Household Labor Supply, Sharing Rule and the Marriage Market *

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Abstract

In this paper we estimate a model of household labor supply based on the collective approach developed by Chiappori (JPE, 1992). This approach assumes that the intra-household decision process leads to Pareto efficient outcomes. Our model extends this theory by allowing the marriage market, and especially the sex ratio, to affect the sharing rule and the household labor supplies. We show that our model imposes new restrictions on the parameters of the labor supply functions. Also, individual preferences and the sharing rule are recovered using an identification procedure that is both simpler and more robust than in Chiappori's initial approach. The model is estimated using PSID data for the year 1988. Our results do not reject the restrictions imposed by the model. Moreover, the sex ratio influences the sharing rule and the labor supply behavior in the directions predicted by the theory. Finally, the impact of individual wage rates suggests that spouses behave in an altruistic manner within the household.

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1 Introduction

Traditionally, household demand and labor supply decisions have been modeled as though household members were maximizing a unique, well behaved, utility function. Recent dissatisfaction with this "unitary" model arose in a large part from the weakness of its theoretical foundations [Chiappori (1992)] and its inability to be used to perform intra-household welfare analysis [Apps and Rees (1988)] or to study decisions such as marriage or divorce [Lundberg (1988)][1]. Since the standard unitary model considers the household as the basic unit of decision, it is generally not possible to recover individual preferences or the parameters of the internal decision process that determines the distribution of utilities and observed outcomes.

Alternative models have recently challenged the unitary model and attempted to incorporate different individual preferences and a model of intra-household decision making process. In particular, the Nash bargaining model assumes that a household maximizes the product of each member's utility in excess of a reservation level reflecting either marriage dissolution [*e.g.*, Manser and Brown (1980), McElroy and Horney (1981)] or an "uncooperative" marriage [*e.g.*, Lundberg and Pollak (1993)]. A collective model of household labor supply has also been developed by Chiappori [(1988), (1992)]. He assumes that household decisions are Pareto efficient but abstracts from the details of the bargaining process. In its most general form, the collective model nests Nash bargaining models as particular cases, since the latter are based on axioms that include Pareto efficiency. It also nests uncooperative repeated game models as long as they lead to Pareto efficient outcomes [see Lundberg and Pollak (1994) and Bergstrom (1997) for a discussion].

A crucial issue concerns the design of empirical tests of these unitary and non-unitary theories. One important implication of the unitary model is pooling: only total exogenous income, not its distribution across household members, plays a role in the decision process. Using various measures of income, many studies attempted to test this income pooling hypothesis [*e.g.*, Schultz (1990), Thomas (1990), Phipps and Burton (1994)]. In all these studies, income pooling is strongly rejected. However, these tests raise two issues. First, while the results reject the unitary model, they cannot be interpreted as supporting any alternative approach in particular since many models could rationalize such results. In order to empirically support a specific model, one must derive, from this setting, restrictions that can potentially be, but are actually not, falsified by empirical observations. Recent work has attempted to derive and provide empirical tests of the collective approach [see Bourguignon *et al.* (1993), Browning *et al.* (1994), Udry (1996), Browning and Chiappori (1997)]. Browning, Lechene and Rasheed

[1] An obvious exception is Becker's (1991) approach, where the household is explicitly modeled as a two-person decision unit, although its behavior can be still analyzed with the tools of standard consumer theory.

(1996) have tested different non-unitary models within a structural framework. However, they assume that labor supply is fixed, which may lead to specification problems. Moreover, individual preferences over consumption and leisure cannot be recovered. Fortin and Lacroix (1997) have provided an analysis that allows labor supply to vary. They found that while the restrictions of the unitary model are rejected, the collective restrictions are not. More recently, Blundell *et al.* (1998) investigate labor participation decisions within a collective context, allowing for unobservable heterogeneity. In both cases, however, the intra-household decision process is not very precisely estimated.

The second issue concerns the use of individual incomes in the design of the tests. In most studies, the distribution of household (total or nonlabor) income plays an important role in the derivation of tests. However this variable is particularly prone to reporting and measurement errors which may severely bias econometric tests [Chiappori *et al.* (1993), Lundberg and Pollak (1996)]. The endogeneity of earnings is likely to be a serious problem as well. Finally, one must also expect nonlabor income to be correlated with some unobservable individual characteristics that influence consumption and labor supply [Behrman, Pollak and Taubman (1995)]. For instance, variations in property income may reflect past saving and therefore unobserved (past and current) productivity heterogeneity[2].

It should however be emphasized that individual incomes are not needed to perform tests of this kind. A more general idea is to use distribution factors [Bourguignon, Browning and Chiappori (1995)], that is, variables that can affect the decision process without influencing preferences or the joint consumption set. Typically, distribution factors include not only individual income variables, but also "extra-environmental parameters" (EEPs) in McElroy's (1990) terminology. EEPs affect opportunities of spouses outside marriage and can therefore influence respective bargaining power and the final allocation. Like individual income variables, EEPs should have no effect on behavior in the unitary framework while the collective approach may impose restrictions as to how they influence outcomes. Moreover, EEPs play a role in some cooperative models while they play none in others. Thus outside opportunities can influence behavior in the Manser-Brown/McElroy-Horney divorce threat bargaining model, while they will have no effect in the Lundberg-Pollak "separate spheres" bargaining model. In this case, the fall-back option is not divorce but an uncooperative marriage in which spouses "revert to a division of work based on socially recognized and sanctioned gender roles".[3] In short, distribution factors (or EEPs) represent a means of providing additional tests

[2] One way to avoid these problems is to exploit "natural" experiments involving exogenous reallocation in intra-household incomes. Thus Lundberg, Pollak and Wales (1997) present a test of pooling based on a policy change in the United Kingdom that transferred child allowances from husbands to wives in the late 1970's. Unfortunately such natural experiments are very scarce.

[3] Lundberg and Pollak (1993) develop a modified version of this model which allows for binding prenuptial

of the unitary and the collective models, and of discriminating between some non-unitary approaches.

Variables that proxy the situation in the marriage market are natural candidates for EEPs. This intuition can be traced back to Becker (1991, ch.3), who emphasized that the marriage market is an important determinant of intra-household utility distribution. In his approach, the state of the marriage market crucially depends on the sex ratio, that is, the relative supplies of males and females in the marriage market.[4] A nice theoretical foundation of this view has been provided by Rubinstein and Wolinsky (1985), who consider a non cooperative repeated game model of transactions between pairs of agents who meet randomly and bargain if they meet. Viewed as a model of marriage, it predicts that, following an increase in the number of males relative to females, males will be willing to concede a larger share of the gains from a marriage contract with a female [Bergstrom (1997)]. Grossbard-Shechtman (1993) has developed a simple general equilibrium model of the interactions between marriage and labor markets in which the sex ratio influences marital and labor supply decisions. At the empirical level, using time series and cross-section data, she found that an increase in the sex ratio reduces the labor force participation of married women in the U.S. However her econometric approach is not explicitly grounded in a structural model and uses aggregate data, which may create serious econometric problems for empirical testing.

The aim of the present paper is to theoretically analyze and empirically estimate the effects of distribution factors in the context of a structural, micro-economic model of household behavior. The underlying model is Chiappori's (1992) collective model of labor supply, where leisure and consumption are privately consumed within the household. Efficiency has, in this setting, a very simple interpretation : household decisions can be modeled as a two-step process, where individuals first share their total nonlabor income according to some sharing rule, then maximize their own utilities subject to separate budget constraints. In particular, the intra-household decision process can be fully summarized by the sharing rule. We first investigate the theoretical consequences of the introduction of a distribution factor. The latter, by definition, only influences behavior through its effect upon the sharing rule. We show that this fact generates new testable restrictions. Also, as in Chiappori's initial model, it is possible to recover the parameters of individual preferences (up to a translation) and of the sharing rule (up to an additive constant) from the sole observation of labor supply. We show, however, that the new context allows for a different identification procedure, that is both simpler and

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agreements on a minimal transfer from one spouse to the other. This model could allow EEPs to influence distribution within marriage in the long run by influencing the value of this transfer in new marriages.

[4] Lundberg and Pollak (1996) insist on the specific features of the marriage contract (*e.g.*, whether marriage agreements are binding or not) as another determinant of the marriage market. Unfortunately, it is difficult to construct empirical measures of these features.

more robust than before. In particular, it only relies upon first order derivatives of labor supply functions, whereas second order derivatives were required in the initial framework.

