Collective Labor Supply

A Single-Equation Model and Some Evidence from French Data

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ABSTRACT

In Chiappori's (1988) collective model of labor supply, hours of work are supposed flexible. In many countries, however, male labor supply does not vary much. In that case, the husband's labor supply is no longer informative about the household decision process and individual preferences. To identify structural components of the model, additional information is needed. We thus consider an approach in which the wife's labor supply is expressed as a function of the household demand for one specific good. We demonstrate that the main properties of Chiappori's initial model are preserved and apply our results on French data.

I. Introduction

The collective model of labor supply, developed by Chiappori (1988, 1992), is by now a standard tool for analyzing household decisions. This model is based on two fundamental hypotheses—each household member is characterized by specific preferences and decisions result in Pareto-efficient outcomes. These turn out to be sufficient to generate strong testable restrictions on spouses' labor supply. Moreover, if consumption is purely private and agents are egoistic, the characteristics of the structural model, such as individual preferences and the rule that determines

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the distribution of welfare within the household, can be identified from the observation of spouses' labor supply.[1]

These features of the collective model have turned out to be very attractive, and the number of empirical studies based on Chiappori's initial framework is considerable. These include Bloemen (2004, Netherlands); Chiappori, Fortin, and Lacroix (2002, United States); Clark, Couprie, and Sofer (2004, United Kingdom); Fortin and Lacroix (1997, Canada); Hourriez (2005, France); Moreau and Donni (2002, France); and Vermeulen (2005, Belgium). However, the large majority of these investigations does not account for the fact that, in most developed countries, male labor supply is rigid and largely determined by exogenous constraints. If the dispersion in husbands' hours is very limited and/or does not stem from spouses' optimal decisions, the identification results given in Chiappori's papers may well be inappropriate.

One important exception in the empirical studies devoted to collective models is given by Blundell et al. (2004). These authors emphasize that in the United Kingdom (but this certainly holds true in other countries), if men work, they work nearly always full-time; the wife's working hours, on the contrary, are largely dispersed. The theoretical model they develop then allows for these essential features: The wife's labor supply is assumed continuous, whereas the husband's choices are assumed to be discrete (either full-time working or nonworking). These authors show that the main conclusions derived by Chiappori in the initial context are still valid here. One drawback, however, is that the result of identifiability and testability given by Blundell et al. (2004) holds only if the husband's choice between full-time working and nonworking is free; in particular, it could be seriously misleading if involuntary unemployment is mistakenly interpreted as the decision of not participating in the labor market.

In the present paper, we deal with the rigidity of the husband's behavior in the French labor market. The approach is quite different from Blundell et al. (2004), though. The starting observation is that the variability in the husband's working hours is very limited. In addition, since the behaviour of the few husbands who do not work can probably be explained by exogenous constraints (as involuntary unemployment), the employment status of the husband can hardly give reliable information about individual preferences and the decision process. The strategy adopted in what follows is then to exploit the information in household consumption to derive testable restrictions and identify the intra-household distribution of welfare. However, instead of considering a system of household demands together with the wife's labor supply, we propose a convenient single-equation approach.[2] In this approach, the wife's labor supply is written as a function of her wage rate, other household incomes, sociodemographic variables and the demand for one good consumed at the household level. The

1. The collective model of labor supply has recently been extended in various directions. Chiappori, Blundell, and Meghir (2005) allow for the existence of both private and public consumption. Donni (2003) incorporates the possibility of nonparticipatory decisions and nonlinear taxation. Apps and Rees (1997), Chiappori (1997) and Donni (2005) recognize the role of domestic production and allow for the fact that a proportion of nonmarket time is spent producing goods and services within the household. Fong and Zhang (2001) study a collective model of labor supply where there are two distinct types of leisure: one type is each person's independent (or private) leisure, and the other type is spousal (or public) leisure. See Vermeulen (2002) and Donni (2008) for a survey of collective models.

2. The multiequation approach is examined in a companion paper (Donni 2007).

idea is that the level of the conditioning good provides information on how the household equilibrium moves along the efficiency frontier when the balance of bargaining power is modified. Indeed, a change in the level of the conditioning good such that the other explanatory variables of the wife's labor supply remain constant can only be explained by a modification in the spouses' bargaining power. We then demonstrate that the estimation of this unique equation permits us to carry out tests of collective rationality and identify some elements of the structural model. In addition, we also show that the present framework is compatible with home production if the production function belongs to some specific family of separable technologies.

This framework is advantageous on three levels. Firstly, the theoretical results do not postulate a particular explanation for the rigidity of the husband's behavior. Contrary to Blundell et al. (2004), identification does not exploit the quite limited variations in husbands' working hours, which may well stem from demand side constraints. Secondly, the econometric techniques developed for the estimation of single-equation models can be used to estimate the wife's labor supply, since the determination of the demand for the conditioning good has not to be explicitly modelled. Thirdly, the variables that affect the distribution of power within the household need not be exactly observed because they are summarized by the level of the conditioning good.

These theoretical results are followed by an empirical application using French data for those couples in which the wife participates in the labor market and the husband works full-time. The conditioning good is the household expenditures on food at home. The wife's labor supply is estimated and the restrictions derived from Pareto efficiency are tested. They are not rejected by the data.

The paper is structured as follows. The theoretical model is developed in Section II and a very general functional form is presented in Section III. The data and the empirical results are described in Section IV. All the proofs are collected in Appendix 1.

II. Theory

A. Basic Framework

Our theoretical framework is very similar to that used in Chiappori (1988, 1992). We consider the case of a two-person household, consisting of a wife (f) and a husband (m), who make decisions about leisure and consumption.[3] The market labor supply of spouse i $(i = m,f)$ is denoted by h_i, with market wage rate w_i. The consumption is purely private and —unlike Chiappori's framework—is arbitrarily broken down into two aggregate goods, which are denoted by c_i and x_i. Each household member is then characterized by specific preferences over (h_i, c_i, x_i), which can be represented by utility functions of the form:

$$(1)\quad u_i(T - h_i, c_i, x_i, z),$$

where T is total time endowment and z is a vector of sociodemographic factors.[4] These utility functions are both strongly concave, infinitely differentiable, and

3. The couple is not necessarily married. The terminology is chosen for convenience.

4. For convenience, we suppose that the same sociodemographic factors z enter both utility functions.

strictly increasing in $(T - h_i)$, c_i and x_i. The household members are "egoistic" in the sense that their utility only depends on their own consumption and leisure. This may seem restrictive but, as shown in Chiappori (1992), all the results immediately extend to the case of "altruistic" agents in a Beckerian sense with utilities represented by the form:

$$W_i\big(u_m(T - h_m, c_m, x_m, z), u_f\big(T - h_f, c_f, x_f, z\big)\big),$$

where $W_i(\cdot)$ is a strictly increasing function. The crucial hypothesis is the existence of some type of separability in the spouses' preferences.

At this stage, we suppose that there is no domestic production.[5] If y is the household nonlabor income, the budget set is written as:

(2) $\quad y + h_m w_m + h_f w_f \geq c + x$

and

(3) $\quad 0 \leq h_i \leq T, c_i \geq 0, x_i \geq 0,$

where $c = c_m + c_f$ and $x = x_m + x_f$. We may note that, in consumer expenditure surveys, consumption is usually recorded at the household level. We thus assume in what follows that the econometrician observes h_i, c, and x, but does not observe c_i and x_i.

In Chiappori's original contributions, the spouses' working hours are supposed to vary continuously as a function of both wage rates and household nonlabor income. This is not very satisfying, though. In France—and in many other countries for that matter—the distribution of men's working hours is very concentrated around the full-time bound. Consequently, as a convenient approximation at least, we assume the husband's labor supply is constant, that is,

(4) $\quad h_m = \bar{h},$

where $0 < \bar{h} \leq T$. The reason for this rigidity is beyond the scope of this paper. It may result from the husband's preferences, demand-side constraints, or institutional rigidities. Quite importantly, however, our theoretical results are general in the sense that they do not rely on a specific explanation of the husband's behavior.

The main originality of the efficiency approach is the fact that the household decisions result in Pareto-efficient outcomes and that no additional assumption is made about the process. That means, for any wage-income bundle, the labor-consumption bundle chosen by the household is such that no other bundle in the budget set could leave both members better off (or more precisely one better off and the other no worse off). This assumption, even if not formally justified, has a good deal of intuitive appeal. First of all, the household is one of the preeminent examples of a repeated game. Then, given the symmetry of information, it is plausible that agents find mechanisms to support efficient outcomes since cooperation often emerges as a long-term equilibrium of repeated noncooperative relations. A second point is that axiomatic models of bargaining with symmetric information, such as Nash or Kalai-Smorodinsky bargaining, which have been previously used to analyze negotiation

5. This assumption is relaxed in Section IIE. We shall show that our theoretical results continue to hold with domestic production for a general class of production technologies.

within the household (Manser and Brown 1980, McElroy and Horney 1981), assume efficient outcomes.

