, Risk Sharing, and Preferences for Risk." *American Economic Review*, 94(4): 1169–82.

Mazzocco, Maurizio. 2007. "Household Intertemporal Behaviour: A Collective Characterization and a Test of Commitment." *Review of Economic Studies*, 74(3): 857–95.

McElroy, Marjorie B., and Mary Jean Horney. 1981. "Nash-Bargained Household Decisions: Toward a Generalization of the Theory of Demand." *International Economic Review*, 22(2): 333–49.

McGinn, Kathleen, and Rachel Croson. 2004. "What Do Communication Media Mean for Negotiations: A Question of Social Awareness." In *The Handbook of Negotiation and Culture*, eds. Michele J. Gelfand and Jeanne M. Brett, 334–49. Palo Alto, CA: Stanford University Press.

Medina, Belen T. G. 2001. *The Filipino Family: A Text With Selected Readings*. Quezon City: University of the Philippines Press, 2001.

Papanek, Hanna, and Laurel Schwede. 1988. "Women are Good with Money: Earning and Managing in an Indonesian City." In *A Home Divided: Women and Income in the Third World*, ed. Daisy Dwyer and Judith Bruce. Palo Alto, CA: Stanford University Press.

Pahl, Jahn M. 1983. "The Allocation of Money and the Structuring of Inequality Within Marriage." *The Sociological Review*, 31(2): 237–62.

Pahl, Jahn M. 1990. "Household Spending, Personal Spending and the Control of Money in Marriage." *Sociology*, 24(1): 119–38.

Peters, Elizabeth, A., Sinan Ünür, Jeremy Clark, and William D. Schulze. 2004. "Free-Riding and the Provision of Public Goods in the Family: A Laboratory Experiment." *International Economic Review*, 45(1): 283–99.

Ramirez, Mina M. 1984. *Understanding Philippine Social Realities Through the Filipino Family: A Phenomenological Approach*. Manila: Asian Social Institute Communication Center.

Rangel, Marcos A. 2006. "Alimony Rights and Intrahousehold Allocation of Resources: Evidence from Brazil." *Economic Journal*, 116(513): 627–58.

Thomas, Duncan. 1990. "Intra-household Resource Allocation: An Inferential Approach." *Journal of Human Resources*, 25(4): 635–64.

Thomas, Duncan. 1994. "Like Father, Like Son or Like Mother, Like Daughter: Parental Education and Child Health." *Journal of Human Resources*, 29(4): 950–989.

Udry, Christopher R. 1996. "Gender, Agricultural Production and the Theory of the Household." *Journal of Political Economy*, 104(5): 1010–46.

Woolley, Frances. 2003. "Control over Money in Marriage." In *Marriage and the Economy: Theory and Evidence from Advanced Industrial Societies*, ed. Shoshana A. Grossbard-Shechtman, 105–28. Cambridge: Cambridge University Press.

Zagorsky, Jay L. 2003. "Husbands' and Wives' Views of the Family Finances." *Journal of Socio-Economics,* 32(2): 127–46.

Zelizer, Viviana A. 2005. *The Purchase of Intimacy.* Princeton, NJ: Princeton University Press.

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2. Jing Zhou, Tianhua Xiao. 2018. Analyzing Determinants of Household Financial Decision-Making: Household Stock Investment in China. *Emerging Markets Finance and Trade* **54**:15, 3385-3400. [Crossref]
3. Girum Abebe, Biruk Tekle, Yukichi Mano. 2018. Changing Saving and Investment Behaviour: The Impact of Financial Literacy Training and Reminders on Micro-businesses. *Journal of African Economies* **27**:5, 587-611. [Crossref]
4. Arthur Alik-Lagrange, Martin Ravallion. 2018. Estimating within-cluster spillover effects using a cluster randomization with application to knowledge diffusion in rural India. *Journal of Applied Econometrics* **113**. . [Crossref]
5. Liz Moor, Shireen Kanji. 2018. Money and relationships online: communication and norm formation in women's discussions of couple resource allocation. *The British Journal of Sociology* **3**. . [Crossref]
6. Mequanint B. Melesse, Adane Dabissa, Erwin Bulte. 2018. Joint Land Certification Programmes and Women's Empowerment: Evidence from Ethiopia. *The Journal of Development Studies* **54**:10, 1756-1774. [Crossref]
7. Joshua Blumenstock, Michael Callen, Tarek Ghani. 2018. Why Do Defaults Affect Behavior? Experimental Evidence from Afghanistan. *American Economic Review* **108**:10, 2868-2901. [Abstract] [View PDF article] [PDF with links]
8. Lutfunnahar Begum, Philip J. Grossman, Asadul Islam. 2018. Gender Bias in Parental Attitude: An Experimental Approach. *Demography* **55**:5, 1641-1662. [Crossref]
9. Hwan-sik Choi, Ron A Laschever. 2018. The Credit Card Debt Puzzle and Noncognitive Ability*. *Review of Finance* **22**:6, 2109-2137. [Crossref]
10. Selma Walther. 2018. Noncooperative decision making in the household: Evidence from Malawi. *Journal of Development Economics* **134**, 428-442. [Crossref]
11. Hernán A. Bruno, Javier Cebollada, Pradeep K. Chintagunta. 2018. Targeting Mr. or Mrs. Smith: Modeling and Leveraging Intrahousehold Heterogeneity in Brand Choice Behavior. *Marketing Science* **37**:4, 631-648. [Crossref]
12. Michele Tuccio, Jackline Wahba. 2018. Return migration and the transfer of gender norms: Evidence from the Middle East. *Journal of Comparative Economics* . [Crossref]
13. Tigabu D. Getahun, Espen Villanger. 2018. Labour-Intensive Jobs for Women and Development: Intra-household Welfare Effects and Its Transmission Channels. *The Journal of Development Studies* **54**:7, 1232-1252. [Crossref]
14. Simone Schaner. 2018. The Persistent Power of Behavioral Change: Long-Run Impacts of Temporary Savings Subsidies for the Poor. *American Economic Journal: Applied Economics* **10**:3, 67-100. [Abstract] [View PDF article] [PDF with links]
15. Ingvild Almås, Alex Armand, Orazio Attanasio, Pedro Carneiro. 2018. Measuring and Changing Control: Women's Empowerment and Targeted Transfers. *The Economic Journal* **128**:612, F609-F639. [Crossref]
16. Thomas Joseph, Yaw Nyarko, Shing-Yi Wang. 2018. Asymmetric Information and Remittances: Evidence from Matched Administrative Data. *American Economic Journal: Applied Economics* **10**:2, 58-100. [Abstract] [View PDF article] [PDF with links]

17. Erwin H. Bulte, Robert Lensink, Anne B. Winkel. 2018. The impact of a gender and business training on income hiding: An experimental study in Vietnam. *Journal of Economic Behavior & Organization* **148**, 241-259. [Crossref]
18. Christoph Strupat, Florian Klohn. 2018. Crowding out of solidarity? Public health insurance versus informal transfer networks in Ghana. *World Development* **104**, 212-221. [Crossref]
19. Janina I. Steinert, Juliane Zenker, Ute Filipiak, Ani Movsisyan, Lucie D. Cluver, Yulia Shenderovich. 2018. Do saving promotion interventions increase household savings, consumption, and investments in Sub-Saharan Africa? A systematic review and meta-analysis. *World Development* **104**, 238-256. [Crossref]
20. François Cochard, Hélène Couprie, Astrid Hopfensitz. 2018. What if women earned more than their spouses? An experimental investigation of work-division in couples. *Experimental Economics* **21**:1, 50-71. [Crossref]
21. C. Yiwei Zhang, Abigail B. Sussman. The Role of Mental Accounting in Household Spending and Investing Decisions 65-96. [Crossref]
22. C. Yiwei Zhang, Abigail B. Sussman. 2018. Perspectives on mental accounting: An exploration of budgeting and investing. *Financial Planning Review* **1**:1-2, e1011. [Crossref]
23. Alistair Munro. 2018. INTRA-HOUSEHOLD EXPERIMENTS: A SURVEY. *Journal of Economic Surveys* **32**:1, 134-175. [Crossref]
24. Xavier Giné, Jessica Goldberg, Dan Silverman, Dean Yang. 2018. Revising Commitments: Field Evidence on the Adjustment of Prior Choices. *The Economic Journal* **128**:608, 159-188. [Crossref]
25. Jörg Peters, Jörg Langbein, Gareth Roberts. 2018. Generalization in the Tropics – Development Policy, Randomized Controlled Trials, and External Validity. *The World Bank Research Observer* **33**:1, 34-64. [Crossref]
26. Youjin Hahn, Asadul Islam, Kanti Nuzhat, Russell Smyth, Hee-Seung Yang. 2018. Education, Marriage, and Fertility: Long-Term Evidence from a Female Stipend Program in Bangladesh. *Economic Development and Cultural Change* **66**:2, 383-415. [Crossref]
27. Dean Karlan, Jonathan Zinman. 2018. Price and control elasticities of demand for savings. *Journal of Development Economics* **130**, 145-159. [Crossref]
28. Christian Biener, Martin Eling, Andreas Landmann, Shailee Pradhan. 2018. Can group incentives alleviate moral hazard? The role of pro-social preferences. *European Economic Review* **101**, 230-249. [Crossref]
29. Jawad M. Addoum. 2017. Household Portfolio Choice and Retirement. *The Review of Economics and Statistics* **99**:5, 870-883. [Crossref]
30. Jessica Goldberg. 2017. The effect of social pressure on expenditures in Malawi. *Journal of Economic Behavior & Organization* **143**, 173-185. [Crossref]
31. Thorsten Beck, Haki Pamuk, Burak R. Uras. 2017. Entrepreneurial Saving Practices and Reinvestment: Theory and Evidence. *Review of Development Economics* **21**:4, 1205-1228. [Crossref]
32. Mario Daniele Amore, Danny Miller, Isabelle Le Breton-Miller, Guido Corbetta. 2017. For love and money: Marital leadership in family firms. *Journal of Corporate Finance* **46**, 461-476. [Crossref]
33. Fenella Carpena, Shawn Cole, Jeremy Shapiro, Bilal Zia. 2017. The ABCs of Financial Education: Experimental Evidence on Attitudes, Behavior, and Cognitive Biases. *Management Science* . [Crossref]
34. Matthew W. Carlson, Jason D. Hans. 2017. Maximizing benefits and minimizing impacts: dual-earner couples' perceived division of household labor decision-making process. *Journal of Family Studies* 1-18. [Crossref]
35. Miriam Beblo, Denis Beninger. 2017. Do husbands and wives pool their incomes? A couple experiment. *Review of Economics of the Household* **15**:3, 779-805. [Crossref]

36. Pierre-Andre Chiappori, Maurizio Mazzocco. 2017. Static and Intertemporal Household Decisions. *Journal of Economic Literature* **55**:3, 985-1045. [Abstract] [View PDF article] [PDF with links]
37. Antonia Fernandez, Uma S. Kambhampati. 2017. Shared agency: The dominant spouse's impact on education expenditure. *World Development* **96**, 182-197. [Crossref]
38. Laura Cordisco Tsai. 2017. The Process of Managing Family Financial Pressures Upon Community Reentry Among Survivors of Sex Trafficking in the Philippines: A Grounded Theory Study. *Journal of Human Trafficking* **3**:3, 211-230. [Crossref]
39. Harounan Kazianga, Zaki Wahhaj. 2017. Intra-household resource allocation and familial ties. *Journal of Development Economics* **127**, 109-132. [Crossref]
40. Michael A. Clemens, Erwin R. Tiongson. 2017. Split Decisions: Household Finance When a Policy Discontinuity Allocates Overseas Work. *The Review of Economics and Statistics* **99**:3, 531-543. [Crossref]
41. Patrick Layer, Sven Feurer, Patrick Jochem. 2017. Perceived price complexity of dynamic energy tariffs: An investigation of antecedents and consequences. *Energy Policy* **106**, 244-254. [Crossref]
42. Olivia S. Mitchell, Anita Mukherjee. 2017. Assessing the demand for micropensions among India's poor. *The Journal of the Economics of Ageing* **9**, 30-40. [Crossref]
43. Laura Cordisco Tsai. 2017. Family financial roles assumed by sex trafficking survivors upon community re-entry: Findings from a financial diaries study in the Philippines. *Journal of Human Behavior in the Social Environment* **27**:4, 334-345. [Crossref]
44. Daniel LaFave, Duncan Thomas. 2017. Extended families and child well-being. *Journal of Development Economics* **126**, 52-65. [Crossref]
45. Ashok K. Mishra, Aditya R. Khanal, Samarendu Mohanty. 2017. Gender differentials in farming efficiency and profits: The case of rice production in the Philippines. *Land Use Policy* **63**, 461-469. [Crossref]
46. Laura Cordisco Tsai. 2017. Household Financial Management and Women's Experiences of Intimate Partner Violence in the Philippines. *Violence Against Women* **23**:3, 330-350. [Crossref]
47. C. Leigh Anderson, Travis W. Reynolds, Mary Kay Gugerty. 2017. Husband and Wife Perspectives on Farm Household Decision-making Authority and Evidence on Intra-household Accord in Rural Tanzania. *World Development* **90**, 169-183. [Crossref]
48. John S. Ahlquist, John R. Hamman, Bradley M. Jones. 2017. Dependency Status and Demand for Social Insurance: Evidence from Experiments and Surveys. *Political Science Research and Methods* **5**:01, 31-53. [Crossref]
49. Jonathan Stieglitz, Michael Gurven, Hillard Kaplan, Astrid Hopfensitz. 2017. Why household inefficiency? An experimental approach to assess spousal resource distribution preferences in a subsistence population undergoing socioeconomic change. *Evolution and Human Behavior* **38**:1, 71-81. [Crossref]
50. Angelino C. G. Viceisza. 2016. CREATING A LAB IN THE FIELD: ECONOMICS EXPERIMENTS FOR POLICYMAKING. *Journal of Economic Surveys* **30**:5, 835-854. [Crossref]
51. David W. Johnston, Sonja C. Kassenboehmer, Michael A. Shields. 2016. Financial decision-making in the household: Exploring the importance of survey respondent, health, cognitive ability and personality. *Journal of Economic Behavior & Organization* **132**, 42-61. [Crossref]
52. Marie Boltz, Isabelle Chort. 2016. The Risk of Polygamy and Wives' Saving Behavior. *The World Bank Economic Review* lhw054. [Crossref]
53. Froilan T. Malit, George Naufal. 2016. Asymmetric Information under the Kafala Sponsorship System: Impacts on Foreign Domestic Workers' Income and Employment Status in the GCC Countries. *International Migration* **54**:5, 76-90. [Crossref]