We then estimate and test this collective model using 1988 PSID data for couples in which both spouses are working. The distribution factor we use is the sex ratio by age, race and location. For estimation purposes, we use a full information Generalized Method of Moments (GMM) applied to a two-equation system with endogenous explanatory variables. We find that the effect of the sex ratio upon labor supply is significant, and that it satisfies the testable restrictions implied by the collective model. Hence, not only does the sex ratio influence behavior, but it does so in exactly the way predicted by the theory. Other things equal, an increase in the proportion of men lowers female labor supply while it increases male labor supply. Empirically, it is found that a one percentage point increase in the sex ratio raises transfers from husbands to their wife by around $2,500 a year. Even more interesting is the fact that no effect of the sex ratio on singles' labor supply can be observed; this indicates that, although the sex ratio may partly reflect conditions on the labor market, it probably is not the whole story.

The other parameters of the sharing rule are also recovered. For instance, we find that a one dollar increase in male (resp. female) hourly wage - which, given the average number of hours per year, represents an average additional yearly income above $2,200 (resp. above $1,700) - increases (resp. decreases) the female share of nonlabor income by $600 (resp. $900). Similarly, one dollar increase in household nonlabor income will increase the wife's income by 55 cents.

Section 2 presents our theoretical framework. Section 3 discusses the choice of the empirical specification adopted for estimating and testing purposes. Section 4 provides an analysis of our econometric strategy. Data and empirical results are discussed in Section 5. Our conclusions are presented in Section 6.

2 The Model

2.1 The basic setting

In this section, we develop a collective labor supply model which extends Chiappori's (1992) approach to take into account distribution factors. In this framework, the household consists of two individuals with distinct utility functions and the decision process, whatever its true nature, leads to Pareto-efficient outcomes. This assumption seems quite natural, given that spouses usually know each other's preferences pretty well (at least, after a certain period of time) and interact very often. Therefore, they are unlikely to leave Pareto-improving decisions unexploited [however, see Udry (1996)].

Formally, let h^i and C^i denote respectively member i's labor supply (with $0 \leq h^i \leq 1$) and consumption of a private hicksian composite good whose price is set to unity, for $i = 1, 2$. Household members have egoistic preferences[5] represented by strictly quasi-concave and increasing, continuously differentiable, utility functions $U^i(1 - h^i, C^i, z)$, where z is a $K-$vector of preference factors, such as age and education of the two agents, number and age of children, *etc*. For convenience, the vector z is assumed the same in both utility functions. Also, let w_1, w_2, y denote respective wage rates and household nonlabor income. Finally, let s denote a $L-$vector of distribution factors.

Under the collective framework, intra-household decisions are Pareto-efficient, that is, for given (w_1, w_2, y, z, s), there exists a weighting factor $\mu(w_1, w_2, y, z, s)$ belonging to $[0, 1]$, and such that the (h^i, C^i) solves the following program:

$$\max_{\{h^1,h^2,C^1,C^2\}} \mu U^1(1 - h^1, C^1, z) + (1 - \mu)\, U^2(1 - h^2, C^2, z)$$

$$\text{subject to} \qquad (\bar{P})$$

$$\begin{aligned} w_1 h^1 + w_2 h^2 + y &\geq C^1 + C^2, \\ 0 &\leq h^i \leq 1, \;\; i = 1, 2, \end{aligned}$$

where the function μ is assumed continuously differentiable in its arguments. It should thus be clear that the particular location of the solution on the Pareto frontier depends on all relevant parameters, since the value of μ depends on w_1, w_2, y, z and s. Furthermore, since the vector of distribution factors, s, appears only in μ, a change in s does not affect the Pareto frontier but only the final location on it. In the particular case where μ is assumed to be constant, the collective framework corresponds to the unitary model. In this situation, the distribution factors have no effect on behavior.

As far as efficiency is concerned, there is basically no restriction upon the form of the function μ. However, for the estimation process, we shall assume that μ is monotonic. A natural interpretation is that, in line with, say, a bargaining interpretation of the decision process,

[5]As shown below, the model also holds in the more general case of "caring' preferences [see Becker (1991)].

any distribution factor that is positively (resp. negatively) correlated with member 1's (resp. 2's) threat point should increase μ.

Now, it is well known from the second fundamental welfare theorem that any Pareto optimum can be decentralized in an economy of this kind [see Chiappori (1992)]. Specifically, we have the following result:

Proposition 1 *The program $(\bar{P})$ is equivalent to the existence of some function $\phi(w_1, w_2, y, z, s)$ such that each member i ($i = 1, 2$) solves the program:*

$$\max_{\{h^i, C^i\}} U^i(1 - h^i, C^i, z)$$

$$\textit{subject to} \qquad (\bar{P}')$$

$$\begin{aligned} w_i h^i + \phi^i &\geq C^i \\ 0 &\leq h^i \leq 1 \end{aligned}$$

where $\phi^1 = \phi$ and $\phi^2 = y - \phi$.

Proof. This is an immediate consequence of the second welfare theorem. ■

The interpretation is that the decision process can always be considered as a two stage process : first, nonlabor income is allocated between household members and then, each member separately chooses labor supply (and private consumption), subject to the corresponding budget constraint. The function ϕ is called the *sharing rule*; it describes the way nonlabor income is divided up, as a function of wages, nonlabor income, distribution factors and other observable characteristics.[6]

2.2 Restrictions on Labor Supplies and the Sharing Rule

The collective framework imposes certain restrictions on the labor supply functions. To analyze this issue, let us first define the unrestricted labor supply functions:

$$h^1 = h^1(w_1, w_2, y, s, z), \qquad (1)$$
$$h^2 = h^2(w_1, w_2, y, s, z). \qquad (2)$$

[6] In the presence of household public goods, a sharing rule can be defined but conditionally on the level of these public goods.

In the remainder, we assume these functions are continuously differentiable. From $(\bar{P}')$, and assuming an interior solution, labor supply functions can be written as:

$$h^1 = H^1(w_1, \phi(w_1, w_2, y, s, z), z), \tag{3}$$

$$h^2 = H^2(w_2, y - \phi(w_1, w_2, y, s, z), z). \tag{4}$$

where H^i is the Marshallian labor supply associated with U^i.

The particular structure of equations (3) and (4) imposes testable restrictions on labor supply behavior; also, it allows the recovery of the partials of the sharing rule. The intuition goes as follows. Consider a change in, say, member 1's wage rate. This can only have an income effect on his or her spouse's behavior through its effect on the sharing rule, just as distribution factors and nonlabor income. Thus, the impact of these variables on labor supply behavior of member 1 allows us to estimate the marginal rate of substitution between w_2 and y as well as between s and y in the sharing rule; technically, it generates two equations involving the corresponding partials of the sharing rule. The same argument applies to member 2's behavior, which leads to two other equations. These four equations allow to directly identify the four partials of the sharing rule. Finally, cross-derivative constraints on the sharing rule imposes restrictions to the model that can be tested.

To be more precise, using equations (3) and (4), let us define $A = h^1_{w_2}/h^1_y$, $B = h^2_{w_1}/h^2_y$, $C_l = h^1_{s_l}/h^1_y$ and $D_l = h^2_{s_l}/h^2_y$, whenever $h^1_y \cdot h^2_y \neq 0$, for $l = 1, \cdots, L$. Note that all these variables are observable and can thus be estimated. The following results hold:

Proposition 2 *Take any point such that* $h^1_y \cdot h^2_y \neq 0$. *Then*

(i) If there exists exactly one distribution factor, and it is such that $C \neq D$ *(the subscript* $l = 1$ *has been removed to simplify the notation), the following conditions are necessary for any pair (*h^1, h^2*) to be solutions of* $(\bar{P}')$ *for some sharing rule* ϕ*:*

(a)

$$\frac{\partial}{\partial s}\left(\frac{D}{D - C}\right) = \frac{\partial}{\partial y}\left(\frac{CD}{D - C}\right)$$

(b)

$$\frac{\partial}{\partial w_1}\left(\frac{D}{D - C}\right) = \frac{\partial}{\partial y}\left(\frac{BC}{D - C}\right)$$

(c)

$$\frac{\partial}{\partial w_2}\left(\frac{D}{D-C}\right)=\frac{\partial}{\partial y}\left(\frac{AD}{D-C}\right)$$

(d)

$$\frac{\partial}{\partial w_1}\left(\frac{CD}{D-C}\right)=\frac{\partial}{\partial s}\left(\frac{BC}{D-C}\right)$$

(e)

$$\frac{\partial}{\partial w_2}\left(\frac{CD}{D-C}\right)=\frac{\partial}{\partial s}\left(\frac{AD}{D-C}\right)$$

(f)

$$\frac{\partial}{\partial w_2}\left(\frac{BC}{D-C}\right)=\frac{\partial}{\partial w_1}\left(\frac{AD}{D-C}\right)$$