Taking account of the restriction on the husband's working hours, Pareto-efficiency essentially means that a scalar μ exists so that the household behavior is a solution to the following problem:

$$(5) \quad \max_{h_f, c_m, c_f, x_m, x_f} (1-\mu) \cdot u_f\left(T - h_f, c_f, x_f, z\right) + \mu \cdot u_m(T - h_m, c_m, x_m, z),$$

with respect to Equations 2–4. The weight μ, which has an obvious interpretation as a "distribution of power" index, is comprised between zero and one. If $\mu = 0$, the household behaves as though the wife always got her way, whereas, if $\mu = 1$, it behaves as if the husband was the effective dictator. The location of the equilibrium along the Pareto frontier will generally be determined by the household characteristics (that is, w_f, w_m, y and z). Hence, using a parameterization, which is convenient for our purposes, we write: $\mu = \mu(w_f, \psi, s, z)$, where $\psi = y + \overline{h}w_m$ is the "nonwife" income and $s = y/\psi$ is the ratio of nonlabor income and nonwife income. To obtain well-behaved labor supplies and demands, we also assume that the function $\mu(w_f, \psi, s, z)$ is single-valued and infinitely differentiable in all its arguments. The solutions to the household optimization problem can then be written as $c^*(w_f, \psi, s, z)$, $x^*(w_f, \psi, s, z)$ and $h_f^*(w_f, \psi, s, z)$. Note that, in these expressions, the ratio of nonlabor income and nonwife income affects household behavior only through its impact on the function μ. In standard terminology, such an explanatory variable that does not influence preferences or the budget constraint is called a distribution factor.[6]

B. Decentralization and Functional Structure

As is well known, if agents are egoistic and consumption is purely private, the efficiency hypothesis implies that the household decision process can be represented by a two-stage budgeting problem.[7] At Stage 1, both spouses agree on a particular distribution of the nonwife income ψ between them. At Stage 2, each spouse freely chooses his or her level of consumption (and labor supply for the wife), conditional on the budget constraint stemming from Stage 1. Technically, if $\left(h_f^*, c_m^*, c_f^*, x_m^*, x_f^*\right)$ are solutions to the household problem (Equation 5), a sharing $(\rho, \rho - \psi)$ of nonwife income exists so that the husband's and the wife's behaviors can be described by the following individual problems:

A. Husband's problem:

$$\max_{c_m, x_m} u_m\left(T - \overline{h}_m, c_m, x_m, z\right)$$

subject to $x_m + c_m \leq \rho$, $c_m \geq 0$ and $x_m \geq 0$,

6. Other classical examples of distribution factors, exploited by Chiappori, Fortin, and Lacroix (2002), are given by the state of the marriage market and divorce legislation. Note that in the "unitary" approach to household behavior, where a single utility function is supposed to be maximized by spouses, labor supplies and demands are independent of distribution factors.

7. As is underlined by Apps and Rees (1997), the decentralization of the decision process can be seen as a direct consequence of the Second Theorem of Welfare Economics.

B. Wife's problem:

$$\max_{h_f, c_f, x_f} u_f\left(T - h_f, c_f, x_f, z\right)$$

subject to $x_f + c_f = \psi - \rho + w_f h_f$, $0 \leq h_f \leq T$, $c_f \geq 0$, and $x_f \geq 0$.

In the remainder of the text, the husband's share ρ is referred to as the sharing rule. This function can be seen as a reduced form of the balance of power between spouses and, in general, depends on the household characteristics, that is, w_f, ψ, s, and z. We follow the common practice that supposes these characteristics are given for the household. In doing that, however, we exclude the possibility that individuals choose their own wage rate (through intensity of work or learning effort for instance) to influence their bargaining position in the marriage.[8] The reader is referred to Konrad and Lommerud (2000) for a model of strategic determination of wage rates.

The decentralized problems determine the functional structure that characterizes the wife's labor supply and the household demand for goods. In particular, the wife's labor supply can be written as:

$$(6) \quad h_f^*\left(w_f, \psi, s, z\right) = \eta_f\left(w_f, \psi - \rho\left(w_f, \psi, s, z\right), z\right),$$

where η is the wife's Marshallian labor supply, which is obtained from the wife's problem. This relation satisfies the Slutsky positivity, that is, for an interior solution,

$$(7) \quad \frac{\partial \eta_f}{\partial w_f} - \frac{\partial \eta_f}{\partial(\psi - \rho)} \cdot h_f > 0.$$

One important point is that the observation of the sole wife's labor supply as a function of $w_f, \psi, s,$ and z is not sufficient to generate testable restrictions or to identify useful structural components of the model. Indeed, for any observed function $h_f^*\left(w_f, \psi, s, z\right)$ and any arbitrary function $\eta_f\left(w_f, \psi - \rho, z\right)$ satisfying $\partial \eta_f / \partial(\psi - \rho) > 0$, it is possible to find a function $\rho\left(w_f, \psi, s, z\right)$ such that equality (Equation 6) identically holds. This function is defined by:

$$\rho\left(w_f, \psi, s, z\right) = \psi - \eta_f^{-1}\left(w_f, h_f^*\left(w_f, \psi, s, z\right), z\right),$$

where η_f^{-1} is the inverse of η_f with respect to $\psi - \rho$. Since η_f is arbitrarily chosen, the sharing rule is not identifiable and the efficiency hypothesis is not testable.

Clearly enough, the econometrician must observe a second outcome of the household decision process to obtain interesting results. In his classical model of labor supply, Chiappori (1988, 1992) supposes that the wife's and the husband's labor supply are simultaneously observed. In the present framework, since the husband's labor supply is exogenously determined and tells nothing about the decision process, we shall exploit the observation of the demand for one good.[9] In particular, the demand for good x (say) can be written as:

8. We thank an anonymous referee for pointing this out.

9. In Chiappori's initial papers, consumption is summarized by one aggregate good and does not provide useful information. However, the observation of two goods would have given overidentifying restrictions.

$$(8) \quad x^*\left(w_f, \psi, s, z\right) = \zeta_m\left(\rho\left(w_f, \psi, s, z\right), z\right) + \zeta_f\left(w_f, \psi - \rho\left(w_f, \psi, s, z\right), z\right),$$

where ζ_m and ζ_f are the husband's and wife's Marshallian demand for good x respectively (conditionally on $\psi - \rho$, the function ζ_m is independent of w_m because the husband's labor supply is fixed). As we shall show, this relation provides information that can be exploited to generate tests and identify structural components of the model.

C. The s-Conditional Approach

In this section, we develop a formulation for the wife's labor supply that incorporates the information contained in the demand for good x. To do that, the wife's working hours are expressed as a function of the wife's wage rate, the nonwife income, the sociodemographic variables, and the level of good x. We then show that the observation of this "conditional" labor supply allows us to identify some structural components of the model and test the efficiency hypothesis.[10]

The existence of these conditional labor supplies relies on the assumption that the level of good x is a valid indicator of the ratio of nonlabor income and nonwife income. This is formally expressed by the following condition of existence:

$$(9) \quad \frac{\partial x^*}{\partial s} \neq 0,$$

in an open subset of the domain of $x^*\left(w_f, \psi, s, z\right)$. In other words, the source of nonwife income (locally) influences the demand for good x. This condition implies that (i) the spouses' relative bargaining weight μ depends on the source of nonwife income, and (ii) the marginal propensity to consume good x for the husband and the wife are different.[11] In particular, if the spouses' demands for good x are characterized by linear Engel curves with the same slope, the demand for good x at the household level will be independent of the sharing rule and, a fortiori, of the source of nonwife income. This is reminiscent of a well-known result in aggregation theory; see Deaton and Muellbauer (1983), for instance. Empirical evidence suggests, however, that the distribution of exogenous income affects the demand for a large number of different goods.[12]

If Condition 9 is satisfied, then the demand for good x can be inverted on s to yield $s = s^*\left(w_f, \psi, s, z\right)$. We incorporate this into the husband's share of income and obtain what we call the "s-conditional" sharing rule, denoted by

10. Conditional demands or supplies are often used in traditional analysis where a single utility function is assumed; see, for instance, Pollak (1969); Chavas (1984); Browning and Meghir (1991); or Browning (1998). However, the conditional function concerned here is somewhat different.

11. Note also that the conditional labor supplies at stake are not defined in the unitary approach because in that case, household behavior is independent of the source of nonwife income. This should not be a serious problem since the unitary approach was rejected in many studies.

12. See Thomas (1990, 1993); Hoddinott and Haddad (1995); Fortin and Lacroix (1997); Lundberg, Pollak, and Wales (1997); Phipps and Burton (1998) for instance. These authors show that the income-pooling hypothesis—according to which the distribution of exogenous income among spouses should not matter to explain household behavior—is generally rejected.

$$\kappa\left(w_f, \psi, x, z\right) = \rho\left(w_f, \psi, s^*\left(w_f, \psi, s, z\right), z\right).$$

In this expression, the level of good x can be interpreted as an indicator of the ratio of nonlabor income and nonwife income and, more generally, as a measure of the intrahousehold distribution of bargaining power. For example, if good x is essentially consumed by the wife, that is, the slope of the wife's Engel curve is greater than that of the husband, then an increase in the wife's bargaining power will be associated, all other things being the same, with an increase in the household demand for good x.

The s-conditional sharing rule differs from the traditional sharing rule in that it has a specific property of separability. This property is described in the following lemma.

Lemma 1 *The s-conditional sharing rule is implicitly defined as the solution of*: $x = \zeta_m\left(\kappa\left(w_f, \psi, x, z\right), z\right) + \zeta_f\left(\psi - \kappa\left(w_f, \psi, x, z\right), z\right)$.

The proof is straightforward: For any κ, the equation of demand for good x must be identically satisfied. The consequence is that the derivatives of the s-conditional sharing rule can be interpreted in terms of the derivatives of the demand for good x.

Now let us assume that there are no corner solutions. In particular, the wife participates in the labor market. We then introduce the s-conditional sharing rule into the wife's labor supply and obtain:

$$(10) \quad h_f\left(w_f, \psi, x, z\right) = \eta_f\left(w_f, \psi - \kappa\left(w_f, \psi, x, z\right), z\right).$$

This concept will be referred to as the "s-conditional" labor supply.[13] The structure of this type of labor supply differs from that of the "unconditional" labor supply (Equation 6) in that the s-conditional sharing rule $\kappa\left(w_f, \psi, x, z\right)$ has a specific property given in Lemma 1.

The attractiveness of the s-conditional approach ultimately depends on the properties of s-conditional labor supplies, namely, whether the underlying assumptions are testable and the structural model identifiable from the observation of one s-conditional labor supply. These important questions are examined in the next section.

D. Properties of s-Conditional Labor Supplies

In order to investigate the testability and identifiability issues we assume that the wife's s-conditional labor supply exists over an open subset S. We now introduce some pieces of notation:

$$\alpha\left(w_f, \psi, x, z\right) = -\frac{\partial h_f}{\partial \psi}\left(\frac{\partial h_f}{\partial x}\right)^{-1},$$

$$\beta\left(w_f, \psi, x, z\right) = \frac{\partial h_f}{\partial x}\left(\frac{\partial \alpha}{\partial \psi}\frac{\partial h_f}{\partial x} - \frac{\partial \alpha}{\partial x}\frac{\partial h_f}{\partial \psi}\right)^{-1}.$$

13. This concept is not completely original, though. Bourguignon, Browning, and Chiappori (1995) examine this form of conditional functions in the context of demand analysis with constant prices. Donni (2006) considers the case of variable prices. However, these authors suppose that the conditioning good is consumed by only one person in the household, which makes things much simpler.