54. N.S. Murshid, G.E. Ely. 2016. Microfinance participation and contraceptive decision-making: results from a national sample of women in Bangladesh. *Public Health* **139**, 141-147. [Crossref]
55. Jenny C. Aker, Rachid Boumnijel, Amanda McClelland, Niall Tierney. 2016. Payment Mechanisms and Antipoverty Programs: Evidence from a Mobile Money Cash Transfer Experiment in Niger. *Economic Development and Cultural Change* **65**:1, 1-37. [Crossref]
56. Lucia Rizzica. 2016. When the Cat's Away The Effects of Spousal Migration on Investments on Children. *The World Bank Economic Review* lhw050. [Crossref]
57. Nathan Fiala, Xi He. 2016. Unitary or Noncooperative Intrahousehold Model? Evidence from Couples in Uganda: Table 1. *The World Bank Economic Review* lhw011. [Crossref]
58. Vellore Arthi, James Fenske. 2016. Intra-household labor allocation in colonial Nigeria. *Explorations in Economic History* **60**, 69-92. [Crossref]
59. Xiaojun Yang, Fredrik Carlsson. 2016. Influence and choice shifts in households: An experimental investigation. *Journal of Economic Psychology* **53**, 54-66. [Crossref]
60. Kristine Husøy Onarheim, Johanne Helene Iversen, David E. Bloom. 2016. Economic Benefits of Investing in Women's Health: A Systematic Review. *PLOS ONE* **11**:3, e0150120. [Crossref]
61. Pamela Jakiela, Owen Ozier. 2016. Does Africa Need a Rotten Kin Theorem? Experimental Evidence from Village Economies. *The Review of Economic Studies* **83**:1, 231-268. [Crossref]
62. Cäzilia Loibl, Tahira K. Hira. Financial Issues of Women 195-203. [Crossref]
63. M. Doepke, M. Tertilt. Families in Macroeconomics 1789-1891. [Crossref]
64. Sarah Anne Reynolds. 2015. Behavioral games and intrahousehold allocation: teenage mothers and their mothers in Brazil. *Review of Economics of the Household* **13**:4, 901-927. [Crossref]
65. Shalini Roy, Jinnat Ara, Narayan Das, Agnes R. Quisumbing. 2015. "Flypaper effects" in transfers targeted to women: Evidence from BRAC's "Targeting the Ultra Poor" program in Bangladesh. *Journal of Development Economics* **117**, 1-19. [Crossref]
66. Musiliu O. Oseni. 2015. Assessing the consumers' willingness to adopt a prepayment metering system in Nigeria. *Energy Policy* **86**, 154-165. [Crossref]
67. Cheryl R. Doss, Ruth Meinzen-Dick. 2015. Collective Action within the Household: Insights from Natural Resource Management. *World Development* **74**, 171-183. [Crossref]
68. Theresa Beltramo, Garrick Blalock, David I. Levine, Andrew M. Simons. 2015. The effect of marketing messages and payment over time on willingness to pay for fuel-efficient cookstoves. *Journal of Economic Behavior & Organization* **118**, 333-345. [Crossref]
69. Jessica B. Hoel. 2015. Heterogeneous households: A within-subject test of asymmetric information between spouses in Kenya. *Journal of Economic Behavior & Organization* **118**, 123-135. [Crossref]
70. Markus M. Grabka, Jan Marcus, Eva Sierminska. 2015. Wealth distribution within couples. *Review of Economics of the Household* **13**:3, 459-486. [Crossref]
71. Jyoti Rai, Jean Kimmel. Gender Differences in Risk Preferences: An Empirical Study using Attitudinal and Behavioral Specifications of Risk Aversion 61-91. [Crossref]
72. Ganesh Seshan, Robertas Zubrickas. 2015. Asymmetric Information about Migrant Earnings and Remittance Flows. *The World Bank Economic Review* lhv032. [Crossref]
73. Antonia Fernandez, Marina Della Giusta, Uma S. Kambhampati. 2015. The Intrinsic Value of Agency: The Case of Indonesia. *World Development* **70**, 92-107. [Crossref]
74. Carolina Castilla. 2015. Trust and Reciprocity between Spouses in India. *American Economic Review* **105**:5, 621-624. [Abstract] [View PDF article] [PDF with links]
75. David Laibson. 2015. Why Don't Present-Biased Agents Make Commitments?. *American Economic Review* **105**:5, 267-272. [Abstract] [View PDF article] [PDF with links]

76. Nava Ashraf, Diego Aycinena, Claudia Martínez A., Dean Yang. 2015. Savings in Transnational Households: A Field Experiment among Migrants from El Salvador. *Review of Economics and Statistics* **97**:2, 332-351. [Crossref]

77. Simone Schaner. 2015. Do Opposites Detract? Intrahousehold Preference Heterogeneity and Inefficient Strategic Savings. *American Economic Journal: Applied Economics* **7**:2, 135-174. [Abstract] [View PDF article] [PDF with links]

78. Catia Batista, Dan Silverman, Dean Yang. 2015. Directed giving: Evidence from an inter-household transfer experiment. *Journal of Economic Behavior & Organization* . [Crossref]

79. Utteeyo Dasgupta, Subha Mani. 2015. Only Mine or All Ours: Do Stronger Entitlements Affect Altruistic Choices in the Household. *World Development* **67**, 363-375. [Crossref]

80. Kate Ambler. 2015. Don't tell on me: Experimental evidence of asymmetric information in transnational households. *Journal of Development Economics* **113**, 52-69. [Crossref]

81. Máximo Torero, Angelino Viceisza. 2015. To remit, or not to remit: that is the question. A remittance field experiment. *Journal of Economic Behavior & Organization* . [Crossref]

82. Miriam Beblo, Denis Beninger, François Cochard, Hélène Couprie, Astrid Hopfensitz. 2015. Efficiency-Equality Trade-off within French and German Couples: A Comparative Experimental Study. *Annals of Economics and Statistics* :117-118, 233. [Crossref]

83. Lars Ivar Oppedal Berge, Kjetil Bjorvatn, Bertil Tungodden. 2015. Human and Financial Capital for Microenterprise Development: Evidence from a Field and Lab Experiment. *Management Science* **61**:4, 707. [Crossref]

84. Luise Görges. 2015. The power of love: A subtle driving force for unegalitarian labor division?. *Review of Economics of the Household* **13**:1, 163. [Crossref]

85. François Cochard, Hélène Couprie, Astrid Hopfensitz. 2014. Do spouses cooperate? An experimental investigation. *Review of Economics of the Household* . [Crossref]

86. J. J. Chen, L. A. Collins. 2014. Let's Talk About the Money: Spousal Communication, Expenditures, and Farm Production. *American Journal of Agricultural Economics* **96**:5, 1272-1290. [Crossref]

87. Nava Ashraf, Erica Field, Jean Lee. 2014. Household Bargaining and Excess Fertility: An Experimental Study in Zambia. *American Economic Review* **104**:7, 2210-2237. [Abstract] [View PDF article] [PDF with links]

88. Maurizio Mazzocco, Claudia Ruiz, Shintaro Yamaguchi. 2014. Labor Supply and Household Dynamics. *American Economic Review* **104**:5, 354-359. [Abstract] [View PDF article] [PDF with links]

89. Rachel Heath. 2014. Women's Access to Labor Market Opportunities, Control of Household Resources, and Domestic Violence: Evidence from Bangladesh. *World Development* **57**, 32-46. [Crossref]

90. Claude d'Aspremont, Rodolphe Dos Santos Ferreira. 2014. Household behavior and individual autonomy: an extended Lindahl mechanism. *Economic Theory* **55**:3, 643-664. [Crossref]

91. M. Menon, F. Perali, M. Veronesi. 2014. Recovering Individual Preferences for Non-Market Goods: A Collective Travel-Cost Model. *American Journal of Agricultural Economics* **96**:2, 438-457. [Crossref]

92. Dean Karlan, Aishwarya Lakshmi Ratan, Jonathan Zinman. 2014. Savings by and for the Poor: A Research Review and Agenda. *Review of Income and Wealth* **60**:1, 36-78. [Crossref]

93. Miriam Beblo,, Christina Boll. 2014. Ökonomische Analysen des Paarverhaltens aus der Lebensverlaufsperspektive und politische Implikationen. *Vierteljahrshefte zur Wirtschaftsforschung* **83**:1, 121-144. [Crossref]

94. Yoko Doi, David McKenzie, Bilal Zia. 2014. Who You Train Matters: Identifying Combined Effects of Financial Education on Migrant Households. *Journal of Development Economics* . [Crossref]

95. Flóra Á Felső, Adriaan R. Soetevent. 2014. Broad and narrow bracketing in gift certificate spending. *European Economic Review* **66**, 284-302. [Crossref]
96. Joost de Laat. 2014. Household allocations and endogenous information: The case of split migrants in Kenya. *Journal of Development Economics* **106**, 108-117. [Crossref]
97. Xun Lu, Halbert White. 2014. Robustness checks and robustness tests in applied economics. *Journal of Econometrics* **178**, 194-206. [Crossref]
98. Francesca de Nicola, Xavier Giné. 2014. How accurate are recall data? Evidence from coastal India. *Journal of Development Economics* **106**, 52-65. [Crossref]
99. Miet Maertens, Ellen Verhofstadt. 2013. Horticultural exports, female wage employment and primary school enrolment: Theory and evidence from Senegal. *Food Policy* **43**, 118-131. [Crossref]
100. Alistair Munro, Bereket Kebede, Marcela Tarazona-Gomez, Arjan Verschoor. 2013. Autonomy and efficiency. An experiment on household decisions in two regions of India. *Journal of the Japanese and International Economies* . [Crossref]
101. Catherine Eckel, Cathleen Johnson, Claude Montmarquette. 2013. Human capital investment by the poor: Informing policy with laboratory experiments. *Journal of Economic Behavior & Organization* **95**, 224-239. [Crossref]
102. B. Kebede, M. Tarazona, A. Munro, A. Verschoor. 2013. Intra-household Efficiency: An Experimental Study from Ethiopia. *Journal of African Economies* . [Crossref]
103. Alistair Munro, Danail Popov. 2013. A portmanteau experiment on the relevance of individual decision anomalies for households. *Experimental Economics* **16**:3, 335-348. [Crossref]
104. Fredrik Carlsson, Peter Martinsson, Ping Qin, Matthias Sutter. 2013. The influence of spouses on household decision making under risk: an experiment in rural China. *Experimental Economics* **16**:3, 383-401. [Crossref]
105. Jennifer Meredith, Jonathan Robinson, Sarah Walker, Bruce Wydick. 2013. Keeping the Doctor Away: Experimental Evidence on Investment in Preventative Health Products. *Journal of Development Economics* . [Crossref]
106. Mohammed Abdellaoui, Olivier l'Haridon, Corina Paraschiv. 2013. Individual vs. couple behavior: an experimental investigation of risk preferences. *Theory and Decision* **75**:2, 175-191. [Crossref]
107. Sarah Adelman. 2013. Keep your friends close: The effect of local social networks on child human capital outcomes. *Journal of Development Economics* **103**, 284-298. [Crossref]
108. Pascaline Dupas,, Jonathan Robinson. 2013. Why Don't the Poor Save More? Evidence from Health Savings Experiments. *American Economic Review* **103**:4, 1138-1171. [Abstract] [View PDF article] [PDF with links]
109. Carolina Castilla,, Thomas Walker. 2013. Is Ignorance Bliss? The Effect of Asymmetric Information between Spouses on Intra-Household Allocations. *American Economic Review* **103**:3, 263-268. [Abstract] [View PDF article] [PDF with links]
110. Isaac Mbiti,, David N. Weil. 2013. The Home Economics of E-Money: Velocity, Cash Management, and Discount Rates of M-Pesa Users. *American Economic Review* **103**:3, 369-374. [Abstract] [View PDF article] [PDF with links]
111. Kyeong Ho Lee, Marc F. Bellemare. 2013. Look Who's Talking: The Impacts of the Intrahousehold Allocation of Mobile Phones on Agricultural Prices. *Journal of Development Studies* **49**:5, 624-640. [Crossref]
112. Jens Bonke. 2013. Pooling of income and sharing of consumption within households. *Review of Economics of the Household* . [Crossref]

113. Alistair Munro, Arjan Verschoor, Amaresh Dubey. 2013. Does working with spouses make teams more productive? A field experiment in India using NREGA. *Economics Letters* **118**:3, 506-508. [Crossref]

114. E. Gummerson, D. Schneider. 2013. Eat, Drink, Man, Woman: Gender, Income Share and Household Expenditure in South Africa. *Social Forces* **91**:3, 813-836. [Crossref]

115. Gustavo J. Bobonis,, Melissa González-Brenes,, Roberto Castro. 2013. Public Transfers and Domestic Violence: The Roles of Private Information and Spousal Control. *American Economic Journal: Economic Policy* **5**:1, 179-205. [Abstract] [View PDF article] [PDF with links]

116. Gary Mortimer. 2013. Rolling in the aisles: a comparative study of male and female grocery shopper typologies. *The International Review of Retail, Distribution and Consumer Research* **23**:1, 1-30. [Crossref]

117. C. Doss. 2013. Intrahousehold Bargaining and Resource Allocation in Developing Countries. *The World Bank Research Observer* **28**:1, 52-78. [Crossref]

118. Pascaline Dupas,, Jonathan Robinson. 2013. Savings Constraints and Microenterprise Development: Evidence from a Field Experiment in Kenya. *American Economic Journal: Applied Economics* **5**:1, 163-192. [Abstract] [View PDF article] [PDF with links]

119. Joyce J. Chen. 2013. Identifying non-cooperative behavior among spouses: Child outcomes in migrant-sending households. *Journal of Development Economics* **100**:1, 1-18. [Crossref]

120. Esther Duflo. 2012. Women Empowerment and Economic Development. *Journal of Economic Literature* **50**:4, 1051-1079. [Abstract] [View PDF article] [PDF with links]

121. Lori Beaman,, Jeremy Magruder. 2012. Who Gets the Job Referral? Evidence from a Social Networks Experiment. *American Economic Review* **102**:7, 3574-3593. [Abstract] [View PDF article] [PDF with links]

122. Fredrik Carlsson, Haoran He, Peter Martinsson, Ping Qin, Matthias Sutter. 2012. Household decision making in rural China: Using experiments to estimate the influences of spouses. *Journal of Economic Behavior & Organization* **84**:2, 525-536. [Crossref]

123. Jonathan Robinson. 2012. Limited Insurance within the Household: Evidence from a Field Experiment in Kenya. *American Economic Journal: Applied Economics* **4**:4, 140-164. [Abstract] [View PDF article] [PDF with links]

124. Hazel Jean L. Malapit. 2012. Why do spouses hide income?. *The Journal of Socio-Economics* **41**:5, 584-593. [Crossref]

125. Diana Fletschner, Dina Mesbah. 2011. Gender Disparity in Access to Information: Do Spouses Share What They Know?. *World Development* **39**:8, 1422-1433. [Crossref]

126. John A. List, Imran Rasul. Field Experiments in Labor Economics 103-228. [Crossref]

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Efficient Intra-Household Allocations and Distribution Factors: Implications and Identification

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This paper provides an exhaustive characterization of testability and identifiability issues in the collective framework in the absence of price variation; it thus provides a theoretical underpinning for a number of empirical works that have been developed recently. We first provide a simple and general test of the Pareto-efficiency hypothesis, which is consistent with all possible assumptions on the private or public nature of goods, all possible consumption externalities between household members, and all types of interdependent individual preferences and domestic production technology. The test is proved to be necessary and sufficient. We then provide conditions for the identification of the sharing rule and the Engel curves of individual household members for a variety of different observational schemes.