(g)

$$h^1_{w_1}-h^1_y\left(\left(h^1+\frac{BC}{D-C}\right)\left(\frac{D-C}{D}\right)\right)\geq 0$$

(h)

$$h^2_{w_2}-h^2_y\left(\left(h^2-\frac{AD}{C-D}\right)\left(-\frac{D-C}{C}\right)\right)\geq\ 0$$

(ii) Assuming that conditions $(a)-(h)$ hold and for a given z, the sharing rule is defined up to an additive function $\kappa(z)$ depending only on the preference factors z. The partial derivatives of the sharing rule with respect to wages, nonlabor income and the distribution factor are given by:

(i)

$$\begin{aligned}\phi_y &= \frac{D}{D-C}\\ \phi_s &= \frac{CD}{D-C}\\ \phi_{w_1} &= \frac{BC}{D-C}\\ \phi_{w_2} &= \frac{AD}{D-C}\end{aligned}$$

(iii) Finally, if there are several distribution factors ($l = 1, \cdots, L$), an additional set of necessary and sufficient conditions are:

(j)

$$\frac{C_l}{D_l} = \frac{C_1}{D_1} \ , \ \ l = 2, \cdots, L$$

Demonstration: see Appendix

Conditions $(a) - (h)$ are analogous to Slutsky restrictions in the (general) sense that they provide a set of partial differential equations and inequalities that must be satisfied by the labor supply equations (1) and (2) in order to be consistent with the collective model. Note, however, that their form is quite different from those obtained in Chiappori (1992) for a similar model without distribution factors. As a matter of fact, the introduction of distribution factors deeply changes the way the model is identified. In Chiappori's initial contribution, identification required second order derivatives. In our case, to the contrary, *first order derivatives are enough*. This suggests that the kind of identification that may obtain is more robust in this case. Note, however, that an alternative approach using second derivatives can still be used (in the case, for instance, when $C_l = D_l$ for all l). This can be shown to generate identical results; intuitively, the second order conditions in Chiappori (1992) are direct consequences of the restrictions in Proposition 2.

Interestingly, the model implies that the relative effects of distribution factors on each labor supply are equal, that is, $h^1_{s_l}/h^1_{s_1} = h^2_{s_l}/h^2_{s_1}$, for $l = 2, \cdots, L$, since both members of this equation are equal to ϕ_{s_l}/ϕ_{s_1}.[7] These latter restrictions are very general in the sense that they can be shown to hold also when public goods and externalities are incorporated into the model [see Bourguignon, Browning and Chiappori (1995)]. The basic reason is that distribution factors affect consumption and labor supply choices only through the location chosen on the Pareto frontier, or equivalently, through the implicit weighting of each spouse's utility. Since this weighting is unidimensional, this implies that the ratio of the impacts of all distribution factors on the two labor supplies are equal. It is worth stressing that these restrictions appear only when there are at least two distribution factors.

[7] These restrictions are implied by conditions (j), since, from the latter, one has $C_1/C_l = D_1/D_l$, and since, from the definitions of the C_l's and D_l's, one has $h^1_{s_l}/h^1_{s_1} = C_1/C_l$ and $h^2_{s_l}/h^2_{s_1} = D_1/D_l$, for $l = 2, \cdots, L$.

2.3 Caring

Up to now, we have assumed that preferences are egotistic. However, as shown in Chiappori (1992), all the previous results also hold in the more general case of "*caring*" agents [see Becker (1991)], that is, whose preferences are represented by a utility function that depends on both his or her egotistic utility and his or her spouse's. Formally, member i's utility function can be written as:

$$W^i = W^i[U^1(1-h^1, C^1, z),\ U^2(1-h^2, C^2, z)], \quad \text{for } i = 1, 2. \tag{5}$$

W^i is continuous, increasing and quasi-concave in "egotistic" utilities U^1 and U^2. These utility functions impose separability between a member's own private goods and his or her spouse's. It is clear that any decision that is Pareto efficient under caring would also be Pareto efficient, were the agents egotistic. Assume not; then it would be possible to increase the egotistic utility of a member without decreasing the utility of the other. But this would increase the caring utility of at least one member without reducing the caring utility of any member, a contradiction. In fact, the Pareto frontier of caring agents is a subset of the Pareto frontier derived by assuming that they are egotistic [Chiappori (1992)]. In section 3, we will use these results to derive the parametric restrictions imposed by the collective model to the particular labor supply system considered in our econometric approach, and to recover the corresponding sharing rule.

2.4 Sex ratio and labor supply: alternative explanations

As mentioned in the introduction, the empirical work below applies the previous results on a specific data set, using the sex ratio (by age, race and state) as a distribution factor. In this particular case, additional predictions can be made about the impact of the distribution factor on household behavior. We expect, following Becker's arguments, that the scarcity of one particular sex on the marriage market will benefit to individuals of this sex. Typically, the latter will be able to attract a larger share of household income, a fact that should be reflected in the structure of the sharing rule and of the resulting behavior; for instance, if leisure is a normal good, then corresponding labor supply should decrease, whereas it should increase for the the other sex. An important test of our model hence relies on the effect of the sex ratio on labor supply.

While marriage market and non-unitary models provide natural explanations for the correlation between sex ratio and labor supply behavior, these are by no means exclusive. For instance, spatial variations in the sex ratio could be related to labor markets considerations

[Grossbard-Shechtman (1993)]. One interpretation is that in States where one observes a relative scarcity of men (due to some exogenous determinants), the demand for their services will be stronger and therefore they will tend to work longer hours than elsewhere. The contrary will be observed for women. Note, however, that, compared to the collective explanation, this argument leads to exactly opposite predictions: male labor supply should decrease with sex ratio (defined as the percentage of males in the population under consideration), whereas the collective model suggests an increase. Hence, the two theories have opposite empirical predictions, which suggests that data should allow to decide.

A second explanation involves demand for labor. Assume that some States specialize in "male" sectors, i.e., sectors with a stronger relative demand for male labor supply. These States will attract relatively more men through migration. Therefore, they will have high (and endogenous) sex ratios and presumably high male hours of work; whereas female hours of work, on the other hand, may well be below the national average in these states. Conversely, States that concentrate in "female" sectors will have low sex ratios and high female hours of work. Note that this effect, in contrast with the previous, goes in the same direction as the "collective" explanation. The empirical distinction between them is thus less straightforward, but still not out of reach. First, as long as the labor demand effects influence hours of work through the wage rates, they are taken into account in our model since we control for individual wage rates. However, they could also affect unobserved variables that influence hours of work such as labor market rationing, nonlabor income, *etc.*

Another way to discriminate between the marriage market and the labor market hypotheses is to analyze the impact of the sex ratio on the labor supply of singles. According to the marriage market hypothesis, the sex ratio should have no effect on their labor supply (at least if one ignores its impact on transfers to potential spouses). In contrast, under the labor market hypothesis, the sex ratio should influence the labor supply of both singles and couples. This suggests a simple and rather strong test that would allow to discriminate between the two explanations.

Finally, it should be stressed that the collective model provides strong restrictions upon how distribution factors may affect behavior. Specifically, the conditions in Proposition 2 relate the effect of the sex ratio to that of wages and nonlabor income. While these conditions are direct consequences of the collective setting, they have no reason to hold whenever the effect under consideration stems from labor market mechanisms. Consequently, they provide a distinct and additional means of testing the collective explanation. These tests will be carefully considered in the empirical sections.

3 Parametric Specification of the Model

3.1 Functional form of labor supplies

In order to estimate and test a collective model of labor supply, we must first specify a functional form for individual labor supply functions. Let us consider the following unrestricted system, where for convenience and to reflect the empirical section, only one distribution factor is assumed:

$$\begin{aligned} h^1 &= f_0 + f_1 \log w_1 + f_2 \log w_2 + f_3 y + \\ &\quad f_4 \log w_1 \log w_2 + f_5 s + f_6' z + f_7' sz; \end{aligned} \tag{6}$$

$$\begin{aligned} h^2 &= m_0 + m_1 \log w_1 + m_2 \log w_2 + m_3 y + \\ &\quad m_4 \log w_1 \log w_2 + m_5 s + m_6' z + m_7' sz, \end{aligned} \tag{7}$$

where the f_i's and the m_i's, for $i = 1, \cdots, 5$, are scalar, and the f_i's and the m_i's, for $i = 6, 7$, are $K-$vectors of parameters.