In the discussion of Proposition 2 below, we shall show that $\alpha(w_f, \psi, x, z)$ can be interpreted as the slope of the husband's Marshallian demand for good x (recovered from the derivatives of the s-conditional labor supply), whereas $\beta(w_f, \psi, x, z)$ corresponds to the inverse of the derivative of this slope.

Let us assume now that the wife's s-conditional labor supply satisfies some regularity conditions.

Assumption R. The wife's s-conditional labor supply is such that, for any $(w_f, \psi, x, z) \in S$,

$$\frac{\partial h_f}{\partial x} \neq 0, \ \frac{\partial \alpha}{\partial x} \neq 0 \text{ and } \frac{\partial \alpha}{\partial \psi}\frac{\partial h_f}{\partial x} \neq \frac{\partial \alpha}{\partial x}\frac{\partial h_f}{\partial \psi}.$$

The first two conditions mean that the slope of the wife's Engel curve for the labor supply and that of the husband's Engel curve for the demand for good x are different from zero. Note that, if the wife does not participate in the labor market, these conditions do not hold, and the conclusions that follow are not valid.

The next result states that the s-conditional sharing rule can be retrieved from the sole observation of the wife's s-conditional labor supply.

Proposition 2 *Let us assume that the wife's s-conditional labor supply* $\mathrm{h_f}(\mathrm{w_f}, \psi, \mathrm{x}, \mathrm{z})$ *satisfies* **R**. *Then,*

(a) *the* s-*conditional sharing rule can be retrieved on S up to a function* $\mathrm{k}(\mathrm{z})$ *of* z*; specifically, its derivatives are given by*

$$\frac{\partial \mathrm{k}}{\partial \mathrm{w_f}} = \frac{\partial \alpha}{\partial \mathrm{w_f}}\beta, \frac{\partial \mathrm{K}}{\partial \mathrm{x}} = \frac{\partial \alpha}{\partial \mathrm{x}}\beta, \frac{\partial \mathrm{K}}{\partial \psi} = \frac{\partial \alpha}{\partial \psi}\beta;$$

(b) *for each choice of* $\mathrm{k}(\mathrm{z})$*, the wife's marginal rate of substitution between total consumption* $(\mathrm{c_f} + \mathrm{x_f})$ *and leisure* $(\mathrm{T} - \mathrm{h_f})$*, that is, the preferences between total consumption and leisure, is uniquely defined;*

(c) *the wife's Marshallian labor supply and the individual Marshallian demands can be retrieved up to a function of* z.

The complete proof of this proposition is given in Appendix 1. We briefly give the first step of the argument here. By definition, the slope of the husband's Marshallian demand for good x is given by the increase in x due to an infinitesimal variation in κ, keeping $\psi - \kappa$, w_f and z constant. Note now that h_f depends only on $\psi - \kappa$, w_f and z. Then, an infinitesimal variation in ψ, so that h_f, w_f and z remain unaffected, provides the slope of the husband's Marshallian demand. Consequently, if we apply the implicit function theorem to $h_f(w_f, \psi, x, z)$ such that x is differentiated with respect to ψ, we obtain the slope of the husband's Marshallian demand:

$$(11) \quad \frac{\partial \zeta_m}{\partial \kappa} = -\frac{\partial h_f / \partial \psi}{\partial h_f / x} = \alpha.$$

Note that $\partial \zeta_m / \partial \kappa$ (and thus α) depends only on κ and z. The identification of the s-conditional sharing rule then follows from the differentiation of Equation 11 and the resolution of the system of partial differential equations that results.

There are two distinct advantages to modelling an *s*-conditional labor supply instead of one unconditional labor supply and one household demand. Firstly, there is no need to model the determination of the conditioning good explicitly. The *s*-conditional approach does not require an explicit structural model for the conditioning good at all. In contrast to usual collective models of labor supply, the *s*-conditional labor supply can be estimated with single-equation techniques. This is useful because the estimation of labor supply models is generally very expensive in computer-time. Secondly, there is no need to observe the distribution of nonwife income between its sources. This is particularly compelling since, in empirical work, such information is often unreliable. More generally, the effect of any distribution factor, even unobserved or unknown for the econometrician, is incorporated in the conditioning good.

However, the *s*-conditional approach has also some limitations as far as identification issues are concerned. Firstly, even if the *s*-conditional sharing rule can be recovered (up to a function of z), its theoretical interpretation is unclear. The reason is that the *s*-conditional sharing rule is expressed as a function of the level of good x, which is endogenously determined. Secondly, the s-conditional sharing rule and the other structural elements can be retrieved as long as the wife participates in the labor market but the identification cannot be extended beyond the participation set. However, these drawbacks are simply a converse of the fact that we need less information to estimate an *s*-conditional labor supply than to estimate, as is made in Donni (2007), an unconditional labor supply together with a system of demands. In particular, there is neither a need to observe the level of the demand for good x when the wife does not work, nor one to observe the sources of nonwife income.

We show in the next proposition that the wife's *s*-conditional labor supply has to satisfy some constraints to be consistent with collective rationality.

Proposition 3 *Let us assume that the wife's s-conditional labor supply* $\mathrm{h_f}(\mathrm{w_f}, \psi, \mathrm{x}, \mathrm{z})$ *satisfies* **R**. *Then, for any* $(\mathrm{w_f}, \psi, \mathrm{x}, \mathrm{z}) \in S$,

$$(a) \quad \frac{\partial\alpha}{\partial w_f}\frac{\partial\beta}{\partial x} - \frac{\partial\alpha}{\partial x}\frac{\partial\beta}{\partial w_f} = \frac{\partial\alpha}{\partial\psi}\frac{\partial\beta}{\partial x} - \frac{\partial\alpha}{\partial x}\frac{\partial\beta}{\partial\psi} = 0;$$

$$(b) \quad \frac{\partial h_f}{\partial w_f} - \frac{\partial\alpha}{\partial w_f}\frac{\partial h_f/\partial x}{\partial\alpha/\partial x} + \frac{\partial h_f/\partial x}{\beta(\partial\alpha/\partial x)}h_f > 0.$$

These restrictions provide a joint test of collective rationality under specific assumptions, that is, consumption is purely private, there is no domestic production and agents are egoistic (or caring). On the one hand, the system of partial differential (Equation a) is due to the separability property that characterizes the wife's labor supply (Equation 10) and the *s*-conditional sharing rule in Lemma 1. If this condition is satisfied, there exists a well-behaved sharing rule of nonwife income. On the other hand, the inequality (Equation b) results from the Condition 7 of Slutsky positivity transposed into the *s*-conditional context. There are three terms in this expression. The first term is the total effect of the wage rate on the *s*-conditional labor supply. The fraction of this total effect that influences wife's behavior through the s-conditional sharing rule is then subtracted. This is the second term. Then, the third term is a more traditional income effect. In particular, the effect of the wife's share on her labor supply is given by

$$\frac{\partial \eta}{\partial(\psi - \kappa)} = -\frac{\partial h_f / \partial x}{\beta(\partial \alpha / \partial x)}.$$

If the condition in Equation b is satisfied, a well-behaved utility function rationalizes the wife's behavior.

We now suppose that leisure and goods are superior (that is, normal). In many circumstances, this assumption is uncontroversial because goods are very aggregated. If so, the s-conditional approach implies several additional restrictions, which are presented in the next proposition.

Proposition 4 *Let us assume that the wife's s-conditional labor supply* $h_f(w_f, \psi, x, z)$ *satisfies* **R**. *Then, for any* $(w_f, \psi, x, z) \in S$,

(a) *if leisure is superior,*

$$-\frac{\partial h_f / \partial x}{\beta(\partial \alpha / \partial x)} < 0;$$

(b) if *goods x and c are superior (for both spouses),*

$$\min\left(1,\ 1 + \frac{1 + w_f(\partial h_f / \partial x)}{\beta(\partial \alpha / \partial x)}\right) > \alpha > \max\left(0,\ \frac{1}{\beta(\partial \alpha / \partial x)}\right).$$

This result, which is a straightforward consequence of Proposition 2, provides a new test of collective rationality under the additional assumption of consumption superiority. In particular, the second statement of Proposition 4 deserves some comments. If one inequality in this statement is violated by α, then (at least) one slope of the four Engel curves must be negative. To illustrate that, let us remember that α coincides with the slope of the husband's Engel curve for good x. Then, if $\alpha < 0$, good x is inferior for the husband (but good c is necessarily superior from the Engel's aggregation condition). On the contrary, if $\alpha > 1$, good x is superior and good c is inferior. The interpretation of the other inequalities, which are related to the wife's behavior, is more complicated, though. See the proof in Appendix 1.

E. Another Interpretation: The Role of Domestic Production

Undoubtedly, the absence of domestic production is a serious shortcoming of the model developed above. In this section, we incorporate the fact that a proportion of time not allocated to market labor supply may be spent producing goods within the household. To do so, we suppose that $h_i^t = h_i + h_i^d$, where h_i^t and h_i^d respectively is spouse i's total labor supply and domestic labor supply.[14] That means, nonmarket time can be broken down into time consumed in leisure, $T - h_i^t$, and time spent in

14. To simplify the presentation of this subsection and emphasize the intuition, we do not take into account the rigidity of the husband's labor supply and we do not specify the various nonnegativity restrictions on domestic labor supplies and consumptions.

domestic production, h_i^d. Then we suppose that goods can be produced using "individual" technologies of the form:

$$(12) \quad h_i^d = f_i\left(c_i^d, x_i^d\right),$$

where f_i is a function, increasing and strictly convex in its arguments, and c_i^d and x_i^d denote the proportion of goods c and x entering spouse i's production process, where as usual a positive number indicates an output and a negative number indicates an input. Note that goods c and x are marketable in the sense that they can either be purchased (or sold) in the market or produced at home.[15] Also, the prices are exogenously fixed by the market.