1. INTRODUCTION

That a household comprising several adult members with specific preferences does not necessarily behave as a single rational agent should not be an object of debate. We know, at least since Arrow's famous impossibility theorem, that groups do not usually behave as individuals. Yet, for decades, most theoretical and applied microeconomic work on household consumption, labour supply, savings, or fertility behaviour has been based on the assumption that indeed household decisions could be analysed as stemming from a unique, well-behaved utility function; this *is* sometimes known as the unitary assumption. As well as being theoretically suspect, the unitary model is poorly supported; there is now a considerable body of empirical evidence that critical implications of the unitary model are rejected when we test for them. These implications fall into two classes. First we have the Slutsky conditions. For example, a widely cited result on household demand data is that of Browning and Chiappori (1998) who find that Slutsky symmetry is rejected for a Canadian sample of couples but not for samples of single men and single women. This finding suggests that the rejection is due to having the wrong model for couples rather than, say, the choice of functional form, the particular goods modelled, or the way heterogeneity is incorporated since these are the same across the three samples. The second set of results that are problematic for a unitary model is the widespread finding that there are variables that affect household decisions even though they do not impact on preferences nor on budgets

directly. Such variables are usually known as distribution factors. Examples of distribution factors that have been suggested in the literature include relative incomes, relative wages, the "marriage market" environment, and the control of land. The household decisions considered range from expenditures on clothing and children through labour supply and time allocation to outcomes such as child health variables and fertility decisions. A convincing empirical example is the empirical analysis of Lundberg, Pollak and Wales (1997) who consider the effect of a change in the payment of child benefits in the U.K. in the 1980's. This change effectively shifted the payment from fathers to mothers without a major impact on household income. In a unitary model, such a shift in "who gets what" should not lead to changes in household decisions ("income pooling"). Lundberg *et al.* show that, contrary to this, the policy changes caused significant increases in the demands for children and women's clothing as compared to men's clothing.

Recognizing that households might not behave according to the single rational agent model does not mean that there cannot be any restriction on their aggregate consumption or joint labour supply behaviour. Rationality may still be present under one form or another at the household level. The problem is precisely to know under what form. The research programme in this area thus consists of investigating alternative hypotheses about decision making in the household and testing them against each other on the basis of the restrictions they may imply for the household demand and labour supply functions. If some of these hypotheses appear to hold against empirical evidence, it may be expected that the corresponding restrictions on household demand behaviour will permit the identification, at least partially, of the intra-household allocation mechanism and then the welfare of individual household members. One widely used hypothesis is that however household decisions are made, the outcomes are Pareto efficient; this is known as the collective model. This was first proposed by Chiappori (1988, 1992) and Apps and Rees (1988) and has subsequently been elaborated by Browning, Bourguignon, Chiappori and Lechene (1994), Browning and Chiappori (1998), and Chiappori and Ekeland (2006). One of the obvious advantages of this approach is its generality. For example, any axiomatic bargaining approach that takes efficiency as an axiom is nested within the collective framework. A second advantage of the collective model is that it is almost as easy to work with as the unitary model (see Browning and Chiappori, 1998).

The question, of course, is whether this approach is not simply too general; that is, does it generate any testable restrictions at all? Surprisingly enough, several contributions have shown that the collective model, even in its most general version, generates strong testable restrictions on observed behaviour. Two families of tests have been distinguished, depending on whether we observe price variations in the data. In this paper, we shall be exclusively concerned with data environments in which we do not observe price variation.[1] This is typically the case for the standard cross-sectional analysis of consumption patterns, where it is assumed that individuals in the population from which the sample is drawn face identical prices. In this context, testing relies exclusively upon the effect of income and distribution factors. Although simple versions of such tests have been used in various contexts (see Bourguignon, Browning, Chiappori and Lechene, 1993; Browning *et al.*, 1994; and Thomas, Contreras and Frankenberg, 1997), no comprehensive theoretical analyses have been provided so far. The first goal of the present paper is to provide such an analysis. We find that there are surprisingly general and powerful tests. First, a simple general test of the Pareto-efficiency hypothesis is presented, which is consistent with all possible assumptions on the private or public nature of goods, all possible consumption externalities between household members, and all types of interdependent individual preferences and domestic production technology.[2] Moreover, the test is proved to be necessary and sufficient: if it is

1. See Chiappori (1992), Browning and Chiappori (1998), and Chiappori and Ekeland (2006, 2008) for testing if we do have price variation.

2. For a related work, see Dauphin and Fortin (2001).

satisfied, then it is always possible to interpret observed behaviour as if it were stemming from a collective framework with well-chosen preferences. Second, a test is provided of some separability properties in the preceding framework, which are equivalent to considering private goods and egotistic or "caring" agents.

If we do not reject the restrictions for a collective model, then the second major issue concerns identification: when and to what extent is it possible to recover the underlying structure—preferences and the decision process—from observed behaviour? With price variations, an identification result was first derived in the labour supply case by Chiappori (1992), then extended by Blundell, Chiappori, Magnac and Meghir (2000), Chiappori, Fortin and Lacroix (2002), and Chiappori and Ekeland (2008). Without price variations, Browning *et al.* (1994) show that it is possible, using a parametric approach, to identify the intra-household allocation process and individual Engel curves[3] under the Pareto-efficiency hypothesis when the consumption by one household member of at least one good is observed. The second goal of the present paper is to extend these results. Specifically, we provide a series of assumptions under which it is possible to identify the decision process and individual Engel curves. These assumptions allow for different observational regimes. For example, we may not observe anything about allocation within the household or we may observe individual consumptions of a specific good.

In the second section we describe the general structure of the model used to represent consumption decisions in a two-person household. We also introduce a novel type of demand function, which is useful in the subsequent analysis. Section 3 considers testing of the collective model. The main result is that a form of proportionality of the effects of distribution factors is both necessary (a known result) and sufficient for the collective model under a very wide range of circumstances. This establishes that the proportionality property is the full empirical content in an environment with no price variation. Section 4 considers the special case in which some goods are known to be private and household members have caring preferences; this case has been used extensively in the literature. The most important concept in this case is the sharing rule, which assigns total expenditures (rather than goods) to each partner. We establish the empirical implications of this case. Section 5 continues with the caring assumption and considers what happens if we observe the assignment of one or more goods within the household. The most popular candidate for an assignable good is clothing but the assignment of other goods is potentially observable. For example, in household expenditure surveys we usually only observe household expenditures on tobacco, but it would be trivial to also record who is actually smoking. In addition to considering additional tests we also provide some results on the identification of the sharing rule and individual Engel curves. In Section 5 we dispense with assignability assumptions and show the surprising result that, subject to some conditions, we can still recover individual Engel curves and the sharing rule. Even though the identification here is more fragile empirically than when we do observe some assignment, the identification is non-parametric in the sense that it exploits particular features of the collective model and does not rely on any functional form assumptions. The final section concludes.

2. THE BASIC FRAMEWORK

2.1. *Private and public goods*

We consider a two adult household in which the two people are denoted A and B. We assume for the moment that there are n consumption goods and that they all are market goods, which may be consumed either privately or publicly by the two agents. For example, "food" is partly private

3. Without price variation it is clearly impossible to identify preferences, even in a unitary model. The best we can hope for is to identify individual Engel curves.

(in the sense of of consumption being rival) and partly public, since some food preparation costs are shared by both partners. We denote the vector of private consumption by household member m $(= A, B)$ as $\mathbf{q}^m \in \mathbb{R}^n_+$ and the vector of public consumption by $\mathbf{Q} \in \mathbb{R}^n_+$. The household consumption vector of private goods $(\mathbf{q}^A + \mathbf{q}^B)$ is denoted by $\mathbf{q}$, and that of total consumption $(\mathbf{q} + \mathbf{Q})$ by $\mathbf{C}$. Since there is no price variation all prices can be normalized to unity so that the budget constraint is

$$\mathbf{e}'(\mathbf{q}^A + \mathbf{q}^B + \mathbf{Q}) = \mathbf{e}'\mathbf{C} = x$$

where $\mathbf{e}$ is a n-vector of 1's. Here, x can be considered either as total income or, as in standard cross-sectional analysis of consumption patterns, as total household expenditure.

Each person has preferences represented by $u^A(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}; \mathbf{a})$ and $u^B(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}; \mathbf{a})$ respectively, where $\mathbf{a}$ is a vector of characteristics that affects preferences directly. We refer to the $\mathbf{a}$ variables as preference factors. Thus $\mathbf{a}$ might include the age, race, and education of the two agents; regional location; the number and age of children etc. Examples of variables that would *not* usually be thought of as preference factors are the relative wages of the two partners, their relative physical attractiveness, and the local sex ratio. We refer to this preference structure as altruistic preferences because the private consumption of each member enters the preferences of the other. Note though that this might simply reflect positive or negative consumption externalities rather than a true altruistic behaviour. Also, this general formulation does not exclude the possibility that one person does not care about the other. Finally, we assume that utilities are three times continuously differentiable and strongly convex; as a consequence, demand functions are three times continuously differentiable. This assumption is rather mild, in the sense that it cannot be falsified on any finite data set.[4] In summary, no restriction is placed on preferences, beyond assuming that they can be represented by a "smooth" utility function for each adult in the household.

Since individual preferences u^A and u^B generally differ, we need to specify how households make decisions about what to buy and how to assign the private elements of the good; that is, how they choose $\mathbf{q}^A$, $\mathbf{q}^B$, and $\mathbf{Q}$, given the budget constraint.[5] We now introduce the important concept of a distribution factor:

Definition 1. A variable z_k is a distribution factor if it does not enter individual preferences nor the overall household budget constraint but it does influence the decision process.

Thus, distribution factors are variables that affect the choices of $(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q})$ directly and not through preferences or the budget constraint. Theoretical examples include those factors mentioned in the previous paragraph as *not* being preference factors. As discussed in the introduction, several examples of distribution factors can be found in the empirical literature. Distribution factors will play a key role in the following for three reasons. First, the existence of such variables is inconsistent with the traditional, unitary framework—as recognized by the papers cited in the introduction. Second, the influence of distribution factors upon behaviour provides the *only* testable restrictions for the collective model (if we do not have any price variation); this is the first main theme of this paper. Finally, distribution factors are extremely helpful in recovering some features of the intra-household decision process; this is the second major theme of the paper.

Below we denote household demand function for good i by $\xi_i(x, \mathbf{a}, \mathbf{z})$ (where $\mathbf{z}$ is a K-vector of distribution factors). We use this notation when we do not want to distinguish between public

4. Specifically, if one observes a finite number of realizations of income and consumption, there exists an infinitely differentiable Engel curve on which these points are located; see Chiappori and Rochet (1987).

5. We here ignore that the determination of total expenditure (and consequently saving) is itself a household decision and the two partners may have different views on this.

goods (then $\xi_i \equiv Q_i$), aggregate consumption of a private commodity (then $\xi_i = q_i^A + q_i^B$), or even individual consumption (then $\xi_i = q_i^A$ or $\xi_i = q_i^B$). In particular, the general tests described in the next section are valid whatever the particular interpretation. In all that follows we assume that demand functions are continuously differentiable.

2.2. *z-conditional demands*

In considering the restrictions implied by various assumptions below we have found it useful to use a novel type of "conditional" demand function whereby the demand for one good is expressed as a function of the demand for another good as well as total expenditure and preference and distribution factors. Conditional demand functions are often used in demand analysis where we assume a single utility function. In that framework, the demand for one set of goods (the "goods of interest") are conditioned on the price of these goods, total expenditures on these goods, and the quantities of another set of goods (the "conditioning goods"); see Browning and Meghir (1991) for further discussion.