The generalized semi-log system (6) and (7) satisfies a number of desirable properties. First, in its unrestricted form, it does not impose all the (equality) conditions of the collective model. Therefore, the latter yields a set of restrictions that can be empirically tested. Second, as shown below, these restrictions do not impose unrealistic constraints on behavior. Third, assuming that the collective restrictions are satisfied, it is possible to recover a closed form for the sharing rule (up to an additive function $\kappa(z)$) and for the pair of individual indirect utility functions (for any given $\kappa(z)$). Finally, the fact that equations (6) and (7) are linear in parameters eases the estimation.

Of course, this generalized semi-log system also has some limitations. While some restrictions of the unitary model consistent with this system do not impose unrealistic labor supply behavior, other restrictions do and therefore cannot be tested.[8] However, this should not be a serious problem since the unitary model of household labor supply has been rejected in many

[8]More specifically, the unitary model imposes that labor supplies are independent from any distribution factor and that the Slutsky matrix of compensated wage effects is symmetric and semi-definite positive. The former constraint requires that $f_5 = f_{7k} = m_5 = m_{7k} = 0$, for all k. These restrictions can be tested. However, the symmetry of the Slutsky matrix requires in addition either that (i) $f_2 = f_3 = f_4 = m_1 = m_3 = m_4 = 0$, which implies that each labor supply depends only on own wage rate and on preference factors, or that (ii) $f_0 = m_0, f_3 = m_3, f_{6k} = m_{6k}$ and $f_1 = f_2 = f_4 = m_1 = m_2 = m_4 = 0$, for all k, which implies that labor

studies [e.g., Kooreman and Kapteyn (1986), Lundberg (1988), Fortin and Lacroix (1997)]. Second, labor supply curves are either everywhere upward sloping or everywhere backward bending, though the sign of $\partial h^i/\partial w_i$ can change with the level of $w_j \ (j \neq i)$.[9] Note, however, that the log form for the wage rates is likely to reflect more realistic behavior than the linear form that is frequently used in empirical studies [*e.g.*, Hausman (1981)]. Thus it allows the effect of the wage rate on labor supply to decrease with the level of hours of work (when the labor supply is upward sloping), which is likely to be the case. It is also worth mentioning that our specification allows for interactions between distribution and preferences factors.

The restrictions imposed by the collective model (see Proposition 2) to the generalized semi-log system can easily be derived. First, using the definitions of $A - D$, one gets:

$$A = \frac{f_2 + f_4 \log w_1}{w_2 f_3}, \qquad B = \frac{m_1 + m_4 \log w_2}{w_1 m_3},$$
$$C = \frac{f_5 + f_7' z}{f_3}, \qquad D = \frac{m_5 + m_7' z}{m_3}.$$

The condition $C \neq D$ is satisfied unless

$$\frac{m_3}{f_3} = \frac{m_5}{f_5} = \frac{m_{71}}{f_{71}} = \cdots = \frac{m_{7K}}{f_{7K}}.$$

It should be stressed that, according to the collective model, these equations cannot be simultaneously satisfied. For one thing, $\frac{m_3}{f_3}$ represents the ratio of income effects on labor supplies; the latter is positive as long as leisure is a normal good for both members and that an increase in y is shared between them. On the other hand, $\frac{m_5}{f_5}$ represents the corresponding ratio of distribution factor effects; since, by definition, a distribution factor affects the husband's and the wife's share of non labor income in opposite direction, the ratio must be negative (assuming again that leisure is a normal good).

Assuming $C \neq D$, the necessary and sufficient conditions take the following form:

$$m_4 \left(f_5 + f_7' z\right) = f_4 \left(m_5 + m_7' z\right).$$

Since this condition must hold for any z, this imposes that $m_4 f_5 = f_4 m_5$ and $m_4 f_{7k} = f_4 m_{7k}$, for $k = 1, \cdots, K$, or, equivalently (assuming that no parameter is equal to zero):

supplies are the same and depend only on nonlabor income and on preference factors. It is clear that these two cases impose severe constraints on behavior.

[9] Using our data set, we test for nonmonotonicity of the effect of own wage rates by introducing the square of these variables in the model. These variables were never statistically significant in any specification.

$$\frac{m_4}{f_4} = \frac{m_5}{f_5} = \frac{m_{71}}{f_{71}} = \cdots = \frac{m_{7K}}{f_{7K}}. \tag{8}$$

Equations (8) impose testable cross-equation restrictions in our labor supply system. They require the ratio of the marginal effects of the cross term in $\log w_1$ and $\log w_2$ to be equal to the corresponding ratio of the marginal effects of the distribution factor on labor supplies. These restrictions stem from the fact that the cross term and the distribution factor enter labor supply functions only through the same function ϕ (the sharing rule). It should be stressed that the collective model imposes no (equality) restriction when there is no distribution factor or no cross term such as $\log w_1 \log w_2$.

3.2 Sharing rule

If the restrictions (8) are satisfied, the partials of ϕ, as given in (ii) of Proposition 2, are given by :

$$\begin{aligned}
\phi_y &= \frac{f_3 m_4}{\Delta} \\
\phi_s &= \frac{m_4}{\Delta}\left(f_5 + f_7' z\right) \\
\phi_{w_1} &= \frac{f_4}{\Delta}\frac{m_1 + m_4 \log w_2}{w_1} \\
\phi_{w_2} &= \frac{m_4}{\Delta}\frac{f_2 + f_4 \log w_1}{w_2}
\end{aligned} \tag{9}$$

where $\Delta = f_3 m_4 - f_4 m_3$.

Solving this four differential equations system, one obtains the sharing rule equation:

$$\begin{aligned}
\phi = {} & \frac{1}{\Delta}\left[m_1 f_4 \log w_1 + f_2 m_4 \log w_2 + f_4 m_4 \log w_1 \log w_2 + \right. \\
& \left. f_3 m_4 y + m_4 f_5 s + m_4 f_7' z s\right] + \kappa(z),
\end{aligned} \tag{10}$$

In equation (10), the function $\kappa(z)$ is not identifiable, since the variable z affects both the sharing rule and the preferences. This reflects the fact that, for any given z, the sharing rule can be recovered up to an additive constant for each individual.

3.3 Individual labor supplies

It is also possible to recover the individual labor supply functions associated with this setting. Since they must have a functional form consistent with the system (3) and (4), it is clear, using equations (6), (7) and (10), that they take the following semi-log form:

$$h^1 = \alpha_1 \log w_1 + \alpha_2 \phi + \alpha_3 (z) \tag{11}$$

$$h^2 = \beta_1 \log w_2 + \beta_2 (y - \phi) + \beta_3 (z) \tag{12}$$

Using the expressions for the partials of the restricted system (3) and (4) with respect to (w_1, w_2, y) as applied to our particular specification, and using the partials of ϕ given by (9), one easily recovers the following parameters: $\alpha_1 = (f_1 m_4 - f_4 m_1)/m4$, $\alpha_2 = \Delta/m_4$, $\beta_1 = (f_4 m_2 - f_2 m_4)/f_4$ and $\beta_2 = -\Delta/f_4$. The functions $\alpha_3 (z)$ and $\beta_3 (z)$ are not identifiable since they depend on $\kappa (z)$ in equation (10), which is not identifiable[10].

Slutsky conditions on compensated individual labor supplies [see (g) and (h) in Proposition 2], are given by:

$$\alpha_1 / w_1 - \alpha_2 h_1 \geq 0; \;\; \beta_1 / w_2 - \beta_2 h_2 \geq 0.$$

These conditions are checked for each observation, in the empirical section. Global conditions for these inequalities are $\alpha_1 \geq 0$ and $\alpha_2 \leq 0$ (women) and $\beta_1 \geq 0$ and $\beta_2 \leq 0$ (men).

3.4 Indirect utility functions

It can be shown [Stern (1986)] that the indirect utility functions consistent with the labor supply functions (11) and (12) must have the following form:

$$v^1 = (\exp(\alpha_2 w_1))/\alpha_2) \, (\alpha_2 \phi^1 + \alpha_3(z) + \alpha_1 \log w_1) - (\alpha_1/\alpha_2) \int_{-\infty}^{\alpha_2 w_1} \exp(t)/t \, dt$$

[10] Identification of these functions would require additional identifying restrictions. For instance, it obtains whenrever a variable in z affects either preferences or the sharing rule, but not both of them.

$$
\begin{aligned}
v^2 &= (\exp(\beta_2 w_2)/\beta_2)\ (\beta_2\phi^2 + \beta_3(z) + \\
&\quad \beta_1 \log w_2) - (\beta_1/\beta_2) \int_{-\infty}^{\beta_2 w_2} \exp(t)/t\, dt
\end{aligned}
$$

It is easy to show that Roy's identity applied to each of these indirect utility functions yields the individual labor supply system (11) and (12). These functions can be used to perform intra-household welfare analysis of changes in exogenous variables.