In the specification of the production technology, the fact that f_i does not depend on $h_j^d (j \neq i)$ is crucial in the development that follows. That implies there is neither substitutability nor complementarity in spouses' time inputs. Overall, this assumption seems to be supported (as a valid approximation at least) by the rare empirical studies of domestic activities (for example, Graham and Greene 1984). Now let us suppose that spouses' utility is a function of leisure (instead of nonmarket time) and consumption. We have:

$$(13) \quad v_i\left(T - h_i^t, c_i^t, x_i^t\right),$$

where c_i^t and x_i^t denote the proportion of c and x which is "directly" consumed by spouse i (which includes the outputs of the production process and excludes the inputs). We have: $c_i^t = c_i + c_i^d$ and $x_i^t = x_i + x_i^d$, where c_i and x_i denote the quantity of goods purchased in the market for spouse i's use.

The basic idea of the reasoning is that if the production technology is of the form of Equation 12, the Utility Function 1, which is used in the preceding sections, can be derived from a more fundamental representation of preferences, described by Equation 13. We have:

$$(14) \quad u_i(T - h_i, c_i, x_i) = \max_{c_i^t, x_i^t, c_i^d, x_i^d} v_i\left(T - h_i - f_i\left(c_i^d, x_i^d\right), c_i^t, x_i^t\right),$$

subject to

$$c_i^t - c_i^d = c_i, \; x_i^t - x_i^d = x_i.$$

Since the price of goods is constant (and equal to one), this result is a straightforward application of the Hicks' aggregation theorem. The intuition goes as follows. The allocation process can now be represented in three stages. Firstly, spouses agree on a sharing of nonwife income as previously. Secondly, each spouse maximizes u_i with respect to h_i, c_i and x_i, taking account of the wife's share of nonwife income. Thirdly, each spouse maximizes v_i with respect to c_i^t, x_i^t, c_i^d and x_i^d, taking account of their individual production technology and their preceding choices of h_i, c_i and x_i. This last stage, which characterizes the domestic production interpretation, is described by Equation 14 above. Note that the arbitrage between domestic and market activities is determined by the comparison of market wage rate and domestic productivity.

15. For example, meals can be produced within the household or bought from a caterer. Gronau (1977) gives a justification of this traditional assumption.

If productivity is high, it is profitable to devote a large proportion of time to domestic activities. This may explain the specialization of one spouse in market or domestic activities.

Now, if the interpretation above is accepted, the individual demands that are retrievable from Proposition 2 can be seen as the difference of the demands of goods which are directly consumed $\left(x_i^t, c_i^t\right)$ and those which are produced (or used as inputs) at home $\left(x_i^d, c_i^d\right)$. In other words, each demand represents the quantity of goods purchased by spouse i with her share of nonwife income in the second stage of the decision process described above. In any case, however, the utility function u_i, which is (partially) identified from observed behavior, continues to represent a valid indicator of spouse i's welfare. In addition, the testability results presented in Proposition 3 and 4 are still valid in the domestic production interpretation.

III. Parametric Specification of the Model

A. Quadratic Conditional Labor Supply

In order to estimate and test the collective model previously developed we must first specify a functional form for the wife's s-conditional labor supply. Let us consider a very general, quadratic functional form:

$$(15)\quad h_f = a_{00}(z) + a_{01}w_f + a_{02}\psi + a_{03}x + a_{11}w_f^2 + a_{22}\psi^2 + a_{33}x^2 + a_{12}w_f\psi + a_{13}w_f x + a_{23}\psi x,$$

where $a_{01}, \ldots, a_{23}$ are parameters and a_{00} is a function of sociodemographic factors. To make things simple, we suppose that a_{00} has a linear form: $a_{00} = \alpha' z$, where α is a vector of parameters.

The theory above yields a set of parametric constraints that the functional form (Equation 15) must satisfy. First, from Statement a in Proposition 3, the coefficients of this functional form have to satisfy the following restrictions:[16]

$$(16)\quad 2a_{33}a_{12} - a_{13}a_{23} = a_{23}a_{23} - 4a_{22}a_{33} = 0.$$

If these restrictions are imposed, the sharing rule can be retrieved. Moreover, Statement b in Proposition 3 implies that

$$(17)\quad \left(a_{01} - \frac{a_{03}a_{13}}{2a_{33}}\right) + 2\left(a_{11} - \frac{a_{13}^2}{4a_{33}}\right)w_f - \left(a_{02} - \frac{a_{03}a_{23}}{2a_{33}}\right)h_f > 0.$$

In principle, this restriction can be globally imposed but it would reduce excessively the flexibility of the functional form. Hence, we prefer checking inequality (Equation 17) for each observation.

16. These restrictions, and the components of the structural model in the next subsection, have been obtained using mathematical computation software.

B. Recovering the Structural Parameters

Let us define $\Theta = a_{03} + a_{23}\psi + a_{13}w_f + 2a_{33}x$ and $\Delta = a_{03}a_{23} - 2a_{02}a_{33}$. Then the s-conditional sharing rule is quadratic and its derivatives are given by

$$\frac{\partial\kappa}{\partial w_f} = a_{13}\frac{\Theta}{\Delta}, \frac{\partial\kappa}{\partial\psi} = a_{23}\frac{\Theta}{\Delta}, \text{and} \frac{\partial\kappa}{\partial x} = 2a_{33}\frac{\Theta}{\Delta}.$$

Solving this system of three partial differential equations, we obtain the s-conditional sharing rule equation:

$$\text{(18)} \quad \rho = K_0(z) + K_1 w_f + K_2\psi + K_3 x + K_4 w_f^2 + K_5\psi^2 + K_6 x^2 + K_7 w_f\psi + K_8 w_f x + K_9\psi x,$$

where $K_0(z)$ is an unidentified function of z, and where

$$K_1 = \frac{a_{03}a_{13}}{\Delta}, K_2 = \frac{a_{03}a_{23}}{\Delta}, K_3 = \frac{2a_{03}a_{33}}{\Delta}, K_4 = \frac{a_{13}^2}{2\Delta}, K_5 = \frac{a_{23}^2}{2\Delta}, K_6 = \frac{2a_{33}^2}{\Delta},$$
$$K_7 = \frac{2a_{12}a_{33}}{\Delta}, K_8 = \frac{2a_{13}a_{33}}{\Delta}, K_9 = \frac{2a_{23}a_{33}}{\Delta}.$$

On the other hand, the Marshallian labor supply does not depend on the conditioning good x and takes the following form:

$$\text{(19)} \quad h_f = A(z) + Bw_f + Cw_f^2 + D(\psi - \rho),$$

where

$$A(z) = a_{00}(z) + \left(a_{02} - \frac{a_{03}a_{23}}{2a_{33}}\right)\times K_0(z), B = a_{01} - \frac{a_{03}a_{13}}{2a_{33}}, C = a_{11} - \frac{a_{13}^2}{4a_{33}},$$

$$D = a_{02} - \frac{a_{03}a_{23}}{2a_{33}}.$$

Hence, the wife's Marshallian labor supply belongs to the family of semi-quadratic specifications, and the normality of leisure implies that $D < 0$. Note that the utility function that rationalizes this functional form exists in closed form and is given by Stern (1986).

Moreover, if goods x and c are superior, the slope of the Engel curves generates a strong test of collective rationality, as is explained in the discussion of Proposition 4. To carry out this test, these slopes have to be computed for the present functional form with the identification results given in Proposition 2. However, the formulas are quite complicated, so that the slopes are not exhibited here. Note that the positivity must be checked for each observation since the Engel curves are not linear.

IV. Data and Empirical Results

A. Data

The data are taken from the French Household Budget Survey 2000 conducted by the French institute of economic and statistical information (INSEE). It contains detailed information on consumption, labor income, working hours, education, and demographic characteristics. We select a sample of married and cohabiting couples where the adults are aged between 20 and 60 and available for the labor market. For this purpose, households where adults are disabled, retired or students are excluded. We also exclude households where adults are self-employed or farmers. The labor supply behavior of these two categories may indeed be rather different from salaried workers and, altogether, would require a different modelling strategy. We further select households where hours of work are positive for wives and at least 35 hours per week for husbands. We also restrict our sample to households with no preschool (under three) children in order to minimize the extent of nonseparable public goods within the household, which is not accounted for in our model. Finally, since Browning and Chiappori (1998) argue that the hypothesis of efficiency in the intra-household decision process is more likely to be satisfied in stable couples, we further restrict our sample to households with at least two years of conjugal life. In all, these selection criteria lead us to 1670 observations.

The choice of the conditioning good is a crucial issue that must be discussed. The theory developed above requires the conditioning good x to be private and nondurable. Moreover, as is demanded by Condition 9, the demand for this good must be responsive to variations in the ratio of nonlabor income and nonwife income. Finally, because expenditures on nondurables are recorded in the survey on diaries covering two-week periods (and extrapolated for the year), infrequency of purchases may be a serious issue. We thus choose the household expenditure on food at home (including alcohol and tobacco) as the conditioning good. One advantage of using that variable is that the number of zeros is far lower than for other goods. More importantly, several studies (Thomas 1993; Hoddinott and Haddad 1995; Phipps and Burton 1998) indicate that the demand for food at home is affected by the fraction of total income controlled by the wife and the husband, respectively.[17] This is also corroborated by our data. We observe, using a simple reduced-form OLS regression, that the impact of husband's income on the expenditure on food at home is significantly different from that of nonlabor income. Interestingly, the source of exogenous income does not influence the expenditure on food at home when the regression is based on a sample of single men.[18] Be that as it may, to check the robustness of our empirical results, we have also estimated the model with two other conditioning goods, namely, food away from home and clothing. In this case, the collective restrictions (Equations 16 and 17) are not rejected by the data but the coefficients are less precisely estimated than with food at home as the conditioning good. These estimations are summarized in Table 6 (Appendix 2).

The other variables are defined as follows. The female labor supply h_f is the number of working hours per week. The wage rate w_f is the average hourly earnings defined by dividing the wife's total labor income on all jobs over annual hours of work on all jobs. As the latter information is not included in the data, it is computed from h_f and the number of months worked during the year. The nonlabor income y is defined as the nonlabor income net of savings and is given by the budget identity:

17. The opinion according to which there are some gender-specific differences in many areas of nutrition is also supported by sociologists. For instance, women eat more fruits and vegetables whereas the consumption of alcohol, tobacco, fatty foods, and high-sucrose foods is higher in men (Aliaga 2002).