In the extended rational setting considered here, we define a somewhat different type of conditional demand function that turns out to be useful. Consider the demand for good j, $\mathbf{C}_j = \xi_j(x, \mathbf{a}, \mathbf{z})$ where some of the elements of $\mathbf{z}$ may not be observed but at least one is. For example, $\mathbf{z}$ might include relative wages which are often available in survey data and the attractiveness of the wife relative to the husband, which may impact on choices but is never observed. We make the following assumption:

Axiom 1 (Assumption). *There is at least one good j and one observable distribution factor z_k such that $\xi_j(x, \mathbf{a}, \mathbf{z})$ is strictly monotone in z_k.*

The observability is not required for this paragraph, but it is for estimation, which is discussed in the next two paragraphs. Given strict monotonicity, and taking the observable factor to be z_1 the demand function for good j can be inverted on this factor:

$$z_1 = \zeta(x, \mathbf{a}, \mathbf{z}_{-1}, \mathbf{C}_j),$$

where $\mathbf{z}_{-1}$ is the vector of distribution factors without the first element. Now substitute this into the demand for good $i \neq j$:

$$\mathbf{C}_i = \xi_i(x, \mathbf{a}, z_1, \mathbf{z}_{-1}) = \xi_i[x, \mathbf{a}, \zeta(x, \mathbf{a}, \mathbf{z}_{-1}, \mathbf{C}_j), \mathbf{z}_{-1}] = \theta_i^j(x, \mathbf{a}, \mathbf{z}_{-1}, \mathbf{C}_j). \tag{1}$$

Thus the demand for good i can be written as a function of total expenditure, preference factors, all distribution factors but the first, and the quantity of good j. To distinguish this conditioning from the more conventional conditional demands discussed above, we shall refer to them as z-conditional demands. Note that, in the unitary setting, there are no distribution factors, so that z-conditional demands are not defined in this case. Various contributions apply the z-conditional demand approach developed here to collective models; the reader is referred in particular to Dauphin and Fortin (2001), Dauphin, Fortin and Lacroix (2003), Donni (2006), and Donni and Moreau (2007).

When we come to estimate z-conditional demands we have to allow that the quantity variable for good j might be endogenous for the z-conditional demand for good i in equation (1). To overcome this, we note that z_1 is excluded from the latter equation and is hence a natural instrument for $\mathbf{C}_j$. We now discuss the econometrics, which requires that we allow for unobservable sources of variation in demands. We show first that even if we start with a demand model with additive taste shifters, we end up with an inherently non-additive model. Without loss of

generality, take the first good as the conditioning good and suppose that demands take the form

$$\mathbf{C}_i = \xi_i(x, \mathbf{a}, \mathbf{z}) + \varepsilon_i, \tag{2}$$

where the ε_i's are unobservable taste shifters. Using the inversion $z_1 = \zeta(x, \mathbf{a}, \mathbf{z}_{-1}, \mathbf{C}_1 - \varepsilon_1)$ and substituting in an equation with $i \neq 1$ we have

$$\mathbf{C}_i = \xi_i(x, \mathbf{a}, , \zeta(x, \mathbf{a}, \mathbf{z}_{-1}, \mathbf{C}_1 - \varepsilon_1), \mathbf{z}_{-1}) + \varepsilon_i, \tag{3}$$

which is non-additive in $(\varepsilon_1, \varepsilon_i)$ unless we make very strong (linearity) assumptions. This non-separability rules out the use of non-parametric techniques for estimation with endogenous regressors and additive errors, such as Newey and Powell (2003).

Given non-additivity, we may as well consider directly the stochastically non-separable model

$$\mathbf{C}_i = \xi_i(x, \mathbf{a}, \mathbf{z}, \varepsilon_i). \tag{4}$$

The 'error' term ε_i is a conventional index that captures all of the missing preference and distribution variables, as well as unobserved heterogeneity. Inverting (4) for $i = 1$ gives $z_1 = \zeta(x, \mathbf{a}, \mathbf{z}_{-1}, \mathbf{C}_1, \varepsilon_1)$ and substituting, we have

$$\begin{aligned} \mathbf{C}_i &= \xi_i(x, \mathbf{a}, z_1, \mathbf{z}_{-1}, \varepsilon_i) \\ &= \xi_i(x, \mathbf{a}, \zeta(x, \mathbf{a}, \mathbf{z}_{-1}, \mathbf{C}_1, \varepsilon_1), \mathbf{z}_{-1}, \varepsilon_i) \\ &= \theta_i(x, \mathbf{a}, \mathbf{z}_{-1}, \mathbf{C}_1, \varepsilon_1, \varepsilon_i). \end{aligned} \tag{5}$$

The econometric problem that arises in estimating the unrestricted equation of interest, (5), is that one of the regressors, $\mathbf{C}_1$, is not independent of the two "error" terms, $(\varepsilon_1, \varepsilon_i)$. But, as discussed above, we do have a good potential instrument, z_1. This is correlated with $\mathbf{C}_1$ (through (4)) but can be excluded from the equation of interest (5). Non-separable models with endogeneity and a single source of stochastic variation are discussed in Chernuzhukov, Imbens and Newey (2007). Non-separable models with exogenous regressors and multiple sources of stochastic variation are discussed in appendix A of Matzkin (2003). To date, we do not have estimators for the general form in (5), which is non-separable and has multiple sources of stochastic variation. Fortunately, for the case to hand, we have extra structure that we can exploit. Blundell and Powell (2003) discuss a control function approach, which is perfectly suited to the current context. In the first stage, we estimate the first equation (4) using whatever non-parametric or semi-parametric estimator is thought appropriate.[6] A 2SLS approach would then take the prediction from this and plug it into (5) and then estimate ignoring the endogeneity. This leads to inconsistent estimates. In contrast, a control function approach takes estimates of ε_1 from the regression (4) for $i = 1$ and replaces ε_1 in (5) with these estimates. Then the problem of estimating (5) reduces to the model with endogeneity and one source of stochastic variation (ε_i). The price to pay for this identification is that we have to assume that the instrument z_1 is observed and satisfies stronger independence assumptions than the usual mean independence assumption; see Blundell and Powell (2003) for exact statements.

3. TESTING FOR THE UNITARY AND COLLECTIVE MODELS

3.1. *The unitary model*

In this section we investigate the restrictions imposed on the demand functions, $\xi_i(x, \mathbf{a}, \mathbf{z})$, and their z-conditional counterparts, $\theta_i(x, \mathbf{a}, \mathbf{z}_{-1}, \mathbf{q}_1)$, by the properties that one may be

6. In practice we would also want to instrument total expenditure, x. The conventional instrument to use is some measure of household income.

willing to assume about the intra-household decision process or its outcome. We shall essentially consider three hypotheses: the "unitary" model; the "collective" approach, as characterized by Pareto efficiency of the allocation of goods; and an additional, bargaining type condition. We begin with the unitary model, in which we assume that a unique utility function is maximized. Formally:

Definition 2. Let $(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q})$ be given demand functions of $(x, \mathbf{a}, z)$. These are compatible with unitary rationality if there exists a utility function $U(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}; \mathbf{a})$ such that, for every $(x, \mathbf{a}, \mathbf{z})$, the vector $(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q})$ maximizes $U(\cdot)$ subject to the budget constraint.

The restrictions implied by this framework are trivial. Indeed, it assumes that the household maximizes a single utility function, that represents the "household preferences" in some sense. A consequence is that, by definition, the household demand functions should depend on total expenditure x and the preference factors $\mathbf{a}$, but not on the distribution factors, $\mathbf{z}$. Formally:

Proposition 1. *A given system of demand functions is compatible with unitary rationality if and only if it satisfies*

$$\frac{\partial \xi_i(x, \mathbf{a}, \mathbf{z})}{\partial z_k} = 0 \quad \forall i, k. \tag{6}$$

This condition is an immediate generalization of the "income pooling" hypothesis, which has been tested (and rejected) by, for example, Schultz (1990), Thomas (1990), Bourguignon *et al.* (1993), Browning *et al.* (1994), Fortin and Lacroix (1997), Phipps and Burton (1998), and Lundberg *et al.* (1997).

An important remark is that a model with individual utility functions and a weighted sum of these as the household utility function *is formally a unitary model so long as the weights do not depend on distribution factors*. This fact has two consequences. First, the key insight of collective models is not that the household does not maximize some common index, but rather that this common index, if it exists, will in general depend *directly* on distribution factors (as well as prices and incomes). It is well known, for instance, that the Nash bargaining solution can be expressed as maximizing the product of individual surpluses. The crucial point, however, is that each agent's surplus (and therefore the index that is maximized by the household) cannot be seen as a "household utility" in the unitary sense because it involves the agent's status quo point, which typically varies with income and distribution factors.

A second and more surprising implication of this result is the following. Consider a model of collective decision making in which the household maximizes a weighted sum of individual utilities, the weights being functions of household income but *not* of distribution factors. Although this model does *not* belong to the unitary class (since the index maximized by the household is income dependent), it is observationally equivalent to a unitary setting, in the sense that any demand function $\xi_j(x, \mathbf{a}, \mathbf{z})$ it generates could alternatively be generated by a unitary framework. This paradoxical conclusion is due to the specific nature of the problem and more precisely to the absence of price variations.[7] This stresses the fact that on cross-sectional data without price variations, distribution factors are indispensable to distinguish between the unitary and the collective setting.

7. On the contrary, it can readily be checked that when price variations are available, the demand stemming from a model entailing income-dependent weights will not in general satisfy Slutsky symmetry.

3.2. *The collective approach*

We now consider the more general framework, in which we explicitly recognize that the household consists of two members with potentially different preferences. Our *only* assumption, at this stage, is that the intra-household decision process, whatever its particular features, always leads to a Pareto-efficient outcome. This hypothesis characterizes what we call "collective rationality". Let us state it formally:

Definition 3. Let $(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q})$ be given functions of $(x, \mathbf{a}, \mathbf{z})$. These are compatible with collective rationality if there exist two utility functions $u^A(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}; \mathbf{a})$ and $u^B(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}; \mathbf{a})$ such that, for every $(x, \mathbf{a}, \mathbf{z})$, the vector $(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q})$ is Pareto efficient. That is, for any other bundle $(\tilde{\mathbf{q}}, \tilde{\mathbf{q}}^B, \tilde{\mathbf{Q}})$ such that

$$u^m(\tilde{\mathbf{q}}^A, \tilde{\mathbf{q}}^B, \tilde{\mathbf{Q}}; \mathbf{a}) \geq u^m(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}; \mathbf{a})$$

for $m = A, B$ (with at least one strict inequality), then

$$\mathbf{e}'(\tilde{\mathbf{q}}^A + \tilde{\mathbf{q}}^B + \tilde{\mathbf{Q}}) > \mathbf{e}'(\mathbf{q}^A + \mathbf{q}^B + \mathbf{Q}).$$

This definition is quite general since no assumption whatsoever is made upon the form of individual preferences, the public or private nature of consumption goods, or particular features of the intra-household decision process (beyond efficiency). Yet, strong restrictions on household demand functions are obtained.

Our first important result is stated in the following proposition, which provides a *necessary and sufficient* characterization for collective demands in a cross-sectional context:

Proposition 2. *Consider a point $P = (x, \mathbf{a}, \mathbf{z})$ at which $\frac{\partial \xi_i}{\partial z_1} \neq 0$ for all i. Without a priori restrictions on individual preferences $u^m(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}; \mathbf{a})$, $m = A, B$, a given system of demand functions is compatible with collective rationality in some open neighbourhood of P if and only if either $K = 1$ or it satisfies any of the following equivalent conditions:*

(i) *there exist real valued functions $\Xi_1, \ldots, \Xi_n$ and μ such that*

$$\xi_i(x, \mathbf{a}, \mathbf{z}) = \Xi_i[x, \mathbf{a}, \mu(x, \mathbf{a}, \mathbf{z})] \quad \forall i, \tag{7}$$

(ii) *household demand functions satisfy*

$$\frac{\partial \xi_i / \partial z_k}{\partial \xi_i / \partial z_l} = \frac{\partial \xi_j / \partial z_k}{\partial \xi_j / \partial z_l} \quad \forall i, j, k, l, \quad \textit{and} \tag{8}$$

(iii) *there exists at least one good j such that*

$$\frac{\partial \theta_i^j(x, \mathbf{a}, \mathbf{z}_{-1}, \mathbf{q}_j)}{\partial z_k} = 0 \quad \forall i \neq j \quad \textit{and} \quad k = 2, \ldots, K. \tag{9}$$

When all consumptions are private, condition (8), which is usually known as the proportionality condition, has been known to be necessary for quite a long time (see Bourguignon *et al.*, 1993; Browning *et al.*, 1994; and Thomas *et al.*, 1997). Proposition 2 extends existing results in three directions. First, it shows that the condition is necessary even in the most general case (with public consumption, externalities etc.). Second, it provides equivalent versions of the conditions,

in particular, the z-conditional form. Third and most importantly, it shows that these conditions are also sufficient, in the sense that any demand function satisfying them is compatible with collective rationality.

How should Proposition 2 be interpreted? The basic idea is that, by definition, distribution factors do not influence the Pareto set. They may affect consumption, but only through their effect upon the *location* of the final outcome on the Pareto frontier—or, equivalently, upon the *respective weighting* of each member's utility that is implicit in this location. The key point is that this effect is one-dimensional. This explains why restrictions appear only in the case where there is more than one distribution factor. Whatever the number of such factors, they can only influence consumption through a single, real-valued function $\mu(\cdot)$. This is what is expressed by the condition (7).

This simple idea has two important consequences. First, let us compute q_i as a z-conditional function of $(x, \mathbf{a}, \mathbf{q}_j, z_{-1})$. Then collective rationality implies that it should not depend on $\mathbf{z}_{-1}$. The reason is that, for given values of x and $\mathbf{a}$, whenever distribution factors $(z_1, \mathbf{z}_{-1})$ contain some information that is relevant for intra-household allocation (hence for household behaviour), this information, which is one-dimensional (as we have seen above), is *fully* summarized by the value of q_j. Once we condition on q_j, $\mathbf{z}_{-1}$ becomes irrelevant. This is the meaning of condition (9).

A second, very important consequence relates to the question of the number of distribution factors to be taken into account. At the level of generality considered here, Proposition 2 says that at least two distribution factors are needed to test the hypothesis of collective rationality. Thus, in full generality, collective rationality imposes *no* restriction on household demand functions in the case where there is only one distribution factor. Now, this does not mean that no other restrictions can possibly be found, but rather that such restrictions require some *additional assumptions* to be made upon the form of individual preferences $u^m(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}; \mathbf{a})$, $m = A, B$. In particular, we shall see below that further restrictions appear in the case of a single distribution factor—and come in addition to those in Proposition 2 in the case of more than one distribution factor—when some goods are private and/or consumed exclusively by one member of the household.