4 Econometric Issues

It is natural to estimate the restricted and unrestricted versions of the labor supply system (6) and (7) using an instrumental variable (IV) approach, given that the wage rates, nonlabor income and fertility variables are potentially endogenous [see Mroz (1987)]. However, to improve the efficiency of our estimator, we take into account the correlation between the error terms in husbands' and wives' labor supply equations. For this purpose, we rely on full information GMM method. One advantage of this approach is that it also takes into account heteroskedasticity of unknown form in the errors, which can not be done using a full information maximum likelihood method [see Davidson and MacKinnon (1993), p.660]. Therefore, in the presence of heteroskedasticity of unknown form, our estimator should be more efficient, asymptotically, than 3SLS or FIML.[11]

More specifically, consider the following labor supply model for the household i, $i = 1, \cdots, N$, in which both spouses are working:[12]

$$
\begin{aligned}
h_i^1 &= \delta_1' x_{i1} + \mu_{i1}, && (13) \\
h_i^2 &= \delta_2' x_{i2} + \mu_{i2}, && (14)
\end{aligned}
$$

where the variables h_i^1 and h_i^2 are respectively the be satisfied. Given our parametric specification and household i female and male labor supply, the δ_j's are the vectors of parameters to

[11] In the unrestricted version of our model, our estimator is identical to the heteroskedastic three-stage least squares (H3SLS) estimator since the model is linear in parameters. This is not the case in the restricted version of the model though, since the restrictions on the parameters are nonlinear.

[12] Conditioning the sample on working spouses may induce a selectivity bias especially in the case of females. We ignore this bias in the analysis. The basic reason is that such a correction requires an extension of the collective model to corner solutions, a task that is beyond the scope of this paper. The reader is referred to Blundell et al (1998) for an investigation of the related (but different) problem of discrete labor supply decisions.There is some evidence that the selectivity bias is not likely to be a problem though. For instance, using PSID data, and based on a standard recursive labor supply model, Mroz (1987) could not reject the hypothesis of no selectivity bias in women's labor supply equation.

be estimated, the x_{ij}'s for $j = 1, 2$ are the vectors of explanatory variables, some of which are potentially endogenous and the μ_{ij}'s are the error terms whose expected value is zero. These error terms are heteroskedastic, correlated within households but uncorrelated across households. Denote $\mu = ((h^1 - \delta_1' x_1)', (h^2 - \delta_2' x_2)')'$, as the stacked vector of error terms. Assume there exists a set of instruments W and define $\bar{W} = I \otimes W$, where I is a 2×2 identity matrix. The moment conditions $E(\mu_i \bar{W}_i) = 0$ are assumed to be satisfied. The GMM estimator for δ $(= (\delta_1', \delta_2')')$, when there are more moment conditions than there are parameters to estimate, is chosen so as to minimize:

$$\mu'[\bar{W}(\bar{W}'\Omega\bar{W})^{-1}\bar{W}']\mu, \tag{15}$$

where $\bar{W}'\Omega\bar{W}$ is the covariance matrix of $\bar{W}'\mu$. The matrix Ω is given by:

$$\begin{pmatrix} \Omega_{11} & \Omega_{12} \\ \Omega_{21} & \Omega_{22} \end{pmatrix}$$

where the sub-matrices Ω_{kj}, for $k, j = 1, 2$, are diagonal with typical element i on the diagonal given by $\frac{1}{N}(\mu_{ik}\ \mu_{ij})$. The sub-matrices Ω_{kj} are not observable. However, they can be approximated by a White's (1980) covariance matrix estimator $\hat{\Omega}_{kj}$, the i^{th} diagonal element of which being given by $\hat{\mu}_{ik}\ \hat{\mu}_{ij} = (h_i^k - \hat{\delta}_k' x_{ik})(h_i^j - \hat{\delta}_j' x_{ij})$, where the estimated parameters are obtained in a first step using a consistent, albeit inefficient, IV estimation.

Following an iteration process suggested by Mackinnon and Davidson (1993), equation (15) is first minimized starting with $\Omega = I$; next we compute $\hat{\Omega}$ and minimize (15) again. Upon convergence, we compute $\hat{\Omega}$ with the new set of parameter estimates and minimize again (15). We iterate until the log of the determinant of $\hat{\Omega}$ converges to a stable value. The asymptotic covariance matrix of $\hat{\delta}$ is then estimated by the inverse of the following matrix:

$$x'\bar{W}(\bar{W}'\hat{\Omega}\bar{W})^{-1}\bar{W}'x \tag{16}$$

where x is the stacked matrix of x_1 and x_2.

5 Data and empirical results

5.1 Data

The data we use in this study come from the University of Michigan Panel Study of Income Dynamics (PSID) for the year 1988 (interview year 1989). Our "full" sample consists of 1618 households in which both spouses have positive hours of work and are between 30 and 60 years of age. This latter restriction was used in order to eliminate as much as possible full-time students and retired individuals, and to reduce cohort effects. Removing couples in which spouses are aged less than 30 increases the proportion of "stable" households, for which the hypothesis of efficiency in the intra-household decision process is more likely to be satisfied. We also present estimation results based on a restricted sample of households with no pre-school (under 6) children, in order to minimize the extent of nonseparable public goods within the household (the best example of which being expenditures on young children) which may influence the validity of the restrictions imposed by our collective model.[13]

The dependent variables, male and female annual hours of work, are defined as total hours of work on all jobs during 1988. The measure of the wage rate is the average hourly earnings, defined by dividing total labor income over annual hours of work. Nonlabor income includes, among other things, imputed income (with a nominal interest rate of 12%[14]) from all household net assets and is net of total household savings.[15] This variable is treated as an endogenous variable in the empirical section. It should be stressed that the PSID provides information on net assets at the beginning of periods 1984 and 1989. Therefore our measure of savings is the annual average change in total net household assets over this period (expressed in 1988 dollars). In order to reduce measurement errors on this variable, we further restricted our sample to households with stable couples over the 1984-1989 period.

Our sex-ratio index is computed at the State level using data from the Census of Population and Housing of 1990. It corresponds to the number of males that are of the same age and same race as the husband of each household over the number of males and females that are of the same race and age group.[16]

[13]Lundberg (1988) has provided evidence that the interaction in the allocation of time between wives and husbands is strongly affected by the presence of pre-school children. Sample size considerations prevented us from focusing on households with no children.

[14]We also experimented with nominal interest rates of 8% and 10% but this did not significantly affect the results.

[15]Removing household savings from the measure of nonlabor income is consistent with an inter-temporally separable life-cycle model involving a two stage budgeting process. In the first stage, the couple optimally allocates life-cycle wealth over each period in order to determine the vector of period-specific levels of nonlabor income net of savings. At each period, nonlabor income net of savings plus total household wage income is equal to the level of household consumption expenditures (this represents period-specific household budget constraints). The second stage corresponds to period-specific Pareto efficient allocations of goods and labor supplies [see Blundell and Walker (1986) for a discussion of a life-cycle two stage budgeting process in the case of a one-individual household].

[16]We experimented with various definitions of the sex-ratio: means of sex-ratios using the number of females who are two years younger than the husband or based on individuals who are at most 2 or 5 years younger than the husband of each household. The results were very robust to the definition used.

Table 1 presents descriptive statistics for both full sample and the sub-sample of households with no preschool children. The upper panel concerns variables that are treated as endogenous in the ensuing empirical analysis. The lower panel concerns exogenous variables. As expected, men work on average more yearly hours than women and earn a somewhat higher hourly wage rate. The next two lines report the average number of pre-schoolers (in the full sample) and school age children per household. These two variables are treated as endogenous in the empirical work. Although there is mixed evidence concerning the endogeneity of number of children in women's labor supply [see, *e.g.*, Schultz (1980) and Mroz (1987)], we deem preferable to instrument these variables.

Men are also slightly older than their spouse but they both have similar schooling, which in turn is above that of their respective father. The distribution by race is identical among men and women. A closer look at the data reveals that there are very few interracial marriages in our sample. The sex ratio is thus computed on the assumption that the relevant marriage market is limited to one's own race. The next lines report the mean of the sex ratios for Whites and Blacks. Although the means are relatively similar, the sex ratios for Blacks depict much more variation. This increased variation is observable both state-wise and age-wise.