18. Results are available upon request.

Table 1
Descriptive Statistics of the Sample

	Mean	Median	Standard Deviation
Whole sample of 2,102 working couples			
Male weekly hours of work	40.65	39.00	8.09
Female weekly hours of work	33.24	35.00	9.56
Our selected sample of 1670 couples			
Female weekly hours of work	33.33	35.00	9.64
Female hourly wage rate	8.78	7.71	4.18
Annual food expenditures	6,101	5,762	2,810
Annual nonwife income	20,632	16,815	19,479
Wife's age	41.00	41.00	8.15
Number of children	1.28	1.00	1.08

Note: All monetary amounts in euros.

$y = c + x - w_m\overline{h}_m - w_f h_f$, so that the nonwife income ψ is equal to: $\psi = c + x_m - w_f h_f$. That is, the nonwife income ψ is the difference between annual household total consumption and female labor earnings. In doing that we follow Blundell and Walker (1986) and adjust nonwife income to be consistent with an intertemporally separable lifecycle model. Finally, the sociodemographic factors z include the number of children and the wife's age.[19]

Some descriptive statistics of the sample are exhibited in Table 1. The first and second rows of the table help us compare the distribution of male and female labor supply for working couples. On average, men work more than women do and their labor supply is more concentrated. The comparison with the United States, for instance, is striking. In the PSID of 1990, using a similar selection as done here for couples, we find that there is no obvious concentration in the distribution of hours, apart from the mode between 35 and 40 weekly hours. This spike itself concerns only 39.5 percent (36.8 percent) of U.S. men (women) in working couples compared to 65.5 percent (45.9 percent) of the French men (women) in working couples. We are inclined to believe that the variability in husbands' working hours can simply be disregarded by a study of French wives' behavior. This issue is examined below with a formal test of the rigidity of male labor supply.

Finally, to have a first look at the form of the wife's labor supply, we report four locally weighted regressions of female hours on the wage rate in Figure 1. Each line refers to a different quartile of nonwife income. The relationship between hours and wage rates is clearly nonmonotonic and the different curves exhibit a substantial income effect. Moreover, for a given wage rate, the slope of these curves depends on

19. In principle, the sociodemographic factors z may also include variables related to the husband. However, these turn out to be insignificant.

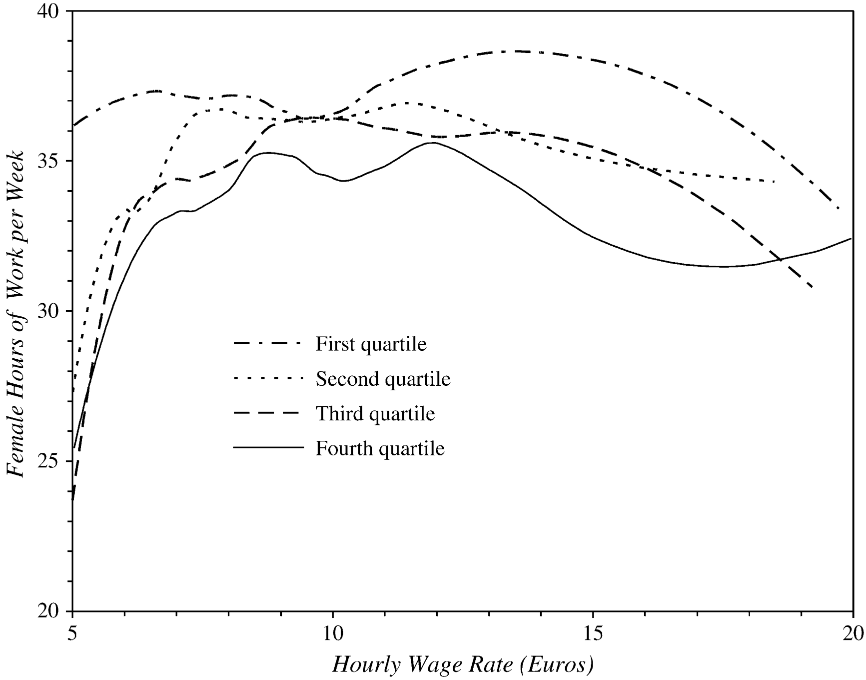

Figure 1
Locally Weighted Regression, FHBS 2000 Data

nonwife income. These observations justify our choice of a very flexible specification for the wife's labor supply.[20]

B. Endogeneity and Choice of Instruments

The wage rate is computed as labor income divided by hours of work. This may induce the so-called "division bias." Hence, the wage rate may well be endogenous. Moreover, nonwife income and food expenditures are likely to be endogenous as they are choice variables in the model. Therefore, we have chosen to instrument the wife's wage rate, the nonwife income, the food expenditures and their squares and cross-products. The possible endogeneity of children deserves further attention. On the one hand, we may assume that we only need to worry about the endogeneity of recently born children and can treat older children as predetermined. On the other hand, there is some evidence that labor force behavior surrounding the first birth is a significant determinant of lifetime work experience (Browning 1992). All things considered, this issue is an empirical one. Hence, since the exogeneity of the number of

20. These results are only illustrative since no allowance is made for the endogeneity of the wage rate or nonwife income.

children is not rejected by our data, the estimations of the model we present below do not instrument the number of children.[21]

At this stage, the selection of the instruments requires some discussion. First of all, we assume that the wife's education is not correlated with the error term in the labor supply equation. This assumption, although debatable, is standard in the labor supply literature (see, among others, Bourguignon and Magnac 1990; Blundell et al. 1998; Chiappori, Fortin, and Lacroix 2002; and Pencavel 1998). The wife's education is a convenient instrument for her wage rate. In addition, the growth of wage rates along the lifecycle is generally a function of education. Thus, we also use as instruments a second order polynomial in age and education for the wife. This gives four excluded instruments (accounting for the fact that the wife's age is a control variable in the labor supply equation).

The various sources of *exogenous* incomes are natural instruments for the nonwife income and the food expenditures. In particular, since the husband's labor supply is exogenously constrained, we may suppose that the husband's annual labor earnings is exogenous.[22] Then, to grasp as much variation as possible in the endogenous regressors, we use a fourth-order polynomial in the husband's labor earnings and obtain four extra instruments. We also use a second order polynomial in exceptional incomes (including inheritance, bequests, and gifts) as instruments.[23]

Other instruments include a second-order polynomial in age and education for the husband (five instruments), two dummies for husband's father's profession, a dummy variable for living in the Paris region and a cross-term of wife's education and husband's labor earnings. Our intuition is that these variables have an impact on the various sources of the household income. As usual, measurement error in the instruments is not supposed to be correlated with the response error for the endogenous variables.[24]

All in all, there are four included instruments (a constant, the wife's age, the number of children, and the inverse of Mill's ratio) and 19 excluded instruments from the labor supply equation. In the next section, we shall check the validity of some of our exclusion restrictions.

C. Results

Before we present any further results, we report the tests of the validity of the instruments.

1. The Validity of the Instruments

We first test the null hypothesis that none of the excluded instruments is correlated with the endogenous variables in the system of equations $Y = W\Gamma + e$, where Y is the matrix of endogenous regressors, W the matrix of instruments, and Γ a matrix

21. However, our conclusions are still valid when the number of children is supposed to be endogenous. In that case, the estimates differ only in that the coefficient of the number of children in the functional form (Equation 15) is no longer significant. These results are available upon request.

22. The husband's wage rate may be endogenous, though. This issue is examined in greater details in section IVC3.

23. To avoid strongly correlated instruments, we replace the polynomials with their corresponding principal components, that is, with orthogonal linear combinations of the original instruments. Estimates are then more stable.

24. For Altonji (1986) and Altonji and Siow (1987), this assumption is reasonable, given that these variables are based on independent questions.

of parameters and e a matrix of random terms. The first panel of Table 7 in Appendix 3 shows F statistic, corresponding p-value and adjusted R-square for each of the nine auxiliary regressions. The p-values are close to zero, indicating that the null hypothesis is clearly rejected. This gives evidence that the instruments are significant for all the endogenous variables. Note, however, that the F statistic concerning the auxiliary regression on ψ^2 is relatively small (less than 5). In a 2SLS context, Staiger and Stock (1997) suggest that estimates and confidence interval may be unreliable with first-stage$F$'s this small.[25] On the other hand, Bound, Jaeger, and Baker (1995) mention that results should be interpreted with caution for first-stage F statistics close to one.

To decide on the potential weakness of our instruments, we test whether the excluded instruments have enough explanatory power *jointly* for all the endogenous variables. For that purpose, we use the test provided in Robin and Smith (2000). This test evaluates the rank of the coefficient matrix on the excluded instruments in the auxiliary regressions. Let $\hat{\Lambda}$ be a consistent and asymptotically normal estimator of a $p \times k$ reduced form parameter matrix Λ on the excluded instruments.[26] Here we have $p = 19$ excluded instruments and $k = 9$ endogenous variables. If Λ is not full rank (that is, $rk(\Lambda) < 9$), the excluded instruments are weak for at least one endogenous variable. If Λ is full rank ($rk(\Lambda) = 9$), the excluded instruments have enough explanatory power jointly for all the endogenous variables. The Robin-Smith test of rank is based on the Eigen values of $\hat{\Lambda}^T \Lambda$.

Following the sequential procedure advocated in Robin and Smith (2000), we test for $H_0: \; rk(\Lambda) = r$ against $H_1: \; rk(\Lambda) > r$ for $r = 1, \ldots, 9$ and halt at the first value of r for which the test statistic indicates a nonrejection of H_0. The second panel of Table 7 in Appendix 3 exposes the results. Again, the p-values are close to zero. The null hypothesis $rk(\Lambda) = 1$ is rejected, so is the null $rk(\Lambda) = 2$, and so on until $rk(\Lambda) = 8$ is also rejected: The reduced form coefficient matrix Λ is full rank. We thus conclude that the excluded instruments are valid enough to give reliable estimates and confidence interval.