Proposition 2 provides two distinct ways of testing for the collective conditions. The first, condition (8), relies on testing for cross-equation restrictions in a system of unconditional demand equations. The other method, based on (9), tests for exclusion restrictions in a z-conditional demand framework. Empirically, the latter is likely to be more powerful for at least two reasons. First we can employ single-equation methods (including non-parametric methods). Second, single equation exclusion tests are more robust than tests of the equality of parameters across equations. As an illustration, assume that the household has three sources of *exogenous* income, (y^A, y^B, y^H) with $x = y^A + y^B + y^H$. Then, while x does enter the budget constraint, the two individual income sources, y^A and y^B (or equivalently their relative sizes y^A/x and y^B/x) do not, and can be taken as distribution factors. Hence Proposition 2 applies. In the present case, the partial derivatives in (8) and (9) may be interpreted as the household "marginal propensity to consume" a given good with respect to the various components of household income. The unitary model would require that these propensities be equal for all goods. Through condition (8), collective rationality requires that these marginal propensities to consume must be proportional *across all goods*, whereas condition (9) requires them to be 0, conditionally on the demand for another good.

Note that Proposition 2 generalizes easily to the Beckerian framework in which domestic goods produced by the household are taken into account. Adding a domestic production function to go from the market inputs to the goods actually consumed by household members and taking into account the allocation of domestic labour gives the restrictions on household demands for market goods derived above.

3.3. *Bargaining*

Many papers that have analysed intra-household decision processes have assumed a bargaining framework (see, for example, Manser and Brown, 1980; and McElroy and Horney, 1981). If we take an axiomatic approach and include efficiency as one of our axioms then necessarily the bargained outcome will satisfy the conditions in Proposition 2. Of course, the bargaining framework should be expected to impose *additional* restrictions. Chiappori and Donni (2006) show, however, that such additional restrictions exist only insofar as specific assumptions are made on the bargaining process and specifically on the nature of the status quo point. Indeed, any efficient outcome can be constructed as a bargaining solution for well-chosen status quo values. An easy example of a specific assumption of this kind is the following. Assume that some distribution factors are known to be positively correlated with member B's (resp. A's) threat point. Then, in programme (P), μ should be increasing (resp. decreasing) in that distribution factor. Taking derivatives through (7) with respect to z_1 and z_2 gives the following proposition.

Proposition 3. *Assume that μ is known to be increasing in z_1 and decreasing in z_2. Then the demand functions consistent with any bargaining model are such that*

$$\frac{\partial \xi_i/\partial z_1}{\partial \xi_i/\partial z_2} = \frac{\partial \xi_j/\partial z_1}{\partial \xi_j/\partial z_2} \leq 0 \quad \forall i = 1, \ldots, n; j = 1, \ldots, n.$$

Thus if we assume *a priori* that two distribution factors have these properties then we have a further testable restriction. The obvious factors to take are the incomes of the two partners. Indeed, if we are willing to go further and assume that it is only the relative value of these incomes, z_1/z_2 that matters then we have in addition

$$\frac{\partial \xi_i}{\partial \ln(z_1)} + \frac{\partial \xi_i}{\partial \ln(z_2)} = 0 \quad \forall i = 1, \ldots, n.$$

This is simple to test and easy to interpret. As an illustration, Browning *et al.* (1994) test the above restrictions on Canadian data and find they are not rejected.

3.4. *Examples*

To round off this section we present two parametric examples. To simplify the exposition we shall assume that there are no preference factors **a** and that there are exactly two distribution factors, z_1 and z_2. We first model the unrestricted household demands as a quadratic in (x, z_1, z_2):

$$\xi_i = a_i + b_i x + c_i x^2 + d_i z_1 + e_i z_2 + f_i z_1^2 + g_i z_2^2 + h_i x z_1 + k_i x z_2 + l_i z_1 z_2. \tag{10}$$

The restrictions implied by the unitary model are simply $d_i = e_i = \ldots = l_i = 0$. The restrictions implied by collective rationality (condition (8)) are a little more difficult to determine. We can show that the ξ_i must be of one of the following two forms:

$$\xi_i = a_i + b_i x + c_i x^2 + \lambda_i (d z_1 + e z_2 + f z_1^2 + g z_2^2 + h x z_1 + k x z_2 + l z_1 z_2) \tag{11}$$

or

$$\xi_i = a_i + b_i x + c_i x^2 + \lambda_i (z_1 + \alpha z_2) + \mu_i (z_1 + \alpha z_2)^2 + \omega_i x (z_1 + \alpha z_2) \tag{12}$$

Thus, either all the terms involving the distribution factors z_1 and z_2 must be proportional across all demand functions, or all the demand functions must be quadratic in the same linear

function $(z_1 + \alpha z_2)$ of these factors. It is also easily shown that the z-conditional demands consistent with (12) have the following expression under collective rationality:

$$\theta_i = \alpha_i + \beta_i x + \gamma_i x^2 + \delta_i q_1 + (\phi_i + \psi_i x)\sqrt{1 + \beta x + \gamma x^2 + \delta q_1} \tag{13}$$

(where conditioning is made on q_1). If (11) holds, we have in addition that $\phi_i = \psi_i = 0$. Note that in the absence of theoretical restrictions, z-conditional demands derived from the quadratic demand functions (10) would also involve terms in z_2, z_2^2, xz_2, and $q_1 z_2$ both in the first part of the RHS of (13) and under the square root sign.

As a second example, consider the case where the household demand functions take the following extended Working–Leser form:

$$\xi_i = a_i + b_i x + c_i x \ln x + d_i \ln z_1 + e_i \ln z_2. \tag{14}$$

The associated z-conditional demand functions, conditioning on q_1, are given by

$$\theta_i = \alpha_i + \beta_i x + \gamma_i x \ln x + \delta_i \ln z_2 + \eta_i q_1. \tag{15}$$

It is then easily shown that collective rationality implies that d_i/e_i be the same for all $i = 1, \ldots, n$, or, equivalently, that $\delta_i = 0$ for $i = 2, \ldots, n$.

4. PRIVATE GOODS AND CARING AGENTS

4.1. *The sharing rule*

In the previous section we did not impose any restrictions on preferences (beyond assuming them representable by a utility function) or on the public or private nature of the goods which are consumed. In this section we concentrate on the allocation of private goods across the members of the household. To do so, we impose the following restriction on individual preferences:

$$u^m(\mathbf{q}^A, \mathbf{q}^B, \mathbf{Q}; \mathbf{a}) = \psi^m[\phi^A(\mathbf{q}^A, \mathbf{Q}; \mathbf{a}), \phi^B(\mathbf{q}^B, \mathbf{Q}; \mathbf{a}), \mathbf{a}] \qquad m = A, B. \tag{16}$$

Here A and B have "egotistic" preferences represented by the felicity functions ϕ^A and ϕ^B, respectively, defined over their own consumptions of private and public goods. Both felicity functions enter person m's overall utility function ψ^m. Following Becker (1991) we refer to (16) as caring. In comparison with the general formulation in the preceding sections, we see that this hypothesis is equivalent to a form of separability in the preferences of the two household members. Of course, caring utility functions include the special case of egotistic preferences for which $\psi^m(\phi^A, \phi^B) = \phi^m$.

The caring representation embodies two important sets of restrictions. First, there are no externalities for individual felicities. For many goods this could be questioned. For example, if one person smokes then the other is affected. As another example, if the good is clothing then it may well be that people care about whether their spouse dresses well. Second, the altruism that partners may feel for each other is restricted to work only through their felicity function. That is, one spouse cares only about the other's felicity and not how it is attained; that is, they defer to the other in their choice of goods. If there were an element of non-deference ("you should stop smoking and spend the money saved on exercising") then this would not be captured by this structure. In the following analysis we shall derive the implications of the caring assumption.

We concentrate here on private goods and we ignore the decision concerning public goods $\mathbf{Q}$. One way to proceed would be to condition everywhere on public goods. For the sake of

simplicity, we prefer to assume the following separability property between private goods and public goods in individual preferences:

$$\phi^m(\mathbf{q}^m, \mathbf{Q}; \mathbf{a}) = f^m[v^m(\mathbf{q}^m; \mathbf{a}), \mathbf{Q}; \mathbf{a}) \quad m = A, B. \tag{17}$$

Also, from now on, x denotes total expenditure on private goods: $x = \mathbf{e}'(\mathbf{q}^A + \mathbf{q}^B)$. It must be stressed that all the preceding assumptions are only useful in empirical work if it is possible to distinguish *a priori* public and private goods. In that case, the consumption vectors $\mathbf{q}^A$ and $\mathbf{q}^B$, on one hand, and the vector $\mathbf{Q}$, on the other, are defined on disjoint sets of goods. Such a requirement was not necessary in the preceding section.

We restrict our attention in this section to the case of a *single* distribution factor z. There is no loss of generality in doing so, since we have seen in Proposition 2 that collective rationality implies that various distribution factors affect the intra-household allocation of goods through the one-dimensional factor μ. If demand functions satisfy conditions (7) – (9), the effects of all distribution factors may be summarized into those of a single one. In this case, Proposition 2 has shown that collective rationality was not imposing any restriction to demand functions. Our objective in this section is precisely to show that this is not the case when one restricts individual preferences through assumptions 16 and 17 to the case of private goods and caring agents. Before doing so we introduce the fundamental notion of a sharing rule:

Proposition 4 (Existence of a sharing rule). *Let $(\mathbf{q}^A, \mathbf{q}^B)$ be functions of $(x, \mathbf{a}, z)$ compatible with collective rationality. Assume, in addition, that the corresponding individual utilities satisfy assumptions 16 and 17 above. Then there exists a function $\rho(x, \mathbf{a}, z)$ such that $\mathbf{q}^m$ is a solution to*

$$\max v^m(\mathbf{q}^m; \mathbf{a}) \text{ subject to } \mathbf{e}'\mathbf{q}^m = x^m,$$

with $m = A, B$, $x^A = \rho(x, \mathbf{a}, z)$ and $x^B = x - \rho(x, \mathbf{a}, z)$.

This proposition is a particular case of the general equivalence between a Pareto-optimum and a decentralized equilibrium if there are no externalities or public goods. It thus requires no formal proof. The function $\rho(x, \mathbf{a}, z)$, which denotes the part of total expenditure on private goods that person A receives is the "sharing rule". It describes the rule of budget sharing that the two agents implicitly apply among themselves when choosing a particular Pareto-efficient allocation. Of course, we are not assuming that households of caring agents explicitly use such a sharing rule. Proposition 4 simply states that the outcome of the household allocation process can be characterized in this way.

4.2. *Collective rationality, private goods, and caring: a first characterization*

In Section 2 we showed that all demand functions (for public or private goods) were consistent with collective rationality if there was only one distribution factor. In this section we restrict attention to the case of caring and separable preferences. The natural question arises of whether there are additional restrictions stemming from these hypotheses, which would permit us to test collective rationality, in the case where observed demands depend on only one distribution factor or which would come in addition of those included in Proposition 2 in the case of two or more distribution factors.

The answer is positive. There are additional restrictions that must be satisfied by joint demand functions in the case of private goods and collectively rational caring agents. These can be expressed at different levels of generality. At a basic level, the restriction is equivalent to taking explicitly into account the sharing rule either in direct, or in z-conditional demands. At a higher

level of generality, we shall then see that it is, in fact, possible to recover the sharing rule between caring agents from the observation of their joint demand for private goods, provided these demands satisfy some restrictions. In turn, these restrictions provide a general test of the joint hypothesis of collective rationality, private goods, and caring agents.

The basic restrictions that must be satisfied by joint demand functions are expressed in the following Lemma (preference factors **a** are dropped for convenience).

Proposition 5. *Assume collective rationality,* 16 *and* 17. *Then*

(i) *direct demands must satisfy the following: there exists a real-valued function* ρ *and* $2n$ *real-valued functions* α_i *and* β_i *such that*

$$q_i(z,x) = \alpha_i[\rho(z,x)] + \beta_i[x - \rho(z,x)] \quad \text{for } i = 1,\ldots,n, \tag{18}$$

(ii) *z-conditional demands must satisfy the following: there exist two real-valued functions F and G such that*

$$\theta_i[s+t, F(t)+G(s)] = \theta_i\,[t, F(t)+G(0)] + \theta_i[s, F(0)+G(s)] - \theta_i[0, F(0)+G(0)], \tag{19}$$

for all t, s *in* $\mathbb{R}_+$ *and for* $i = 2,\ldots,n$.

In (18), α_i and β_i are A and B's respective Engel curves for good i. Condition (18) is restrictive because it must be fulfilled across goods for the same function ρ. In (19), t and s represent the total expenditures of A and B, respectively, that is, ρ and $(x-\rho)$, and F and G are the demands for the conditioning good (here taken to be good 1) by A and B, respectively.[8] Again, the testable restriction in (19) is that the functions F and G must be the same across all goods but the conditioning one. Note that this condition does not put any restriction on the individual demands for the conditioning good. An equivalent but more direct set of restrictions will be given in the next subsection.

Although the conditions given in (18) and (19) may appear somewhat involved, they are not too difficult to work with for particular functional forms for θ_i. As an illustration, we may consider again the case of Working–Leser demand equation (14) above:

$$\xi_i = a_i + b_i x + c_i x \ln x + d_i \ln z_1 + e_i \ln z_2$$

$$\theta_i = \alpha_i + \beta_i x + \gamma_i x \ln x + \delta_i \ln z_2 + \eta_i q_1.$$

As we have seen, collective rationality imposes $\delta_i = 0$, which is equivalent to the d_i's and e_i's being proportional across goods. Now, let us consider (19). We have that

$$\begin{aligned}\theta_i &= \alpha_i + \beta_i(t+s) + \gamma_i(t+s)\ln(t+s) + \eta_i.[F(t)+G(s)]\\ &= \alpha_i + \beta_i t + \gamma_i t \ln t + \eta_i[F(t)+G(0)] + \alpha_i + \beta_i s\\ &\quad + \gamma_i s \ln s + \eta_i[F(0)+G(s)] - \alpha_i - \eta_i[F(0)+G(0)],\end{aligned}$$

which gives

$$\gamma_i(t+s)\ln(t+s) = \gamma_i t \ln(t) + \gamma_i s \ln(s).$$

8. With a single distribution factor and no preference factors there are only two arguments in the z-conditional demands.

This imposes that $\gamma_i = 0$ for $i > 1$, so that the three sets of coefficients c_i, d_i, and e_i must now be proportional. Then direct demands become

$$\xi_i = \mathbf{a}_i + b_i x + r_i \pi, \quad \text{where } \pi = x \ln x + d \ln z_1 + e \ln z_2.$$

5. EXCLUSIVE AND ASSIGNABLE GOODS

5.1. *One exclusive good*

The analysis of the previous section assumes that we only observe household demands for private goods and not their allocation between partners. We now enrich the data environment by assuming that some assignability is observable. We start with two particular cases where some information is available about *individual* consumption of household members. This provides new tests and alternative ways of recovering the sharing rule. While, in principle, rather specific (and somewhat tedious to go through), these cases are empirically very important; most existing empirical analyses rely on assumptions of this type.