5.2 Empirical Results

The parametric form that is estimated was presented in equations (6) and (7). As mentioned above, two specifications are considered for estimation purposes, one using the full sample and the other limited to households with no pre-school children. Also, given the difficulty of obtaining information on distribution factors, we consider only one of those, namely the sex ratio.[17] Moreover, no interaction terms with the sex ratio were found statistically significant. Therefore, estimation results presented in this section ignore these terms. Finally, preference factors are the number of pre-school age children (in the first specification), the number of school age children, education, age, dummy regional variables and a race dummy (=1 if white). This specification is relatively standard in the labor supply literature [*e.g.*, Mroz (1987), Smith Conway (1997)]. It must be stressed that the race dummy allows to deal with the correlation between the sex ratio and labor supplies that could be due to a race effect (since the sex ratio is smaller on average and has a larger variance in the case of black households)[18].

[17] We did estimate the model by distinguishing between husband's and wife's nonlabor income to provide one additional distribution factor. Unfortunately, the parameter estimates were never statistically significant when doing so. One basic difficulty lies in properly defining and measuring each spouse's nonlabor income.

[18] We also estimate the model separately for Blacks and Whites. The results are quite similar but less precise than those reported in this sub-section.

Before dwelling into the results, the issue of endogenous covariates must be addressed. Indeed, unobserved individual characteristics may be positively correlated with wages and/or nonlabor income and hours of work, thus creating spurious correlation between right hand-side variables and the error terms of the hours equations. We thus follow Mroz (1987) and use a second-order polynomial in age and education to instrument the wages, the nonlabor income and the number of pre-schoolers (in the specification using total sample) and school age children.[19] Other instruments include father education, religion and city size (3 dummies). In the unrestricted version with total sample, there are 28 parameters to estimate and over 68 instruments (see Tables 2 and 3 for the complete list of instruments).

Table 2 provides estimation results using the full sample. Its first two columns present the parameter estimates of equations (6) and (7), respectively, *i.e.*, the unrestricted version. Notice that all parameters are statistically significant at conventional levels, except, in women's equation, education, White dummy and two regional variables and, in men's equation, children dummies, White dummy and two regional variables. Hansen's test does not reject the validity of the instruments and the over-identifying restrictions. The test statistic of 25.1 is to be compared with the critical value of the $\chi^2_{0.05}(40) = 55.7$.

The parameter estimates of the unrestricted model provide interesting results that are worth mentioning. For instance, the parameter estimate associated with the sex ratio is negative in women's equation and positive in men's equation. These results thus reject an important restriction of the unitary model according to which no distribution factor influences behavior.[20] It also rejects the simple version of the "separate spheres" model which assumes that the threat point is not divorce but an uncooperative marriage.[21]

As discussed above, it can be argued that these tests are biased since the sex ratio is likely to be correlated with unobserved variables; the observed effect might result, for instance, from labor markets mechanisms. We suggested in Section 2 a convenient way to discriminate between the marriage market and the labor market hypotheses, namely to analyze the impact of the sex ratio on the labor supply of singles: the latter should be zero according to the marriage market hypothesis, whereas, in the labor market story, the sex ratio should influence the labor

[19] The estimated coefficients of wages and nonlabor income are rather insensitive to the instrumentation of the children variables. Therefore, restricting the sample to households with no pre-school children (as in our second specification) is not likely to generate severe selectivity biases.

[20] Of course, one could argue that this test is subject to a specification problem since, as shown earlier, the functional form considered for labor supplies imposes unrealistic behavior when all restrictions of the unitary model are assumed.

[21] Theoretically, one could also test restrictions of this model (or alternative bargaining models) that stem from the particular formulation of the Nash bargaining program. However, these restrictions are likely to be very difficult to derive formally [see McElroy (1990) and Chiappori (1992) for a recent discussion].

supply of both singles and couples in a similar way. Table 4 reports results from OLS and GMM regressions as applied to (male and female) singles between 20 and 60 years of age[22]. In both GMM estimations, Hansen's test does not reject the validity of the instruments and the over-identifying restrictions. We also find that the impact of the sex ratio on singles' labor supply is never significant at the 5% level. In the case of GMM estimation for women, it is significant at the 10% level, but the coefficient is of the opposite sign to that of wives. We conclude that although the sex ratio may partly reflect conditions on the labor market, it probably is not the whole story.

Another point is that, should the sex ratio reflect only labor market mechanisms, there is no reason to expect that the specific restrictions derived in Proposition 2 be satisfied. Given our parametric specification and using equations (8), these restrictions boil down to $\frac{m_4}{f_4} = \frac{m_5}{f_5}$ in equations (6) and (7) since $f_{7k} = m_{7k} = 0$, for $k = 1, \cdots, K$). This simply states that the ratio of the coefficients of $\log w_1 \log w_2$ and the sex ratio must be the same in both equations. To assess the validity of the collective model, we report the parameter estimates of the restricted model in columns (3) and (4) of Table 2. Newey-West's test does not reject the validity of the restriction. The test statistic is equal to the difference in function values of the restricted and unrestricted versions ($= 2.0$) and is to be compared with a critical value of $\chi^2_{0.05}(1) = 3.84$.

Interestingly, using a Wald test (test statistic of 6.9), one rejects the hypothesis that $C = D$. This provides support for the theoretical approach we used to derive the restrictions of the collective model. Also, Slutsky conditions on the labor supply of women are globally satisfied while they are locally satisfied for all men in the sample.

Column (5) of the table reports the implicit parameters of women's sharing rule as derived from the restricted parameters of columns (3) and (4) and using equation (10). All parameter estimates of the sharing rule are statistically significant at conventional levels. In order to gain insight into the interpretation of the parameters of the sharing rule, Table 5 reports, for the full sample, the partial derivatives of the sharing along with their standard errors. The first column of the table replicates last column of Table 2. The second column reports the partial derivatives themselves. These partial derivatives represent the impact of a marginal change in one variable on the nonlabor income accruing to the wife after sharing. According to our parameter estimates, a one dollar increase in the wife's wage rate, ω_f, (which is equivalent to an annual increase of $1,740 (1988) in her labor income, at the mean of hours worked by women) translates into more income being transferred to her husband. At sample mean, the transfer amounts to $915 (or 52% of her annual income increase), although this effect is not very precisely estimated. Also, a one dollar increase in the husband's wage rate, ω_h,

[22] We did not use the same age group as the one used for couples (30-60) since doing this severely reduced the sample size and made most coefficients non significant.

(equivalent to an annual increase of $2,240 in his labor income) translates into more nonlabor income being transferred to his wife. Indeed, the table shows that, at the mean of the sample, $614 (or 27% of his income increase) will be transferred to his wife, but again this effect is somewhat imprecisely estimated. These results lend support to the notion that there is some form of altruism within couples. The next line indicates that a one dollar increase in household nonlabor income will increase the wife's income by 55 cents. Furthermore, a one percentage point increase in the sex ratio index, according to our parameter estimates, induces husbands to transfer an additional $2,562 of nonlabor income to their spouse.

Finally, the other columns of Table 5 report various labor supply elasticities. In general these elasticities are comparable to those found in the empirical labor supply literature. At the sample mean, women's wage elasticities are positive and statistically significant in both unrestricted and restricted versions (=0.152 and 0.145, resp.). Men's wage elasticities are negative but very small (=-0.013 and -0.016, resp.) and are not statistically significant. Cross-wage elasticities are all negative and not statistically significant either. Moreover, both men's and women's labor supply elasticities with respect to nonlabor income are negative and significant.

The last two columns report the own-wage elasticities on after sharing individual labor supplies (*i.e.*, for a given ϕ), as given by equations (11) and (12). These elasticities are obtained from individual preferences alone since they ignore the effect of wage rates on the intra-household decision process. Both women's and men's elasticities are smaller than their counterpart reported in the previous columns. This simply reflects the fact that a marginal increase in their wage rate reduces their share of the nonlabor income, which in turn increases their labor supply through an income effect.

The setup of Tables 3 and 6 which focuses on households with no pre-school children (1,197 observations) is similar to that of Tables 2 and 5. Note that nearly all the parameter estimates of the upper panel of Table 3 are statistically significant at conventional levels, except for the coefficients of the nonlabor income which are now less precise. As in the previous case, the validity of instruments and of the over-identifying restrictions cannot be rejected on the basis of the usual χ^2 tests. The Newey-West test at the bottom of the table indicates that the restriction imposed by the collective model is rejected at the 5% level but not rejected when using a 1% level. As in the previous case, the sex ratio has a negative and statistically significant impact on women's hours of work and a positive and statistically significant impact on men's hours of work. Finally, the identifiable parameters of the sharing rule are all statistically significant at 10% or better.