Finally, we consider whether Paris region, female education, and unemployment rates (which appear in the selection equation; see Appendix 3) are valid exclusion restrictions. Including the Paris region or the unemployment rates variables in the labor supply equation does not have significant effects on the original parameters estimates. The t-value for the coefficient of the Paris region is below 1.2 whereas the t-values for the unemployment rates variables are below 0.4. We hence maintain these exclusion restrictions. If we allow the wife's education level to appear in the labor supply equation, it is statistically significant but the estimates of the parameters of interest change and become very imprecise. In fact, the first-stage F's of the auxiliary regressions related to her wage rate decrease substantially. When her education level is not excluded from her labor supply equation, her wage rate is weakly instrumented. We therefore maintain this exclusion restriction.

25. We allow for heteroskedasticity of unknown form. We do not know whether these differences significantly affect their asymptotic or not.

26. The matrix Λ contains only the parameters of related to the excluded instruments in the s-conditional labor supply equation.

2. Labor Supply Estimates

Conditioning the sample on stable households with working wives and no children under three years of age may induce a selectivity bias. To account for these selection rules we estimate a reduced-form participation equation and compute the inverse Mill's ratio.[27] The latter is denoted by $\hat{\lambda}$ and the matrix of residuals obtained from the regression of the variables on the instruments (that is, $Y = W\Gamma + e$) by $\hat{e}$. Then the first and third columns of Table 2 provide estimates of the unrestricted and restricted models obtained by applying OLS (NLS) on the following relation:

$$(20) \quad h_f = g(w_f, \psi, x, z, a) + \hat{\lambda} b_\lambda + \hat{e} b_e + v,$$

where $g(\cdot)$ is the functional form (Equation 15) of the wife's labor supply, v is a random term that represents the unobserved heterogeneity, and a, b_λ, and b_e are parameters. The inclusion of the residuals in the labor supply equation is to control for the endogeneity of the regressors.[28] The t-statistics of the estimates of b_e also provides a direct test of exogeneity; see Smith and Blundell (1986), or Blundell, Duncan, and Meghir (1998) for a recent application. To save space, only the test of exogeneity for the wife's wage rate is reported in Table 2. The residual of the regression of the wife's wage rate on the instruments is denoted by $\hat{e}_{w_f}$. Then, under the null hypothesis, the parameter $b_{e_{w_f}}$ corresponding to the residual $\hat{e}_{w_f}$ in Equation 20 must be equal to zero. This is clearly rejected by the data. The wage rate has to be instrumented.

The second and fourth columns of Table 2 are the unconstrained and constrained models obtained by using GMM on the following equation:

$$(21) \quad h_f = g(w_f, \psi, x, z, a) + \hat{\lambda} b_\lambda + v.$$

The Hansen's test does not reject the validity of the instruments and the overidentifying restrictions. The test statistics 9.393 and 9.548 are less than the critical values of the $\chi^2_{0.05}(10) = 18.307$ and of the $\chi^2_{0.05}(12) = 21.026$.

Let us take a closer look at the results of Table 2. Except for the interaction term $\psi \times x$, the OLS and GMM estimations give similar results. Since the GMM estimator attains greater efficiency under the presence of heteroskedasticity of unknown form (Davidson and MacKinnon 1993, p. 599), we only refer to the GMM results in what follows.

To begin with, we note that the parameters of the unrestricted model are not estimated with precision. Only the wife's age, the number of children, the wage rate, its square, its interaction with food expenditures and the nonwife income have an impact at the 5 percent or 10 percent level. This lack of precision can be explained

27. The estimates of the selection equation are shown in Table 8 (Appendix 3).

28. The asymptotic covariance matrix is computed using the results of Newey (1984) and Newey and McFadden (1994) to take into account that we are conditioning on generated regressors (that is, $\hat{\lambda}$ and $\hat{e}$). This matrix is robust to heteroskedasticity of unknown form and the covariance of the coefficients $\hat{\Gamma}$ across the nine reduced forms is taken into account. Still, we ignore the covariance between $\hat{\Gamma}$ and the estimated coefficients of the participation equation.

Table 2
Estimated Parameters of the Reduced Form Labor Supply

		Unrestricted Model		Restricted Model	
		OLS	GMM	NLS	GMM
a_{01} :	w_f	4.430***	4.727***	4.190***	4.501***
		(1.082)	(1.109)	(0.976)	(0.989)
a_{02} :	$\psi \times 10^{-2}$	−0.105*	−0.104*	−0.093**	−0.095**
		(0.059)	(0.059)	(0.042)	(0.039)
a_{03} :	x	0.003	0.003	0.004*	0.004**
		(0.003)	(0.003)	(0.002)	(0.002)
a_{11} :	w_f^2	−0.106*	−0.118**	−0.122***	−0.125***
		(0.056)	(0.054)	(0.044)	(0.042)
a_{22} :	$\psi^2 \times 10^{-9}$	4.044	4.531	3.589	4.121*
		(3.031)	(2.782)	(2.446)	(2.171)
a_{33} :	$x^2 \times 10^{-8}$	9.548	11.910	6.458	8.656
		(19.687)	(19.780)	(5.430)	(5.579)
a_{12} :	$w_f \psi \times 10^{-2}$	0.005	0.006	0.006*	0.006**
		(0.005)	(0.005)	(0.003)	(0.003)
a_{13} :	$w_f x \times 10^{-2}$	−0.032	−0.033*	−0.026	−0.029*
		(0.020)	(0.019)	(0.018)	(0.017)
a_{23} :	$\psi x \times 10^{-9}$	1.374	−18.600	−30.450	−37.800**
		(89.958)	(92.490)	(20.521)	(18.600)
α_0 :	Intercept	21.231**	18.255*	17.932**	16.137**
		(9.444)	(9.545)	(6.946)	(7.051)
α_{ch} :	Number of children	−1.415**	−1.393**	−1.556**	−1.462**
		(0.718)	(0.705)	(0.642)	(0.623)
α_{age} :	Wife's age	−0.257***	−0.275***	−0.261***	−0.274***
		(0.089)	(0.085)	(0.085)	(0.079)
b_λ :	Inverse Mill's ratio	1.880	2.472	2.428	2.848
		(2.276)	(2.306)	(2.039)	(2.059)
$b_{e_{w_f}}$:	$\hat{e}_{w_f}$	−3.433***		−3.193***	
		(1.126)		(1.021)	
Objective function			9.393		9.548

Notes: Asymptotic standard errors in parentheses. Significance levels of 10, 5, and 1 percent are noted *, ** and *** respectively.

by the flexibility of our functional form. Nonetheless, the coefficients of the restricted model (that is, with the imposition of Condition 16) are very similar, but exhibit smaller standard errors, so that most of them are statistically significant at the 5 percent or 10 percent level. In particular, the wife's age and the number of children have a significant, negative effect on the number of working hours.

We now turn to the test of the collective restrictions. First, we perform a Newey-West's test of Condition 16. Since the difference in the function values ($9.548 - 9.393 = 0.155$) is much smaller than the critical value, $\chi^2_{0.05}(2) = 5.99$, we do not reject the restrictions at stake. However, this evidence in favor of the collective model must be interpreted with caution. Indeed, the standard error of the coefficient a_{33} is large. Since this coefficient enters conditions (Equation 16), the test we carry out is not likely to be powerful.

Using the estimates of the restricted model, we note that the Slutsky Condition 17 is satisfied for a large majority (93 percent) of the households in the sample, and the wife's leisure is superior.[29]

These results support the collective model and they will be more closely examined below. In addition, the positivity of the slopes of the Engel curves can be checked since it is reasonable to assume that both goods are superior. This corresponds to a test of the second statement in Proposition 4. Actually, we observe that the slopes of the four Engel curves are positive for 95 percent of the households in the sample. This confirms that the goods are superior and, incidentally, validate our estimations.

On the whole, the empirical tests we describe above do not reject the collective model. We now consider the various labor supply elasticities that are shown in Table 3. The elasticities of the constrained and unconstrained models are similar and quite precisely estimated. Women's wage elasticities are positive and statistically significant. Income elasticities are negative and also statistically significant. The amplitude of these figures is somewhat different from that found in other studies using French data. For example, estimating a unitary model that accounts for nonlinear taxation and nonparticipation, Blundell and Laisney (1988) report, at the sample mean, wage and income elasticities, which are equal to two and -0.7, respectively. According to the specification used, these elasticities range from 0.05 to one respectively and from -0.3 to -0.2 in Bourguignon and Magnac (1990). The elasticities presented in Table 3 differ from previous estimations because our sample is restricted to working wives.

The estimation of the reduced form parameters allows us to retrieve some structural components of the model. The first panel of Table 4 reports the estimates of the parameters of the Marshallian labor supply (Equation 19). The coefficients have the expected signs but the effect of the wife's share of income is imprecisely estimated. Note also that the wife's Marshallian labor supply is backward bending. For small values of the wife's wage rate, the substitution effect dominates the income effect so that an increase in the wife's wage rate has a positive impact on the working hours. For large values of the wife's wage rate the converse is true. Then the rejection of Slutsky positivity appears for some households in which the wife is characterized

29. Remember that the Marshallian labor supply is linear in income. Hence, the superiority of leisure is "global." See Table 4 for more details.