We may, in some cases, observe how much of a particular good each person consumes; this good is then said to be "assignable". For instance, we may observe independently male and female clothing expenditures or individual food consumptions. Alternatively, some goods may be consumed by one person only. This is the "exclusive" case. One example would be information on the smoking or drinking patterns of one household member, provided that the same commodity is not consumed by the spouse—an idea reminiscent of Rothbarth's "adult goods" assumption. Note that in the present framework with no price variation, an assignable good can always be thought of as a pair of exclusive goods, one being consumed by A and the other by B.[9]

Before considering successively these two cases, we may stress their common feature. Whenever one good is known to be exclusively consumed by one member (member A, say), this provides some information on the sharing rule, as described in the following proposition.

Proposition 6 (One exclusive good). *Assume collective rationality and* 16 *and* 17. *If the consumption of exactly one exclusive good (consumed by member A) is observed, and if the demand function of member A for this good is strictly monotone, then we can recover the sharing rule* $\rho(z, x)$ *up to a strictly monotone transformation. That is, if* $\rho(z, x)$ *is one solution, then any solution is of the form* $F[\rho(z, x)]$, *where* F *is strictly monotone.*

Note that if the implicit individual demand function is not (globally) monotone, then the result holds on any subset of income and distribution factors over which the demand function is monotone. In particular, the result holds locally almost everywhere.

The next step, of course, is to identify the transformation $F(\cdot)$. This is what is done in the remainder of this section. Notice, however, that, except in the case where all goods are assignable, and therefore the total (private) consumption of both members can be observed, the sharing rule can only be identified up to an additive constant. In all the other cases, we can only observe how the sharing rule changes with total expenditure, x, and the distribution factor, z, but not total individual expenditures (see Chiappori, 1992 for a precise statement).

The preceding proposition suggests that it is more convenient to use z-conditional rather than direct-demand functions wherever a good may be safely assumed to be exclusive. Indeed, conditioning on that good is equivalent to considering combinations of z and x such that the sharing rule is constant and should permit us to easily identify the individual Engel curves for

9. If we have prices, then the pair of "exclusive" goods associated with an assignable good always have the same price.

non-exclusive or non-assignable goods. This explains why many of the following propositions are expressed in terms of z-conditional demands.

5.2. *One assignable good*

We begin with the simplest case in which we observe both members' respective consumptions of an assignable good (or, equivalently, of an exclusive good for member *A and* an exclusive good for member *B*). Then the following restrictions on the two observed demand functions must hold.

Proposition 7 (One assignable good). *Assume collective rationality,* 16 *and* 17. *Assume in addition that good 1 is an exclusive good consumed by member A and that good 2 is an exclusive good consumed by member B. Consider an open set on which the demand for good 2, z-conditional on that for good 1 is such that $\frac{\partial \theta_2}{\partial x} \neq 0$ and $\frac{\partial \theta_2}{\partial q_1} \neq 0$. Then the following, equivalent properties hold:*

(i) *there exists a function $F(t)$ satisfying*

$$\theta_2[t+s, F(t)] = \theta_2[s, F(0)] \tag{20}$$

for all non-negative s and t,

(ii) *there exist two functions $\beta(\cdot)$ and $g(\cdot)$ such that*

$$\theta_2(x, q_1) = \beta[x - g(q_1)], \tag{21}$$

(iii) *θ_2 satisfies*

$$\frac{\partial}{\partial x}\left[\frac{\partial \theta_2/\partial q_1}{\partial \theta_2/\partial x}\right] = 0. \tag{22}$$

This proposition provides a way of testing collective rationality, private goods and caring in the case where the consumption of an exclusive good is observed for each household member. The test is presented in terms of z-conditional demand and is most easily implemented for condition (22). For example, if good 1 is women's clothing and good 2 is men's clothing then we work with the demands for men's clothing conditional on total expenditures and women's clothing. If condition (22) is rejected this can be seen as a rejection of the caring assumption or the assumption that clothing is a private good (recall that we cannot reject the collective model with a single distribution factor).

The transposition to direct demand can be made by the change of variables $(x, q_1) \to (x, z)$ based on the observation of the direct demand function for good 1, $q_1(x, z)$. Likewise, the sharing rule is easily recovered through that same change of variable. The function $g(q_1)$ in (21) is the amount of private expenditures going to member A. This function is obtained, up to an additive constant, by integrating the following differential equation, which is derived from differentiating (21):

$$g'(q_1) = -\frac{\partial \theta_2/\partial q_1}{\partial \theta_2/\partial x}. \tag{23}$$

Then replacing q_1 by its direct demand expression $q_1(x, z)$ yields the sharing rule

$$\rho(x, z) = g[q_1(x, z)].$$

It is also possible to use direct demand functions throughout, as shown in the following.

Proposition 8 (Recovering the sharing rule with one assignable good). *Assume collective rationality,* 16 *and* 17, *and that q_1 and q_2 are consumed exclusively respectively by members*

A and B. Assume that the direct demand for both goods (as functions of x and z) are observed and that the corresponding conditional demand for good 2, $\theta_2(x, q_1)$ fulfills the conditions of Proposition 7. Then, the sharing rule is given, up to an additive constant, by the following equivalent differential equations:

(i)

$$g'(q_1) = -\frac{\partial\theta_2/\partial q_1}{\partial\theta_2/\partial x} \tag{24}$$
$$\rho(x, z) = g[q_1(x, z)]$$

(ii)

$$\frac{\partial\rho}{\partial x} = \frac{\frac{\partial q_1/\partial x}{\partial q_1/\partial z}}{\frac{\partial q_1/\partial x}{\partial q_1/\partial z} - \frac{\partial q_2/\partial x}{\partial q_2/\partial z}} \tag{25}$$
$$\frac{\partial\rho}{\partial z} = \frac{1}{\frac{\partial q_1/\partial x}{\partial q_1/\partial z} - \frac{\partial q_2/\partial x}{\partial q_2/\partial z}}.$$

Several remarks are in order. First, it is possible in the present case to recover not only the sharing rule, but also the Engel curves for each individual, up to an additive constant. Note that this identification result still holds when, say, the preferences are identical for the two household members, or when they are linear. With an assignable good, it is therefore possible to identify the sharing rule, and the Engel curves, up to a constant with no restriction at all on preferences; as we will see later, this is not possible in the general case. Secondly, the identification of the sharing rule and individual Engel curves can be performed using only the observed marginal propensities to consume out of the total budget and out of the distribution factor. In other words, identification requires use of only the first derivatives of the observed demand functions and does not rely upon non-linearities. This is important, since identification based upon non-linearities is generally less robust. Finally, since condition (25) allows us to compute the two partials of ρ independently, the cross derivative conditions $\frac{\partial}{\partial x}\left(\frac{\partial\rho}{\partial z}\right) = \frac{\partial}{\partial z}\left(\frac{\partial\rho}{\partial x}\right)$ generate cross equation restrictions on the demands q_1 and q_2. One can readily check that these are equivalent to the conditions of Proposition 7.

5.3. *One exclusive good and one private good*

A less demanding assumption is that one good only is known to be exclusive. This may be particularly adequate whenever the private nature of some consumption is debatable. For instance, Browning *et al.* (1994) assume that female clothing is indeed an exclusive consumption, whereas they allow for a public good component in male clothing. We thus consider a situation in which the (individual) consumption of an exclusive good and the aggregate consumption of a private non-assignable good are observed.

As before, the restrictions implied by collective rationality turn out to be easier to express (and to test) in terms of z-conditional demands. Specifically, the demand for good 2 conditional on good 1 are summarized in the following.

Proposition 9 (One private and one exclusive good). *Assume collective rationality,* 16 *and* 17. *Assume in addition that good 1 is an exclusive good consumed by member A, and that good 2 is a private joint consumption good. Consider an open set on which the z-conditional*

demand $\theta_2(x, q_1)$ *is such that* $\partial^2\theta_2/\partial x^2 \neq 0$ *and* $\partial^2\theta_2/\partial x\partial q \neq 0$. *Then the following, equivalent properties hold*

(i) *there exists a function* $F(t)$ *satisfying*

$$\theta_2[t+s, F(t)] = \theta_2[t, F(t)] + \theta_2[s, F(0)] - \theta_2[0, F(0)] \tag{26}$$

for all positive s *and* t.

(ii) *equivalently, there exist three functions* α, β, *and* g *such that*

$$\theta_2(x, q_1) = \alpha[g(q_1)] + \beta[x - g(q_1)], \tag{27}$$

(iii) *equivalently,* θ_2 *is such that*

$$\frac{\partial}{\partial x}\left[\frac{\partial^2\theta_2/\partial x\partial q}{\partial^2\theta_2/\partial x^2}\right] = 0. \tag{28}$$

The basic difference between the present case and that of an assignable good is essentially that both the identification of the sharing rule and the test for collective rationality, private goods and caring agents now rely on second (rather than first) derivatives of the observed demand functions. They may thus be less robust. For the same reason identification now requires demand functions to be non-linear.

One could also consider other cases where more than a private good, or more than one or two exclusive goods would be observed. As in the general case, these additional observations do not give more information on the sharing rule, but they provide further tests of the joint hypothesis of collective rationality, private goods (and, possibly, exclusiveness of the goods assumed to be so).

5.4. *Examples*

To illustrate the preceding properties consider the case where good 1 is exclusive and the observed demand for it is linear in x and z, and where the observed demand for good 2 is quadratic.

$$q_1 = a_0 + a_1 x + a_2 z$$

$$q_2 = \alpha_0 + \alpha_1 x + \alpha_2 x^2 + \beta_1 z + \beta_2 z^2 + \gamma xz.$$

If only the demand for good 1 is observed then the sharing rule is of the type

$$\rho(x, z) = F(a_1 x + a_2 z),$$

and identification can only be obtained through an additional arbitrary restriction. If both goods 1 and 2 are observed, then it is possible to derive the z-conditional demand for good 2. It is also quadratic in x and q_1:

$$\theta_2 = A_0 + A_1 x + A_2 x^2 + B_1 q_1 + B_2 {q_1}^2 + Cxq_1.$$

If good 2 is exclusive to member B then condition (22) implies that $B_2 = C = 0$ and Proposition 8 yields

$$g'(q_1) = -[B_1 + 2B_2 q_1]/A_1$$

and, after integration

$$g(q_1) = k - [B_1 q_1 + B_2 {q_1}^2]/A_1$$

where k is some constant. The corresponding sharing rule thus is

$$\rho(x,z) = k - [B_1(a_1x + a_2z) + B_2(a_1x + a_2z)^2]/A_1.$$

If good 2 corresponds to the joint consumption of both members, then Proposition 9 applies. Condition (28) does not impose any restriction because the z-conditional demand is quadratic on x and q_1. The sharing rule is given by

$$g'(q_1) = -C/(2A_2); \rho(x,z) = k - [C/(2A_2)](a_1x + a_2z).$$

It is thus linear in x and z. Indeed, this is a particular case of the example analysed in Section 3 of a linear sharing rule consistent with two private goods and quadratic demand functions.

6. ESTIMATION AND TEST FROM JOINT DEMANDS: THE GENERAL CASE

6.1. *The general argument*

The previous results suggest that whenever information is available about individual consumptions, then it is in general possible to recover the sharing rule and individual Engel curves (up to additive constants). We now show a much more surprising result—namely that, generically on preferences, identification obtains *even without information on the assignment of private goods*. Let us start with a single consumption good. According to (18), collective rationality implies that aggregate demand by the two household members is of the form

$$q_i(z,x) = \alpha_i[\rho(z,x)] + \beta_i[x - \rho(z,x)].$$

This leads to the following partial derivatives

$$\frac{\partial q_i}{\partial z} = (\alpha_i' - \beta_i')\frac{\partial \rho}{\partial z}$$
$$\frac{\partial q_i}{\partial x} = (\alpha_i' - \beta_i')\frac{\partial \rho}{\partial x} + \beta_i', \tag{29}$$

where it is assumed that q_i does indeed depend on z. Then from (29), we can compute α_i' and β_i':

$$\alpha_i' = \frac{\rho_z q_{i,x} + (1-\rho_x)q_{i,z}}{\rho_z} \tag{30}$$
$$\beta_i' = \frac{\rho_z q_{i,x} - \rho_x q_{i,z}}{\rho_z},$$

where $q_{i,x}$ is the derivative of q_i with respect to x (and similarly for $q_{i,z}$).

But α_i (resp. β_i) must be a function of $\rho(z,x)$ (resp. $x - \rho(z,x)$). Along the locus holding $\rho(z,x)$ constant, the derivative of α_i' must be equal to 0. This leads to the following partial differential equation in $\rho(z,x)$:

$$\frac{1}{q_{i,z}}\left[q_{i,xx}\rho_z + q_{i,xz}(1-2\rho_x) - q_{i,zz}\frac{\rho_x(1-\rho_x)}{\rho_z}\right]$$
$$= \frac{1}{\rho_z}\left[\rho_{xx}\rho_z + \rho_{xz}(1-2\rho_x) - \rho_{zz}\frac{\rho_x(1-\rho_x)}{\rho_z}\right]. \tag{31}$$

This is a first information on the sharing rule $\rho(z,x)$. If one observes the aggregate demand function of the household for a given good, $q_i(z,x)$, then the sharing rule must satisfy the partial

differential equation (31). Equivalently a test of collective rationality for an observed aggregate demand function $q_i(z,x)$ is that there exists a function $\rho(z,x)$ such that equations (31) hold. However, this equation is rather complex and does not say much on the way the sharing rule depends on the observed demand behaviour for good i.