Table 6 provides some interesting results concerning the impact of the presence of young children. First, the impact of the sex ratio on women's sharing rule considerably increases as compared with the impact observed in the full sample (from $2,625 to $3,890). This suggests that women's bargaining power is reduced when there are young children in the household, perhaps because divorce is less credible when there are young children in the household. Moreover, the results suggest that wives show more altruism towards their husband when there are no children in the household. Indeed, the effect of an increase in wives' wage rate on transfers to their spouse markedly increases in households with no pre-school children. But again the coefficient is not very precisely estimated.

6 Conclusion

In this paper we provide evidence that the marriage market, as proxied by a sex ratio index, influences household labor supplies. Our results thus reject one important prediction of the unitary model according to which no distribution factor affects intra-household decisions. Our results also contradict those Nash bargaining models that assume that the fall-back option is internal to the household. Rather, we provide some support to Becker's initial claim that the state of the market for marriage should influence the intra-household decision process. Moreover, we develop a model which introduces distribution factors into the Chiappori's (1992) collective model of household labor supply, according to which the intra-household outcomes are Pareto-efficient. We show that the introduction of these factors, which include the sex ratio, strongly simplifies the way the model is identified. In addition, identification appears to be both more precise and more robust in the present context. Also, our results do not reject the restrictions imposed by our model to the parameters of labor supply functions.

The parameters of the sharing rule associated with this model can be recovered, and turn out to be significantly different from zero. We find that a one percentage point increase in the proportion of males in the population induces husbands aged between 30 and 60 to increase their transfer to their wife by $2,562 (1988) on average. This transfer is more important for households with no pre-school children. Finally, our results suggest that spouses appear to behave in an altruistic manner. For instance, a one dollar increase in a female's wage rate induces her to transfer close to 52% of her annual income increase to her spouse while the corresponding figure, in the case of a husband, is a transfer of 27% to his wife.

Our analysis is subject to some limitations though. Since our estimates are conditional to the choice of living in couple, they could suffer from a selection bias. In regions where the sex ratio is relatively small, more "low-quality" men are likely to marry, given the scarcity of men in the marriage market. As long as there is a positive correlation between quality in the marriage market and in the labor market, this may create a spurious (positive) correlation between the sex ratio and male hours of work. More research on collective models that endogenize both marital choices and labor supply is clearly needed.

Our approach assumes that the sex ratio is exogenous. However it could be viewed as a variable that adjusts across regions to equilibrate the marriage markets [Becker (1991)]. While we discuss some evidence that suggest that this interpretation is not likely to seriously bias our estimates, it would be important to provide an analysis of the factors that explain variations of the sex ratio across regions. Another useful extension of our model would be to introduce a variable of sex ratio *at the beginning of marriage*. As long as marriage agreements are binding, this variable should be the relevant one to explain the intra-household distribution process and labor supply behavior. Finally, introducing household production in the model would be worth considering [see Apps and Rees (1997) and Chiappori (1997) for a discussion].

APPENDIX : Proof of Proposition 2

A One distribution factor

Start from :

$$h^1 = H^1\left(w_1, \phi\left(w_1, w_2, y, s, z\right), z\right)$$
$$h^2 = H^2\left(w_2, y - \phi\left(w_1, w_2, y, s, z\right), z\right)$$

Then :

$$A = \frac{h^1_{w_2}}{h^1_y} = \frac{\phi_{w_2}}{\phi_y}$$
$$B = \frac{h^2_{w_1}}{h^2_y} = \frac{-\phi_{w_1}}{1-\phi_y}$$
$$C = \frac{h^1_s}{h^1_y} = \frac{\phi_s}{\phi_y}$$

and

$$D = \frac{h^2_s}{h^2_y} = \frac{-\phi_s}{1-\phi_y}$$

Assume that $C \neq D$. Then the last two equations give :

$$\phi_y = \frac{D}{D-C},$$
$$\phi_s = \frac{CD}{D-C}.$$

Then the first two lead to :

$$\phi_{w_1} = \frac{BC}{D-C},$$
$$\phi_{w_2} = \frac{AD}{D-C}.$$

These partials are compatible if and only if they satisfy the usual cross derivative restrictions. Hence, the following conditions are necessary and sufficient :

$$\frac{\partial}{\partial s}\left(\frac{D}{D-C}\right)=\frac{\partial}{\partial y}\left(\frac{CD}{D-C}\right)$$

$$\frac{\partial}{\partial w_1}\left(\frac{D}{D-C}\right)=\frac{\partial}{\partial y}\left(\frac{BC}{D-C}\right)$$

$$\frac{\partial}{\partial w_2}\left(\frac{D}{D-C}\right)=\frac{\partial}{\partial y}\left(\frac{AD}{D-C}\right)$$

$$\frac{\partial}{\partial w_1}\left(\frac{CD}{D-C}\right)=\frac{\partial}{\partial s}\left(\frac{BC}{D-C}\right)$$

$$\frac{\partial}{\partial w_2}\left(\frac{CD}{D-C}\right)=\frac{\partial}{\partial s}\left(\frac{AD}{D-C}\right)$$

$$\frac{\partial}{\partial w_2}\left(\frac{BC}{D-C}\right)=\frac{\partial}{\partial w_1}\left(\frac{AD}{D-C}\right)$$

If these equations are fulfilled, then ϕ is defined up to an additive function $\kappa(z)$ depending only on the preference factors z. The inequalities (g) and (h) of Proposition 2 follow from standard integrability arguments. Finally, the knowledge of Marshallian demands allows to recover preferences for any given value of $\kappa(z)$.

B Several distribution factors

Finally, if there are several distribution factors, then they can enter labor supply functions only through the same function ϕ. This implies that :

$$\frac{h^1_{s_l}}{h^1_{s_1}}=\frac{\phi_{s_l}}{\phi_{s_1}}=\frac{h^2_{s_l}}{h^2_{s_1}}$$

for all l. ■

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TABLE 1

DESCRIPTIVE STATISTICS

(Standard Deviation in Parentheses)

	Full Sample		Households with No Preschool Children	
	Wives	*Husbands*	*Wives*	*Husbands*
Endogenous Variables				
Hours of Work (/1000)	1.74	2.24	1.78	2.24
	(0.57)	(0.64)	(0.55)	(0.65)
Log-wage	2.04	2.46	2.04	2.47
	(0.68)	(0.61)	(0.67)	(0.64)
Nonlabor Income (/1000)	8.07		9.50	
	(24.19)		26.37	
Children ($\leq$ 6)	0.26		–	
	(0.44)		–	
Children (7 – 17)	0.55		0.55	
	(0.49)		(0.50)	
Exogenous Variables				
Age	37.7	40.6	39.6	42.3
	(7.7)	(7.8)	(7.8)	(7.9)
Schooling	5.2	5.2	5.1	5.2
	(1.5)	(1.6)	(1.5)	(1.7)
White	0.75	0.75	0.78	0.78
Sex Ratio				
Whites	0.496		0.495	
	(0.008)		(0.008)	
Blacks	0.461		0.462	
	(0.022)		(0.023)	
North East	0.18		0.19	
North Central	0.24		0.23	
West	0.15		0.15	
Observations	1618		1197	

Note: The schooling variables follow the 1989 coding. Thus, for example, a value of 4 corresponds to 12 grades and no further training, whereas a value of 5 corresponds to 12 grades plus non academic training.

TABLE 2
GMM PARAMETER ESTIMATES – FULL SAMPLE
HOURS/1000

	Unrestricted Version		Restricted Version		Sharing Rule of Wives
	Wives	Husbands	Wives	Husbands	
$\log\omega_f$	1.348	-0.671	1.019	-0.998	-63.923
	(0.339)	(0.328)	(0.369)	(0.272)	(28.919)
$\log\omega_h$	0.813	-0.498	0.537	-0.771	-39.828
	(0.283)	(0.288)	(0.307)	(0.243)	(21.286)
$\log\omega_f \times \log\omega_h$	-0.439	0.230	-0.311	0.360	23.067
	(0.123)	(0.125)	(0.135)	(0.102)	(10.640)
Nonlabor Income (/1000)	-0.007	-0.008	-0.007	-0.007	0.547
	(0.003)	(0.004)	(0.003)	(0.004)	(0.185)
Sex Ratio	-2.767	5.020	-3.452	3.999	256.162
	(0.985)	(1.175)	(0.894)	(1.237)	(93.461)
Intercept	1.501	0.715	2.638	2.011	
	(0.856)	(0.952)	(0.738)	(0.804)	
Children (≤ 6)	-0.659	0.172	-0.765	0.099	
	(0.207)	(0.143)	(0.201)	(0.141)	
Children (7–17)	-0.154	0.093	-0.174	0.066	
	(0.070)	(0.073)	(0.069)	(0.072)	
Schooling	-0.011	0.033	-0.007	0.033	
	(0.018)	(0.012)	(0.018)	(0.012)	
Age	-0.131	0.077	-0.159	0.048	
	(0.047)	(0.043)	(0.045)	(0.042)	
White	-0.019	-0.015	-0.008	0.006	
	(0.049)	(0.051)	(0.049)	(0.053)	
North East	-0.180	-0.035	-0.169	-0.028	
	(0.037)	(0.038)	(0.037)	(0.037)	
North Central	-0.037	0.010	-0.018	0.027	
	(0.040)	(0.036)	(0.040)	(0.035)	
West	0.041	-0.117	0.059	-0.101	
	(0.045)	(0.041)	(0.044)	(0.040)	
Value of Function	25.098		27.105		
Newey-West Test	2.007				