Table 3
Elasticities of Labor Supply

	Estimates	Asymptotic Standard Errors	p-Values
Estimated wage elasticity of the unconstrained labor supply			
at $w_f = 5.87$ (first quartile)	0.374	0.103	0.000
at $w_f = 7.71$ (median)	0.405	0.102	0.000
at $w_f = 10.33$ (third quartile)	0.379	0.089	0.017
Estimated wage elasticity of the constrained labor supply			
at $w_f = 5.87$ (first quartile)	0.386	0.086	0.000
at $w_f = 7.71$ (median)	0.416	0.088	0.000
at $w_f = 10.33$ (third quartile)	0.384	0.083	0.000
Estimated income elasticity of the unconstrained labor supply			
at $\psi = 9842$ (first quartile)	−0.143	0.057	0.012
at $\psi = 16815$ (median)	−0.217	0.084	0.009
at $\psi = 27341$ (third quartile)	−0.286	0.106	0.007
Estimated income elasticity of the constrained labor supply			
at $\psi = 9842$ (first quartile)	−0.136	0.049	0.006
at $\psi = 16815$ (median)	−0.207	0.074	0.005
at $\psi = 27341$ (third quartile)	−0.276	0.098	0.005

Notes: Asymptotic standard errors are computed with the Delta method. Elasticities are computed at $h_f = 39$. Other covariates are at the sample mean.

by a very large wage rate. The second panel of Table 4 includes the wage elasticity conditional on the sharing of nonwife income. This ignores any effect the wage rate may have on the intra-household decision process. We note that the wage elasticity is positive, concave, and statistically significant at the 10 percent level. Its value is twice as big as those reported in Table 3 and is close to one at the mean of the sample. It is noteworthy that this figure may be compared with what is found in the literature on collective models. For example, Chiappori, Fortin, and Lacroix (2002) report a wage elasticity of 0.178 with United States data, Fortin and Lacroix (1997) a wage elasticity of 0.361 with Canadian data, and Moreau and Donni (2002) a wage elasticity of 0.394 with French data. The elasticities in Table 4 are substantially greater. However, they are compatible with previous researches since the standard errors of the estimated parameters are quite large.

Finally, the sharing rule estimates are shown in Table 5. The parameters turn out not to be precisely estimated: no coefficient is significant at the 10 percent level. We finally compute the marginal impacts of the exogenous variables on the sharing rule (these are not reported here) but none of them is significant.

Table 4
Estimated Parameters of the Structural Model: The Marshallian Labor Supply

		Parameters	Asymptotic Standard Errors	p-Values
B :	w_f	11.011	6.187	0.075
C :	w_f^2	-0.374	0.235	0.111
D :	$(\psi - \rho) \times 10^{-2}$	-0.011	0.013	0.368
Estimated wage elasticity of the Marshallian labor supply				
at $h_f = 39$, with $w_f = 5.87$ (first quartile)		0.996	0.529	0.060
at $h_f = 39$, with $w_f = 7.71$ (median)		1.035	0.537	0.054
at $h_f = 39$, with $w_f = 10.33$ (third quartile)		0.868	0.449	0.053

Note: Asymptotic standard errors are computed with the Delta method.

3. *Tests of Husband's Labor Supply Rigidity*

Our theoretical results crucially rely on the postulate that the wife's labor supply is independent of the husband's wage rate (conditionally on the levels of nonwife income and one reference good). This is a consequence of the husband's labor supply rigidity. In particular, if the husband's hours of work vary, the wife's labor supply will in general depend on the husband's wage rate. In that case, our conclusions will be invalidated.

As a matter of fact, the data indicate that the dispersion of the husband's working hours is quite limited. In spite of that, the husband's wage rate can possibly influence the wife's behavior and question the validity of our approach. Also, the rigidity of the husband's behavior must be tested. To do that, we introduce an additional term, w_m, in the functional form (Equation 15) and assess its significance.[30] We perform this test whether W_m is included or not in the set of instruments, where W_m is the matrix of variables constructed from the husband's labor income. In both cases, the husband's wage rate has no impact statistically different from zero.

We also test in the estimation of Equation 15 for the endogeneity of the subset of instruments W_m. Suppose that the husband's wage rate is exogenous. Now it is orthogonal to the error term if husband's labor supply is exogenously constrained. Otherwise, it is not. The corresponding test statistic is simply the difference in the criterion functions for GMM estimation with and without the questionable instruments W_m (Ruud 2000, p. 576). Under the null hypothesis of orthogonality it converges in distribution to a $\chi^2(k)$ random variable, where $k = 5$ is the number of questionable instruments. The difference gives a test statistic of 8.139 (8.115 if the collective restrictions (16) are imposed). At conventional levels we do not reject the null hypothesis.[31] In conclusion, even if the husband's working hours exhibit some dispersion, this should not prevent us from applying the present theory. In

30. This procedure is intended to test the implication of the dispersion in husband's hours that may invalidate our theory.
31. Further details are available upon request.

Table 5
Estimated Parameters of the Structural Model: The Sharing Rule

		Parameter Estimates	Standard Errors	p-Value
K_1 :	w_f	−56,923.450	84,039.060	0.498
K_2 :	ψ	−7.317	10.105	0.469
K_3 :	x	33.532	41.789	0.422
K_4 :	w_f^2	2,180.998	2,933.883	0.457
K_5 :	$\psi^2 \times 10^{-3}$	0.036	0.047	0.440
K_6 :	$x^2 \times 10^{-3}$	0.757	0.811	0.351
K_7 :	$w_f \times \psi$	0.561	0.660	0.396
K_8 :	$w_f \times x$	−2.569	2.764	0.353
K_9 :	$\psi \times x \times 10^{-2}$	−0.033	0.038	0.382

Note: Asymptotic standard errors are computed with the Delta method.

addition, this test reinforces the evidence that the husband's labor supply is exogenously determined in France.

V. Conclusion

In the present paper, we suppose that the husband's labor supply is exogenously determined. We then advocate a simple approach to model the wife's labor supply, in which the wife's behavior is explained by her wage rate, other household incomes, sociodemographic variables, and the demand for one good consumed at the household level. In this approach, the level of the conditioning good can be interpreted as an indicator of the distribution of power within the household.

We then demonstrate that the estimation of a single equation (including one conditioning good as argument) permits to carry out tests of collective rationality and to identify some elements of the structural model. The simplicity of the estimation method suggests that the approach used in this paper is especially profitable to perform empirical tests.

Another important contribution of the present paper is to show that our approach (and the collective setting as a whole for that matter) is compatible with domestic production on the condition that the household production function belongs to some specific family of separable technologies.

Finally, these theoretical considerations are followed by an empirical application using a French sample of working wives. We show that, overall, the collective restrictions are satisfied by the data. However, the estimates of the structural model are not precisely estimated. One way of dealing with that is to exploit the information on nonparticipating wives.

Indeed, the parameters that enter the "reduced" participation equation (used in constructing the inverse Mill's ratio) are not related to the parameters of the labor supply equation. In that case, the basic idea is to estimate a "structural" participation equation, derived from the comparison of a shadow wage equation (incorporating the parameters of the wife's labor supply) and a market wage equation. The implementation of this idea raises some econometric difficulties, though. This is the topic of future work.

Appendix 1

Proof of Propositions

A. Proof of Proposition 2

In what follows, we first demonstrate Statements a and c of Proposition 2; we then demonstrate Statement c.

Identification of $\partial\zeta/\partial\kappa$. Differentiating the s-conditional labor supply with respect to ψ and x gives:

$$\frac{\partial h_f}{\partial\psi} = \frac{\partial\eta_f}{\partial(\psi-\kappa)}\left(1-\frac{\partial\kappa}{\partial\psi}\right), \frac{\partial h_f}{\partial x} = -\frac{\partial\eta_f}{\partial(\psi-\kappa)}\left(\frac{\partial\kappa}{\partial x}\right),$$

Since $\partial h_f/\partial\psi \neq 0$ from **R**, this yields:

$$(22)\quad -\frac{\partial h_f}{\partial\psi}\left(\frac{\partial h_f}{\partial x}\right)^{-1} = \left(1-\frac{\partial\kappa}{\partial\psi}\right)\left(\frac{\partial\kappa}{\partial x}\right)^{-1}.$$

Similarly, using Lemma 1 and differentiating the household demand for good x with respect to x and ψ gives:

$$(23)\quad 1 = \left(\frac{\partial\zeta_m}{\partial\kappa} - \frac{\partial\zeta_f}{\partial(\psi-\kappa)}\right)\frac{\partial\kappa}{\partial x},$$

$$(24)\quad \frac{\partial\zeta_m}{\partial\kappa} = \left(\frac{\partial\zeta_m}{\partial\kappa} - \frac{\partial\zeta_f}{\partial(\psi-\kappa)}\right)\left(1-\frac{\partial\kappa}{\partial\psi}\right),$$

or

$$(25)\quad \frac{\partial\zeta_m}{\partial\kappa} = \left(1-\frac{\partial\kappa}{\partial\psi}\right)\left(\frac{\partial\kappa}{\partial x}\right)^{-1}.$$

Substituting Equation 22 into Equation 25 yields the husband's Engel curve:

$$(26)\quad \frac{\partial\zeta_m}{\partial\kappa} = -\frac{\partial h_f}{\partial\psi}\left(\frac{\partial h_f}{\partial x}\right)^{-1} = \alpha.$$

Identification of $\partial\kappa/\partial w_f, \partial\kappa/\partial\psi,$ and $\partial\kappa/\partial x$. Differentiating (26) with respect to w_f, ψ, and x yields:

$$\frac{\partial^2\zeta_m}{\partial\kappa^2}\frac{\partial\kappa}{\partial w_f} = \frac{\partial\alpha}{\partial w_f}, \frac{\partial^2\zeta_m}{\partial\kappa^2}\frac{\partial\kappa}{\partial\psi} = \frac{\partial\alpha}{\partial\psi}, \frac{\partial^2\zeta_m}{\partial\kappa^2}\frac{\partial\kappa}{\partial x} = \frac{\partial\alpha}{\partial x}.$$

Since

$$\frac{\partial\alpha}{\partial\psi}\frac{\partial h_f}{\partial x} \neq \frac{\partial\alpha}{\partial x}\frac{\partial h_f}{\partial\psi},$$

this system of partial differential equations, together with Equation 22, can be solved with respect to $\partial\kappa/\partial w_f, \partial\kappa/\partial\psi,$ and $\partial\kappa/\partial x$. That is,

$$(27) \quad \frac{\partial\kappa}{\partial w_f} = \frac{\partial\alpha}{\partial w_f}\beta, \frac{\partial\kappa}{\partial\psi} = \frac{\partial\alpha}{\partial\psi}\beta, \frac{\partial\kappa}{\partial x} = \frac{\partial\alpha}{\partial x}\beta.$$