More can be obtained when the aggregate demand for two goods, rather than a single one, is observed. Without loss of generality, assume these are goods 1 and 2. Then (31) must be satisfied for $i = 1$ and 2. Equalizing the L.H.S. of (31) for $i = 1, 2$ then yields

$$\mathbf{Q}^{12}_{xx} + \mathbf{Q}^{12}_{xz}\frac{1-2\rho_x}{\rho_z} - \mathbf{Q}^{12}_{zz}\frac{\rho_x(1-\rho_x)}{\rho_z^2} = 0 \tag{32}$$

with

$$\mathbf{Q}^{ij}_{at} = \frac{q_{iat}}{q_{iz}} - \frac{q_{jat}}{q_{jz}}.$$

In other words, when two demands are observed, the sharing rule must satisfy two second-order P.D.E.'s; moreover, these can be combined into a first-order P.D.E., so that the sharing rule must equivalently satisfy one first-order and one second-order P.D.E.

A result by Chiappori and Ekeland (2005) guarantees that, generically, (31) and (32) identify ρ, in our case up to a constant and a permutation of members. Intuitively, an equation such as (32) defines ρ up to some boundary condition (say, to some function $f(z) = \rho(z, \bar{x})$ for some given $\bar{x}$). Again in general, the equation (31) will be sufficient to pin down the function f. We provide below an illustration in the case of quadratic demands. Note, however, that identification is only generic. There may exist specific forms for which identification does not obtain, but they are "non-robust". A counterexample is provided below. Finally, overidentifying restrictions are usually generated.

That identification should obtain up to a permutation of members is no surprise: from the observation of aggregate demand, it may be possible to say that one individual in the household is getting $\rho(z,x)$ and has associated Engel curves $\alpha_1, \alpha_2, \ldots$, but certainly not whether that individual is A or B. Formally, one can readily check that whenever some function $\rho(x,z)$ satisfies equations (31) and (32) above, then the function $\bar{\rho}(x,z) = x - \rho(x,z)$ is also a solution. In order to pin down who is who in the absence of assignable or exclusive commodities, a bargaining argument may be used. If the distribution factor is known to favour member A, then ρ represents member A's allocation (instead of member B's) if and only if ρ is increasing in z.

Also, it is clear that recovering the sharing rule, up to a constant, implies at the same time recovering the individual Engel curves. Indeed, equations (30) give the individual marginal propensity to consume each good i as a function of z and x. Integrating these equations yields the individual curves up to a constant, and, of course, up to a permutation of the two individuals.

6.2. *The linear case as a non-generic exception*

Identification is only "generic", in the sense that it relies on the non-linearities of the demand functions. Estimation and tests might then lack robustness. More precisely, the following proposition shows that the identification of the sharing rule and the test of collective rationality is not possible in the case of linear or "quasi-linear" demand functions.

Proposition 10 (Linear and quasi-linear demand systems). *Assume collective rationality,* 16 *and* 17. *The following two properties are equivalent:*

(i) *Direct demands are of the form*

$$q_i = a_i + b_i x + c_i A(z,x), \tag{33}$$

(ii) *Conditional demands are linear*

$$\theta_i = \alpha_i + \beta_i x + \eta_i q_1. \tag{34}$$

Moreover, if these conditions are fulfilled, any function of the form $f[A(y,m)]$*, and any function of the form* $f[m - A(y,m)]$*, where* f *is an arbitrary monotonic transformation, is a possible sharing rule.*

6.3. *A quadratic example*

We now illustrate the previous results on a specific example.[10] We consider the case where the demand functions may be assumed to be quadratic:

$$q_i = a_i + b_i x + c_i x^2 + d_i z + e_i z^2 + f_i xz \qquad i = 1, 2.$$

Then equation (31) can be written as

$$\frac{1}{d_i + ie_i z + f_i x}\left[2c_i\rho_z + f_i(1-2\rho_x) - 2e_i\frac{\rho_x(1-\rho_x)}{\rho_z}\right]$$
$$= \frac{1}{\rho_z}\left[\rho_{xx}\rho_z + \rho_{xz}(1-2\rho_x) - \rho_{zz}\frac{\rho_x(1-\rho_x)}{\rho_z}\right] \tag{35}$$

while (32) becomes

$$\begin{aligned} 0 = {} & \frac{2c_1}{d_1 + 2e_1 z + f_1 x} - \frac{2c_2}{d_2 + 2e_2 z + f_2 x} \\ & + \left(\frac{f_1}{d_1 + 2e_1 z + f_1 x} - \frac{f_2}{d_2 + 2e_2 z + f_2 x}\right)\frac{1-2\rho_x}{\rho_z} \\ & - \left(\frac{2e_1}{d_1 + 2e_1 z + f_1 x} - \frac{2e_2}{d_2 + 2e_2 z + f_2 x}\right)\frac{\rho_x(1-\rho_x)}{\rho_z^2}. \end{aligned} \tag{36}$$

As it turns out, the solution to equations (35) and (36) is linear. Indeed, if ρ_x and ρ_z are constant, so are

$$U = \frac{1-2\rho_x}{\rho_z} \quad \text{and} \quad V = \frac{\rho_x(1-\rho_x)}{\rho_z^2}, \tag{37}$$

so that (32) can be written as

$$\begin{aligned} 0 = {} & \frac{(2c_1 f_2 - 2c_2 f_1 - 2Ve_1 f_2 + 2Ve_2 f_1)}{(d_1 + 2e_1 z + f_1 x)(d_2 + 2e_2 z + f_2 x)}x \\ & + \frac{(4c_1 e_2 - 4c_2 e_1 + 2Uf_1 e_2 - 2Uf_2 e_1)}{(d_1 + 2e_1 z + f_1 x)(d_2 + 2e_2 z + f_2 x)}z \\ & + \frac{2c_1 d_2 + 2Ve_2 d_1 - 2c_2 d_1 + Uf_1 d_2 - Uf_2 d_1 - 2Ve_1 d_2}{(d_1 + 2e_1 z + f_1 x)(d_2 + 2e_2 z + f_2 x)}, \end{aligned}$$

which is satisfied as soon as

$$2c_1 f_2 - 2c_2 f_1 - 2Ve_1 f_2 + 2Ve_2 f_1 = 0$$

$$4c_1 e_2 - 4c_2 e_1 + 2Uf_1 e_2 - 2Uf_2 e_1 = 0$$

$$2c_1 d_2 + 2Ve_2 d_1 - 2c_2 d_1 + Uf_1 d_2 - Uf_2 d_1 - 2Ve_1 d_2 = 0.$$

10. We are grateful to an anonymous referee for suggesting this example to us.

The first two equations give

$$U = 2\frac{c_1 e_2 - c_2 e_1}{e_1 f_2 - e_2 f_1} \quad \text{and} \quad V = \frac{-c_1 f_2 + c_2 f_1}{-e_1 f_2 + e_2 f_1}.$$

One can readily check that the third equation is always satisfied for these values, which shows that the solution is indeed linear.

Knowing U and V, equations (37) enable us to recover the partials ρ_x and ρ_z. If z is favourable to A ($\rho_z > 0$) then the solution is

$$\rho_x = \frac{1}{2} - \frac{1}{2}\frac{U}{\sqrt{4V + U^2}}, \quad \rho_z = \frac{1}{\sqrt{4V + U^2}} \quad \Rightarrow$$

$$\rho = \left(\frac{1}{2} - \frac{1}{2}\frac{U}{\sqrt{4V + U^2}}\right)x + \frac{1}{\sqrt{4V + U^2}}z + K,$$

where K is an arbitrary constant. Finally, one can readily check that (31) holds true as well.

Knowing the sharing rule up to a constant and a permutation, one readily recovers individual Engel curves; in our case, they are quadratic. Specifically, choosing the first solution and setting $K = 0$, we have for $i = 1$:

$$\alpha_1(\rho) = A_1\rho^2 + A_1'\rho + K'$$

$$\beta_1(t) = B_1 t^2 + B_1' t + a_1 - K',$$

where

$$A_1 = \frac{e_1}{2}(4V + U^2) - \frac{\sqrt{4V + U^2}}{U}\left(c_1 - \frac{e_1}{2}(2V + U^2)\right)$$

$$A_1' = \frac{1}{2}d_1(\sqrt{4V + U^2} + U) + b_1$$

$$B_1 = \frac{\sqrt{4V + U^2}}{U}\left[c_1 - \frac{e_1}{4}(\sqrt{4V + U^2} - U)^2\right]$$

$$B_1' = -\frac{1}{2}d_1(\sqrt{4V + U^2} - U) + b_1$$

and K' is a constant. A similar expression obtains for other commodities.

6.4. *More than two commodities*

Finally, if the demand functions of a household are observed for three goods or more, stronger results are obtained. Intuitively, the sharing rule can be identified (up to a constant and a permutation) from the first two commodities; compatibility with the third generates overidentifying restrictions. In fact, the identification is easier than previously, because one can now derive two (or more) first-order PDE's, namely (32) and

$$\mathbf{Q}^{13}_{xx} + \mathbf{Q}^{13}_{xz}\frac{1 - 2\rho_x}{\rho_z} - \mathbf{Q}^{13}_{zz}\frac{\rho_x(1 - \rho_x)}{\rho_z^2} = 0. \tag{38}$$

Therefore, we have a system of two quadratic equations in two scalar unknowns ρ_x and ρ_z. Solving the system gives two solutions for the two partials, which must moreover satisfy

cross-derivative restrictions. The important and remarkable result here is that collective rationality implies enough restrictions on aggregate household demand functions so as to recover the sharing rule and individual Engel curves from the observation of aggregate marginal propensities to consume and the way they change as a function of both total expenditures and the distribution factor.

7. CONCLUSION

In this paper, we have investigated the properties of the "collective" approach to household behaviour. This only relies upon one general assumption: that decisions taken within a household are "cooperative" or "collectively rational", that is, lead to Pareto-efficient outcomes. What we have shown is that this very general setting has considerable empirical implications. It leads in particular to a sequence of tests, which throw some light into the usual black box that is used to analyse household consumption decisions. Remarkably enough, our techniques only require a distinction between those factors, which may be behind the allocation process within the household ("distributions factors") and those that are likely to affect personal preferences. It does not require in particular any knowledge of the actual intra-household allocation of goods. The most general test of cooperation does not even require any assumption on the nature of the goods that are consumed or produced within the household.

The mere interpretation of the distribution factors raises interesting issues. A difficult question, in particular, is the following. Suppose that distribution factors are random variables, which will be realized after the couple's marriage contract has been negotiated. If spouses are risk averse, efficiency requires that these variations be insured away in the marriage contract—in which case the impact on behaviour should be nil.[11] In this context, two types of arguments may justify the role of distribution factors. One is incomplete contracts and unforeseen contingencies; that is, the spouses failed to consider some possible future situations when writing the initial contract. For instance, all British couples who married in the 1960's may not have taken into account the possibility of the reform of child benefits that took place in the 1980's or the changes in divorce settlements that took place in England in the early 2000's, as studied by Kapan (2008). A related but different argument relies on imperfect commitment. Perfect risk sharing relies on the parties' ability to fully commit. In practice, such a complete commitment may be difficult to achieve, if only because people cannot legally commit not to divorce. Under unilateral divorce, therefore, any change in the environment (that is, in the rules governing settlements after divorce) that has a sufficiently large impact on a spouse's reservation utility must lead to a renegotiation of the existing agreement, at least for existing marriages.[12]

A second interpretation of distribution factors relies more on a "comparative statics" perspective. Assume, for simplicity, perfect commitment, and consider agents belonging to two different "marriage markets" (or submarkets); one in which single women are rare, and another in which they are in excess (say, rural Wisconsin versus New York). The distribution of resources between spouses will probably reflect this asymmetry; typically, when many men are competing for a few women, the latter should be able to attract a larger share of household resources. Empirically, when studying a cross-section of such couples, we may then find a correlation between the state of the market for marriage (which will provide the distribution factors needed) and the

11. We are grateful to an anonymous referee for raising this important point.

12. For marriages taking place after the reform, the logic is quite different, because the new rules are taken into account in the design of the marriage contract. Even in that case, however, the reform tends to influence the intra-household allocation; for instance, a reform increasing the settlements obtained by the wife in case of divorce will be compensated by a reduction in the share of marital surplus she will receive while married. See Chiappori, Iyigun and Weiss (2008) for a precise investigation along these lines.

structure of household consumption. This strategy has been used in a number of empirical papers (*e.g.* Chiappori *et al.*, 2002).

Finally, the results presented here are not exhaustive. Additional tests are available when one wants to go further and infer from the joint spending behaviour on private goods by the household some information on who gets what. A general test is available in the case where the analysis is restricted to private goods only. It has even been shown that it is possible, if that test is satisfied, to recover from the observation of joint consumption behaviour, information on the intra-household allocation of these goods and on individual preferences (Engel curves). More information and more restrictive tests may be obtained in the case where at least one individual consumption is observed. Whether those tests are robust and will actually provide more information on intra-household decision processes will be taken up in forthcoming empirical work.

APPENDIX A

Proof of Proposition 2.

Consider first the case where there are at least two distribution factors. From the Pareto-efficiency assumption, demands should be solutions of the following programme:

$$\max_{\mathbf{q}^A,\mathbf{q}^B,\mathbf{Q}} \quad u^A(\mathbf{q}^A,\mathbf{q}^B,\mathbf{Q};\mathbf{a}) + \mu.\, u^B(\mathbf{q}^A,\mathbf{q}^B,\mathbf{Q};\mathbf{a})$$

$$\text{subject to} \quad \mathbf{e}'(\mathbf{q}^A+\mathbf{q}^B+\mathbf{Q}) = x.$$

Here, the set of Pareto-efficient allocations is fully described when μ varies within $\mathbb{R}^n_+$. The particular location of the solution on the Pareto frontier should, of course, be allowed to depend on all relevant parameters: that is, μ will in general be a function of $(x,\mathbf{a},z)$. Household demand functions can thus be written

$$\xi_i(x,\mathbf{a},z) = \Xi_i[x,\mathbf{a},\mu(x,\mathbf{a},z)] \quad \forall i = 1,\ldots,n$$

as stated in condition (7). Then (8) comes from the fact that

$$\frac{\partial\xi_i/\partial z_k}{\partial\xi_i/\partial z_1} = \frac{\partial\mu/\partial z_k}{\partial\mu/\partial z_1} \quad \forall i,k. \tag{39}$$

Finally, in the neighbourhood of any point where a z-conditional demand can be defined, (7) allows us to (locally) express μ as a function of $\mathbf{q}_j$, x, and $\mathbf{a}$. Replacing in the direct demand function for good i leads to (9). Hence (7), (8), and (9) are equivalent necessary conditions for observed demand functions to be consistent with collective rationality.