Notes:

1. *Asymptotic standard errors in parentheses.*
2. *Instruments: Second order polynomial in age and schooling (M-F), Father Education (M-F), White (M-F),Spanish (M-F), City size (3 dummies), North-East, North-Central, West, Protestant (M-F), Jewish (M-F), Catholic (M-F), Sex ratio.*
3. *The parameters of the sharing rule are divided by 1,000.*

TABLE 3
GMM PARAMETER ESTIMATES
HOUSEHOLDS WITH NO PRESCHOOL CHILDREN
HOURS/1000

	Unrestricted Version		Restricted Version		Sharing Rule of Wives
	Wives	Husbands	Wives	Husbands	
$\log \omega_f$	2.145	-1.249	1.946	-1.605	-185.924
	(0.377)	(0.363)	(0.431)	(0.342)	(98.515)
$\log \omega_h$	1.510	-0.841	1.345	-1.103	-131.708
	(0.305)	(0.302)	(0.346)	(0.289)	(69.428)
$\log \omega_f \times \log \omega_h$	-0.748	0.423	-0.667	0.564	65.292
	(0.137)	(0.137)	(0.159)	(0.128)	(35.091)
Nonlabor Income (/1000)	-0.004	-0.006	-0.005	-0.004	0.489
	(0.003)	(0.004)	(0.003)	(0.004)	(0.274)
Sex Ratio	-2.639	6.139	-3.973	3.358	389.052
	(1.143)	(1.359)	(0.978)	(1.321)	(220.455)
Intercept	-0.642	1.563	0.408	3.638	
	(0.760)	(0.894)	(0.864)	(0.557)	
Children (7–17)	-0.190	-0.025	-0.185	-0.028	
	(0.064)	(0.072)	(0.063)	(0.072)	
Schooling	-0.025	0.030	-0.026	0.026	
	(0.018)	(0.014)	(0.018)	(0.014)	
Age	-0.069	0.031	-0.077	0.001	
	(0.021)	(0.031)	(0.021)	(0.030)	
White	0.088	-0.099	0.130	-0.014	
	(0.053)	(0.061)	(0.049)	(0.062)	
North East	-0.229	-0.038	-0.231	-0.040	
	(0.042)	(0.044)	(0.042)	(0.045)	
North Central	-0.104	0.033	-0.095	0.040	
	(0.041)	(0.039)	(0.042)	(0.039)	
West	0.007	-0.089	0.019	-0.076	
	(0.048)	(0.046)	(0.048)	(0.046)	
Value of Function	31.971		36.757		
Newey-West Test	4.786				

Notes:

1. *Asymptotic standard errors in parentheses.*
2. *Instruments: Second order polynomial in age and education (M-F), Father Education (M-F), White (M-F),Spanish (M-F), City size (3 dummies), North-East, North-Central, West, Protestant (M-F), Jewish (M-F), Catholic (M-F)*
3. *The parameters of the sharing rule are divided by 1,000.*

TABLE 4
Parameter Estimates – Singles
Hours/1000

	OLS		GMM	
	Women	Men	Women	Men
$\log \omega$	-0.039	-0.039	-0.335	0.167
	(0.048)	(0.047)	(0.192)	(0.205)
Nonlabor Income (/1000)	-0.001	-0.0008	-0.0029	-0.002
	(0.001)	(0.0005)	(0.0038)	(0.002)
Intercept	-0.346	1.139	-0.598	1.466
	(1.241)	(1.013)	(1.302)	(1.095)
Sex Ratio	4.039	1.294	5.043	0.439
	(2.547)	(2.029)	(2.719)	2.167
Schooling	0.077	0.038	0.112	0.001
	(0.020)	(0.020)	(0.030)	(0.045)
Age	0.052	-0.013	0.102	-0.048
	(0.038)	(0.029)	(0.058)	(0.036)
White	0.129	0.177	0.210	0.212
	(0.110)	(0.089)	(0.131)	(0.107)
North East	-0.078	-0.058	-0.039	-0.104
	(0.103)	(0.081)	(0.110)	(0.099)
North Central	-0.204	-0.037	-0.211	0.018
	(0.077)	(0.075)	(0.080)	(0.078)
West	-0.251	-0.163	-0.245	-0.153
	(0.100)	(0.092)	(0.104)	(0.112)
Value of Function			5.238	9.715
Number of Observations	572	498	572	498

Notes:

1. *Asymptotic standard errors in parentheses.*
2. *Instruments in GMM estimation: Second order polynomial in age and education, Father Education, White, Spanish, City size (3 dummies), North-East, North-Central, West, Protestant, Jewish, Catholic, Sex ratio.*

TABLE 5
SHARING RULE AND ELASTICITIES – FULL SAMPLE

Variable	Sharing Rule of Wives		Elasticities					
			Unrestricted version		Restricted version		Conditional on $\phi(\cdot)$	
	Coefficients	$\frac{\partial \phi}{\partial \text{Variable}}$ †	Wives	Husbands	Wives	Husbands	Wives	Husbands
$\log \omega_f$	-63.923	-914.990	0.152	-0.046	0.145	-0.049	0.090	
	(28.919)	(679.812)	(0.072)	(0.033)	(0.072)	(0.033)	(0.080)	
$\log \omega_h$	-39.828	613.822	-0.047	-0.013	-0.056	-0.016		-0.058
	(21.286)	(740.077)	(0.057)	(0.049)	(0.058)	(0.049)		(0.077)
$\log \omega_f \times \log \omega_h$	23.067							
	(10.640)							
Nonlabor Income	0.547	0.547	-0.032	-0.028	-0.034	-0.026		
	(0.185)	(0.184)	(0.015)	(0.013)	(0.015)	(0.013)		
Sex-Ratio	256.162	2561.616‡						
	(93.461)	(934.613)						

Notes:

1. *Asymptotic standard errors in parentheses.*
2. † *The derivatives are computed with respect to the ω_f and ω_h, not with respect to $\log \omega_f$ and $\log \omega_h$. Furthermore, these derivatives are taken with respect to non-normalized $\phi(\cdot)$. Also Nonlabor income is non-normalized.*
3. ‡ *This figure represents the impact of a one percentage point increase in the sex-ratio.*

TABLE 6

SHARING RULE AND ELASTICITIES

HOUSEHOLDS WITH NO PRESCHOOL CHILDREN

Variable	SHARING RULE OF WIVES		ELASTICITIES					
			Unrestricted version		Restricted version		Conditional on $\phi(\cdot)$	
	Coefficients	$\frac{\partial\phi}{\partial \text{Variable}}$ †	Wives	Husbands	Wives	Husbands	Wives	Husbands
$\log\omega_f$	-185.924	-3202.896	0.167	-0.091	0.168	-0.095	0.026	
	(98.515)	(1926.373)	(0.072)	(0.036)	(0.072)	(0.035)	(0.089)	
$\log\omega_h$	-131.708	141.269	-0.010	0.010	-0.009	0.022		0.015
	(69.428)	(846.910)	(0.056)	(0.053)	(0.055)	(0.053)		0.064)
$\log\omega_f \times \log\omega_h$	65.292							
	(35.091)							
Nonlabor Income	0.489	0.489	-0.024	-0.025	-0.027	-0.018		
	(0.274)	(0.274)	(0.017)	(0.016)	(0.017)	(0.015)		
Sex-Ratio	389.052	3890.517‡						
	(220.455)	(2204.546)						

Notes:

1. *Asymptotic standard errors in parentheses.*
2. † *The derivatives are computed with respect to the ω_f and ω_h, not with respect to $\log\omega_f$ and $\log\omega_h$. Furthermore, these derivatives are taken with respect to non-normalized $\phi(\cdot)$. Also Nonlabor income is non-normalized.*
3. ‡ *This figure represents the impact of a one percentage point increase in the sex-ratio.*