Identification of $\partial\eta_f/\partial(\psi-\kappa),$ and $\partial\eta_f/\partial w_f$. If we differentiate the wife's s-conditional labor supply with respect to x and w_f, we obtain:

$$(28) \quad \frac{\partial h_f}{\partial x} = -\frac{\partial\eta_f}{\partial(\psi-\kappa)}\frac{\partial\kappa}{\partial x}, \frac{\partial h_f}{\partial w_f} = \frac{\partial\eta_f}{\partial w_f} - \frac{\partial\eta_f}{\partial(\psi-\kappa)}\frac{\partial\kappa}{\partial w_f}.$$

Since $\beta \neq 0$ and $\partial\alpha/\partial x \neq 0$, substituting Equation 27 into Equation 28 yields:

$$(29) \quad \frac{\partial\eta_f}{\partial(\psi-\kappa)} = -\frac{\partial h_f}{\partial x}\frac{1}{\beta(\partial\alpha/\partial x)}, \frac{\partial\eta_f}{\partial w_f} = \frac{\partial h_f}{\partial w_f} - \frac{\partial h_f}{\partial x}\frac{\partial\alpha/\partial w_f}{\partial\alpha/\partial x}.$$

Identification of $\partial\zeta_f/\partial(\psi-\kappa)$ and $\partial\zeta_f/\partial w_f$. The slopes of the demand for good x can be retrieved in a similar way. Substituting Equations 26 and 27 into Equation 23 gives:

$$(30) \quad \frac{\partial\zeta_f}{\partial(\psi-\kappa)} = \alpha - \frac{1}{\beta(\partial\alpha/\partial x)}.$$

Differentiating the household demand for good x with respect to w_f, and using Equations 26 and 27 yields:

$$\frac{\partial\zeta_f}{\partial w_f} = -\frac{\partial\alpha/\partial w_f}{\partial\alpha/\partial x}.$$

Identification of other elements. The derivatives of the Marshallian demands for good c can be obtained from the individual budget constraints. Moreover, once the function $k(z)$ is picked up, the wife's total consumption can be retrieved. Then, the wife's utility function is derived as usual; see Deaton and Muellbauer (1983) for instance.

B. Proof of Proposition 3

1. Substituting Equation 29 into Equation 7 yields:

$$\frac{\partial h_f}{\partial w_f} - \frac{\partial\alpha}{\partial w_f}\frac{\partial h_f/\partial x}{\partial\alpha/\partial x} + \frac{\partial h_f/\partial x}{\beta(\partial\alpha/\partial x)}h_f > 0.$$

2. From Young's Theorem, the derivatives of the sharing rule have to satisfy a symmetry restriction. Using Statement a in Proposition 2 and simplifying yield:

$$\frac{\partial\alpha}{\partial w_f}\frac{\partial\beta}{\partial x} - \frac{\partial\alpha}{\partial x}\frac{\partial\beta}{\partial w_f} = \frac{\partial\alpha}{\partial\psi}\frac{\partial\beta}{\partial x} - \frac{\partial\alpha}{\partial x}\frac{\partial\beta}{\partial\psi} = 0.$$

C. Proof of Proposition 4

(a) From Equation 29,

$$\frac{\partial h_f/\partial x}{\beta(\partial\alpha/\partial x)} > 0,$$

if wife's leisure is normal. This gives the first statement in Proposition 4.

(b) From Equations 26 and 30,

$$\alpha > 0, \alpha - \frac{1}{\beta(\partial\alpha/\partial x)} > 0,$$

if good x is normal (for both spouses). From these expressions and the individual budget constraints, we obtain:

$$1 - \frac{\partial\zeta_m}{\partial\kappa} = 1 - \alpha > 0,$$
$$1 - \frac{\partial\zeta_f}{\partial(\psi-\kappa)} - w_f\frac{\partial\eta_f}{\partial(\psi-\kappa)} = 1 - \alpha + \frac{1 + w_f\left(\partial h_f/\partial x\right)}{\beta(\partial\alpha/\partial x)} > 0,$$

if good c is normal (for both spouses). Rearranging these expressions gives the second statement.

Appendix 2

Alternative Estimations

We carry out two alternative estimations of the model, with expenditures on food away from home and clothing as the conditioning good respectively. One problem, however, is that reported expenditures on clothing (food away from home) are equal to zero for 7.5 percent (18 percent) of the 1670 households of our selection. Be that as it may, these estimations are presented in Table 6. For the sake of comparability, the estimated parameters are obtained with the same set of instruments as those used for the regression in the main text. To complete these results, note that the parameters B and C of the Marshallian labor supply are significant at the 1 percent level when the conditioning good is food away from home; in that case, the parameters K_6 and K_9 are also significant (at the 5 percent and the 10 percent level). Furthermore, the Slutsky condition is satisfied for 92 percent of the sample, while Conditions 1 and 2 of Proposition 4 are satisfied for 100 percent and 34 percent of the sample respectively. On the other hand, when the conditioning good is clothing, the results are less convincing. No parameters of the structural model are significant. The Slutsky condition is satisfied for 66 percent of the sample, and the Conditions 1 and 2 are satisfied for 100 percent and 8 percent of the sample respectively.

Table 6
Estimation with Two Alternative Conditioning Goods

		Unrestricted Model		Restricted Model	
		Food away from home	Clothing	Food away from home	Clothing
a_{01} :	w_f	5.406*	5.104***	4.169**	4.018***
		(2.801)	(1.881)	(1.738)	(1.021)
a_{02} :	$\psi \times 10^{-2}$	−0.059	−0.054	−0.068*	−0.043
		(0.050)	(0.044)	(0.041)	(0.032)
a_{03} :	x	−0.001	−0.003	0.002	−0.000
		(0.007)	(0.006)	(0.004)	(0.004)
a_{11} :	w_f^2	−0.207*	−0.222**	−0.142***	−0.139***
		(0.106)	(0.092)	(0.050)	(0.040)
a_{22} :	$\psi^2 \times 10^{-9}$	5.879**	2.504	6.010**	2.394
		(2.969)	(2.896)	(2.751)	(2.130)
a_{33} :	$x^2 \times 10^{-8}$	60.380	25.920	48.680	1.984
		(52.380)	(50.360)	(41.230)	(9.804)
a_{12} :	$w_f\psi \times 10^{-2}$	0.002	0.005	0.002	0.002
		(0.003)	(0.004)	(0.003)	(0.003)
a_{13} :	$w_f x \times 10^{-2}$	0.017	0.031	−0.017	−0.006
		(0.050)	(0.041)	(0.022)	(0.021)
a_{23} :	$\psi x \times 10^{-9}$	−193.000	−134.000	−108.00*	−13.800
		(132.400)	(111.600)	(59.570)	(34.550)
α_0 :	Intercept	15.673	19.564*	22.412**	23.100***
		(14.619)	(10.231)	(10.146)	(6.109)
α_{ch} :	Number of children	−0.244	−1.019	−0.162	−1.169
		(0.868)	(0.979)	(0.766)	(0.768)
α_{age} :	Wife's age	−0.150**	−0.144**	−0.159***	−0.151***
		(0.062)	(0.059)	(0.051)	(0.046)
b_λ :	Inverse Mill's ratio	3.355	1.599	1.924	0.974
		(3.624)	(2.239)	(2.815)	(1.811)
Objective function		6.391	7.437	8.383	12.263

Notes: Asymptotic standard errors in parentheses. Significance levels of 10, 5 and 1 percent are noted *, ** and *** respectively.

Table 7
Tests of the Validity of the Instruments

	F-statistic	p-Value	$\overline{R}^2$
The Fisher's test			
$1: w_f$	31.538	0.000	0.386
$2: \psi$	8.644	0.000	0.157
$3: x$	9.061	0.000	0.255
$4: w_f\psi$	13.369	0.000	0.206
$5: w_f x$	23.543	0.000	0.422
$6: \psi x$	9.974	0.000	0.238
$7: w_f^2$	16.494	0.000	0.277
$8: \psi^2$	4.744	0.000	0.059
$9: x^2$	7.386	0.000	0.209
The Robin-Smith's test			
H_0: $rk = i$, H_1: $rk > i$ $\quad i = 1, \dots, 7$		0.000	
H_0: $rk = 8$, H_1: $rk = 9$		0.000	

Appendix 3

Auxiliary Regressions

We carry out several tests to check the instruments used in the regressions. These tests are described in Table 7.

In Table 8, the wife's age is represented by dummies, Age_i with $i = 1, \dots, 6$. The age groups are <30, 31-34, 35-39, 40-44, 45-49, and ≥ 50. The wife's education level is also represented by dummies, Educ_i, with $i = 1, \dots, 7$, which represent the highest diploma attained by the wife. The unemployment rate is specific to gender and varies with age and education for the year 2000. It is denoted by urate_i, with $i = m, f$.

The results show a strong effect of age, education, and income, whereas the unemployment rates have a significant effect. Hence, the labor supply equation, which excludes the latter variables, is well identified. The statistics for the normality test is equal to 4.014 (with two degrees of freedom), which is acceptable at conventional levels.

Table 8
Reduced Form Participation Probit

	Parameters estimates	Asymptotic standard errors
Intercept	−17.413***	3.627
Age_1	0.892***	0.088
Age_2	−0.495***	0.079
Age_3	*reference*	*reference*
Age_4	0.400***	0.086
Age_5	0.335***	0.091
Age_6	0.509***	0.110
$Educ_1$	−1.480***	0.194
$Educ_2$	−0.865***	0.197
$Educ_3$	−0.666***	0.126
$Educ_4$	−0.699***	0.121
$Educ_5$	−0.188	0.133
$Educ_6$	−0.339***	0.109
$Educ_4$	*reference*	*reference*
$\ln(w_m h_m)$	3.760***	0.745
$\ln^2(w_m h_m)$	−0.202***	0.038
$urate_m$	0.055***	0.021
$urate_f$	0.067***	0.017
$urate_m \times urate_f$	−0.003**	0.001
Nonnormality (2)	4.014	p-Value = 0.134
Skewness (1)	3.129	p-Value = 0.077
Kurtosis (1)	2.564	p-Value = 0.109
Nonparticipants = 1,096, Participants = 1,670		

Note: Significance levels of 10, 5 and 1 percent are noted *, ** and *** respectively. The statistics of tests have a χ^2−distribution (degrees of freedom are in parentheses). The normality test statistics reported here follow the Generalised Residual methodology of Chesher and Irish (1987).

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