For sufficiency, note that according to (7) there exists some function $\nu(x,\mathbf{a},z)$ such that $\xi(x,\mathbf{a},z)$ can be expressed as a function $\Xi(x,\mathbf{a},\nu)$ of x, $\mathbf{a}$, and ν alone. Take some arbitrary function $G(\xi_1,\xi_2,\ldots,\xi_n;\mathbf{a})$ that is positive, increasing and quasi-concave with respect to the variables ξ_1. Define then

$$M(x,\mathbf{a},\nu) = G[\Xi_1(x,\mathbf{a},\nu),\ldots,\Xi_n(x,\mathbf{a},\nu)].$$

We will now show that there exist two increasing and quasi-concave utility functions $v^A(\mathbf{Q},\mathbf{a})$ and $v^B(\mathbf{Q},\mathbf{a})$ such that the observed demand functions are solutions of (P) for $\mu(x,\mathbf{a},z) = M[x,\mathbf{a},\nu(x,\mathbf{a},z)]$. Clearly, these utility functions $v^i(X,z)$ are particular cases of the general utility functions $u^i()$ appearing in (P) because they depend only on public goods.

The necessary and sufficient first-order conditions implied by (P) are

$$\forall(x,\mathbf{a},z) \quad D_\xi v^A(\xi,\mathbf{a}) + \mu D_\xi v^B(\xi,\mathbf{a}) = \lambda\mathbf{e},$$

where $D_\xi v^i$ is the gradient of v^i and λ is an arbitrary scalar function of $(x,\mathbf{a},z)$. Define then

$$v^B(\xi,\mathbf{a}) = A(\xi_1+\xi_2+\cdots+\xi_n) + B[(G(\xi,\mathbf{a})]$$

$$v^A(\xi,\mathbf{a}) = \mathbf{C}[(G(\xi,\mathbf{a})],$$

where A, $\mathbf{C}$ are arbitrary, increasing scalar functions and B is a scalar function defined by

$$B'(\mathbf{q}) = -\mathbf{q}\mathbf{C}'(\mathbf{q}).$$

A is taken to be large enough with respect to B so that v^B is increasing. These functions v^A and v^B are thus increasing and quasi-concave. Moreover, it can easily be checked that they satisfy (A1). It follows that the solution of (P) with these functions v^i is the set of observed demand functions $\xi(x, \mathbf{a}, z)$, which satisfy the equivalent conditions (7)–(9) in Proposition 2.

It remains to show that the proposition remains valid in the case where there is only one distribution factor, $K = 1$. On one hand, condition (7) is trivially satisfied since it corresponds to a mere change of variable of z, whereas conditions (8) and (9) become irrelevant. On the other hand, the above sufficiency argument in the case $K > 1$ remains valid when $K = 1$ since it is solely based on condition (7). This shows that in the case of a single distribution factor and without *a priori* restrictions on individual preferences all observed demand functions are consistent with collective rationality. ‖

Proof of Proposition 6.

From (18), an exclusive good consumed by member A is such that

$$\mathbf{q}(\mathbf{z}, x) = \alpha[\rho(\mathbf{z}, x)].$$

The function ρ is thus some transformation of the observed demand function $\mathbf{q}(\mathbf{z}, x)$. ‖

Proof of Proposition 7.

Equation (20) is directly obtained from (19) and the exclusivity condition on good 2. (21) expresses the fact that the demand for good 2 is that of member B and thus depends only on the share of private expenditure going to him/her. The function $g(\mathbf{q}_1)$ in that expression is the share going to member A and thus the inverse of his/her own demand function (as in Proposition 9), which is in fact the function $F(\cdot)$ appearing in (20). Finally, (22) is a translation of (21) into a partial differential equation. Differentiating (21) with respect to x and $\mathbf{q}_1$ yields

$$\partial\theta_2/\partial x = \beta'[x - g(\mathbf{q}_1)]$$

and

$$\partial\theta_2/\partial\mathbf{q}_1 = -g'(\mathbf{q}_1).\beta'[x - g(\mathbf{q}_1)].$$

Assuming that Θ is non-linear in x, we have that

$$g'(\mathbf{q}_1) = -\frac{\partial\theta_2/\partial\mathbf{q}_1}{\partial\theta_2/\partial x}. \tag{40}$$

This must be a function of $\mathbf{q}_1$ alone, which generates condition (22). Reciprocally, (23) implies that $\theta_2(\ )$ is a transformation of a function that is additively separable in x and $\mathbf{q}_1$. ‖

Proof of Proposition 8.

Only a proof of (ii) is needed at this stage. From (18) for exclusive goods we have

$$\mathbf{q}_1(z, x) = \alpha[\rho(z, x)]; \quad \mathbf{q}_2(z, x) = \beta[x - \rho(z, x)].$$

Differentiating the observed demand functions with respect to z and x yields

$$\frac{\partial\mathbf{q}_1}{\partial z} = \alpha'\frac{\partial\rho}{\partial z}$$

$$\frac{\partial\mathbf{q}_1}{\partial x} = \alpha'\frac{\partial\rho}{\partial x}$$

$$\frac{\partial\mathbf{q}_2}{\partial z} = -\beta'\frac{\partial\rho}{\partial z}$$

$$\frac{\partial\mathbf{q}_2}{\partial x} = \beta'\left(1 - \frac{\partial\rho}{\partial x}\right).$$

Solving for ρ_x and ρ_z yields (25). It may be shown that the condition under which that resolution is possible, that is, $\frac{\partial\mathbf{q}^A}{\partial z} \neq 0\ \frac{\partial\mathbf{q}B}{\partial z} \neq 0\ \frac{\partial\mathbf{q}^A/\partial x}{\partial\mathbf{q}^A/\partial z} \neq \frac{\partial\mathbf{q}^B/\partial x}{\partial\mathbf{q}^B/\partial z}$—is equivalent to the z-conditional demand $\theta_2(x, \mathbf{q}_1)$ being well defined, that is, $\partial\theta_2/\partial x \neq 0$; $\partial\theta_2/\partial\mathbf{q} \neq 0$—as in Proposition 8. It may also be shown that the integrability condition of (25), that is, the cross-derivative restriction

$$\frac{\partial}{\partial z}\left(\frac{\frac{\partial\mathbf{q}^A/\partial x}{\partial\mathbf{q}^A/\partial z}}{\frac{\partial\mathbf{q}^A/\partial x}{\partial\mathbf{q}^A/\partial z} - \frac{\partial\mathbf{q}^B/\partial x}{\partial\mathbf{q}^B/\partial z}}\right) = \frac{\partial}{\partial x}\left(\frac{1}{\frac{\partial\mathbf{q}^A/\partial x}{\partial\mathbf{q}^A/\partial z} - \frac{\partial\mathbf{q}^B/\partial x}{\partial\mathbf{q}^B/\partial z}}\right)$$

is equivalent to condition (22) above after a change of variables. ‖

Proof of Proposition 9.

(i) is simply (19). (ii) is a restatement of (18) where $g(\mathbf{q}_1)$ is the share of total expenditures going to member A, given that $\mathbf{q}_1$ is exclusively consumed by him/her. Finally (28) is the partial differential equation expression of (27). The equivalent of relationship (23) above is obtained now by differentiating (27) twice:

$$g'(\mathbf{q}_1) = -\frac{\partial^2\theta_2/\partial\mathbf{q}_1\partial x}{\partial^2\theta_2/\partial x^2}, \tag{41}$$

which leads to (28). Reciprocally (28) implies that θ_{2x} is the transformation of a function that is additively separable in x and $\mathbf{q}_1$. Hence (27).

As in the preceding case, the sharing rule may be easily recovered from the preceding differential equation in x_1 and the direct demand function $\mathbf{q}_1(x,z)$ through $\rho(x,z) = g[\mathbf{q}_1(x,z)]$. As before, it is thus defined up to an additive constant. Things are a little more complex in the present case when one uses direct demand functions, although, as in the preceding case, all properties on z-conditional demands have their counterpart on direct demand functions. We leave these derivations to the interested reader. ‖

Proof of Proposition 10.

That (33) and (34) are equivalent is obvious. Also, for any f, define α_i and β_i by

$$\alpha_i(u) = c_i f^{-1}(u) + b_i u$$

and

$$\beta_i(v) = a_i + b_i v.$$

Then (29) is obviously fulfilled. Note that, in this case, the conditions of Proposition 9 do not apply. Also, it is interesting to note that all equations (30) are proportional, so that considering several consumption goods does not bring additional information. The only way to identify the sharing rule in that case is to observe an assignable good. ‖

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REFERENCES

APPS, P. F. and REES, R. (1988), "Taxation and the Household", *Journal of Public Economics*, **35** (3), 355–369.
BECKER, G. (1991), *A Treatise on the Family* (Cambridge, MA: Harvard University Press).
BLUNDELL, R. and POWELL, J. (2003), "Endogeneity in Nonparametric and Semiparametric Regression Models", in M. Dewatripont, L. P. Hansen and S. J. Turnovsky (eds.) *Advances in Economics and Econometrics: Theory and Applications: Eighth Econometric Society World Congress*, Vol II (Cambridge: Cambridge University Press) 312–357.
BLUNDELL, R., CHIAPPORI, P. A., MAGNAC, T. and MEGHIR, C. (2000), "Discrete Choice and Collective Labor Supply" (Mimeo, UCL).
BOURGUIGNON, F., BROWNING, M., CHIAPPORI, P.-A. and LECHENE, V. (1993), "Intra-Household Allocation of Consumption: A Model and some Evidence from French Data", *Annales d'Économie et de Statistique*, **29**, 137–156.
BROWNING, M. and CHIAPPORI, P.-A. (1998), "Efficient Intra-Household Allocations: A General Characterization and Empirical Tests", *Econometrica*, **66**, 1241–1278.
BROWNING, M. and MEGHIR, C. (1991), "The Effects of Male and Female Labour Supply on Commodity Demands", *Econometrica*, **59** (4), 925–951.
BROWNING, M., BOURGUIGNON, F., CHIAPPORI, P.-A. and LECHENE, V. (1994), "Incomes and Outcomes: A Structural Model of Intra-Household Allocation", *Journal of Political Economy*, **102**, 1067–1096.
CHERNOZHUKOV, V., IMBENS, G. W. and NEWEY, W. (2007), "Instrumental Variable Estimation of Nonseparable Models", *Journal of Econometrics*, **139** (1), 4–14.
CHIAPPORI, P.-A. (1988), "Rational Household Labor Supply", *Econometrica*, **56**, 63–89.
CHIAPPORI, P.-A. (1992), "Collective Labor Supply and Welfare", *Journal of Political Economy*, **100**, 437–467.
CHIAPPORI, P.-A and DONNI, O. (2006), "Learning from a Piece of Pie: The Empirical Content of Nash Bargaining" (Mimeo, Columbia University).
CHIAPPORI, P.-A. and EKELAND, I. (2005), "Non Parametric Identification Using PDEs" (Mimeo, University of Chicago).

CHIAPPORI, P.-A. and EKELAND, I. (2006), "The Microeconomics of Group Behavior: General Characterization", *Journal of Economic Theory*, **130**, 1–26.
CHIAPPORI, P.-A. and EKELAND, I. (2008), "The Microeconomics of Group Behavior: Identification", *Econometrica* (forthcoming).
CHIAPPORI, P. A. and ROCHET, J. C. (1987), "Revealed Preferences and Differentiable Demand", *Econometrica*, **55**, 687–691.
CHIAPPORI, P. A., FORTIN, B. and LACROIX, G. (2002), "Household Labor Supply, Sharing Rule and the Marriage Market", *Journal of Political Economy*, **110** (1), 37–72.
CHIAPPORI, P. A., IYIGUN, M. and WEISS, Y. (2008), "An Assignment Model with Divorce and Remarriage" (Mimeo, Columbia University).
DAUPHIN, A. and FORTIN, B. (2001), "A Test of Collective Rationality for Multi-Person Households", *Economics Letters*, **71** (2), 211–216.
DAUPHIN, A., FORTIN, B. and LACROIX, G. (2003), "A Test of Collective Rationality Within Bigamous Households in Burkina Faso" (Mimeo, Université Laval).
DONNI, O. (2006), "Collective Consumption and Welfare" *Canadian Journal of Economics*, **39** (1), 124–144.
DONNI, O. and MOREAU, N. (2007), "Collective Labor Supply—a Single-Equation Model and Some Evidence from French Data", *Journal of Human Resources*, **42** (1), 214–246.
FORTIN, B. and LACROIX, G. (1997), "A Test of the Unitary and Collective Models of Household Labour Supply", *Economic Journal*, **107**, 933–955.
KAPAN, T. (2008), "Property Division at Divorce and Household Bargaining: The Equitable Distribution Reform in England" (Mimeo, Columbia University).
LUNDBERG, S., POLLAK, R. and WALES, T. (1997), "Do Husbands and Wives Pool Their Resources? Evidence from the UK Child Benefit", *Journal of Human Resources*, **32** (3), 463–480.
MANSER, M. and BROWN, M. (1980), "Marriage and Household Decision Making: A Bargaining Analysis", *International Economic Review*, **21**, 31–44.
MATZKIN, R. L. (2003), "Nonparametric Estimation of Nonadditive Random Functions", *Econometrica*, **71** (5), 1339–1375.
MCELROY, M. B. and HORNEY, M. J. (1981), "Nash Bargained Household Decisions", *International Economic Review*, **22**, 333–349.
NEWEY, W. K. and POWELL, J. L. (2003), "Instrumental Variable Estimation of Nonparametric Models", *Econometrica*, **71** (5), 1565–1578.
PHIPPS, S and BURTON, P. (1998), "What's Mine is Yours? The Influence of Male and Female Incomes on Patterns of Household Expenditure", *Economica*, **65**, 599–613.
SCHULTZ, T. P. (1990), "Testing the Neoclassical Model of Family Labor Supply and Fertility", *Journal of Human Resources*, **25** (4), 599–634.
THOMAS, D. (1990), "Intra-Household Resource Allocation: An Inferential Approach", *Journal of Human Resources*, **25**, 635–664.
THOMAS, D., CONTRERAS, D. and FRANKENBERG, E. (1997), "Child Health and the Distribution of Household Resources at Marriage" (Mimeo, RAND, UCLA).