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The Collective Marriage Matching Model: Identification, Estimation and Testing

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Abstract

We develop and estimate an empirical collective model with endogenous marriage formation, participation, and family labor supply. Intra-household transfers arise endogenously as the transfers that clear the marriage market. The intra-household allocation can be recovered from observations on marriage decisions. Introducing the marriage market in the collective model allows us to independently estimate transfers from labor supplies and from marriage decisions. We estimate a semi-parametric version of our model using 2000 US Census data. Estimates of the model using marriage data are much more consistent with the theoretical predictions than estimates derived from labor supply.

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1 Introduction

An influential empirical model of intra-household allocations is the collective model of Chiappori (1988, 1992). There are several reasons for its popularity. The collective model is appealing from a theoretical standpoint because it assumes individuals, as opposed to households, have distinct preferences. Under a minimal set of assumptions, it is possible to separately identify the preferences and relative bargaining power of each member of a married couple from observations on labor supply in the collective framework.[1] This is an extremely useful result for empirical work and policy analysis: many policy changes can be expected to cause redistribution *between* and *within* the households and the collective model is able to quantify both effects. A large body of empirical evidence (for example Lundberg, 1988; Thomas, 1990; Fortin and Lacroix, 1997; Chiappori, Fortin, and Lacroix, 2002; and Duflo, 2003) finds the restrictions implied by the unitary model, where the spousal preferences coincide, are rejected while those implied by the collective model are not.[2] The existing theoretical work highlights, and the empirical work confirms, that substantial redistribution may occur within households. To measure the welfare implications of changes in policy, it is important to take intra-household redistribution into account. The collective model makes such measurement possible.

While the collective model has been a useful tool for opening the 'black box' of household decision making, it is silent on other questions that also have welfare implications: Why do some marriages form and not others? How is bargaining power determined? Lundberg and Pollak (1996), and many others, recognize that "marriage is an important determinant of distribution between men and women." Furthermore, many studies (for exam-

[1]The standard identifying assumptions in this version of the collective model are that household allocations are Pareto efficient and preferences are egotistic or caring. For further details, see Browning and Chiappori (1998) and Chiappori and Ekelund (2005).

[2]There are exceptions: for example, Dauphin, El-Lahga, Fortin and Lacroix (2008) reject the collective model in several specifications.

ple, Chiappori, Fortin and Lacroix, 2002 (CFL hereafter), Amuedo-Dorantes and Grossbard-Schectman, 2007; among others) find that features of the marriage market, including sex ratios and divorce laws, are determinants of household labor supply behavior. Such studies suggest there may be strong connections between the marriage market and redistribution within marriage. These studies provide motivation to empirically investigate the joint determination of marriage matching and intra-household allocations. In Choo, Seitz, and Siow (2008; CSS hereafter), we develop the collective marriage matching model, a model that integrates the collective model of Chiappori and the marriage matching model of Choo and Siow (2006; hereafter CS). The collective marriage matching model allows us to analyze both marriage matching and the intra-household allocation of resources.

The general form of the collective marriage matching model in CSS, which includes risk sharing and public goods in marriage, is empirically intractable. The goal of the current paper is to present identification, testing, and estimation results for a version of the collective marriage matching model that is amenable to empirical work. The particular collective model we employ here is based on CFL. As in CFL, our attention is limited to households in which all consumption and leisure is private. In such a setting, the household's Pareto problem can be decentralized and the resource allocation in the household can be summarized by a lump sum transfer of income, the *sharing rule*.

The decentralization of the household's problem generates indirect utilities for each spouse which are functions of own wages and the sharing rule. In the marriage market, individual marriage decisions are made by comparing the indirect utilities that can be obtained from different marriage choices, including the option to remain unmarried. Changes in shares of nonlabor incomes via changes in the sharing rule will affect the level of spousal utility obtained in a particular marriage. Our collective model extends CFL by producing a sharing rule that is the equilibrium outcome of marriage matching.

This paper shows that partial derivatives of the equilibrium sharing rules are identified from marriage data. Our debt to Chiappori (1988, 1992) and CFL is clear: we exploit the indirect utilities generated by the pure private goods collective model to estimate marital choice models.

In deciding whether to enter into a marriage, both potential spouses have to consider the gains from alternative choices. We focus on the wages and nonlabor incomes that a potential couple could obtain by remaining unmarried. The inclusion of such 'alternative' wages and nonlabor incomes fundamentally changes the interpretation of how own wages and nonlabor income affect bargaining within the marriage. In the standard collective framework, where alternative wages are not included in the estimation, there is no theoretical prediction as to how own wages affect bargaining power. Empirically, researchers have generally estimated a positive effect. In our framework, where own wages and alternative wages are included in estimation, an increase in own wages *within the current match* makes the current match more desirable *relative to available alternatives*, decreasing one's bargaining power in the current match. On the other hand, increases in the wages and nonlabor incomes when in alternative living arrangements, holding own wages constant, increase one's bargaining power within the current marriage. The inclusion of alternative wages and nonlabor incomes in the sharing rule and their interpretation are new to the collective marriage matching model.

We establish two new identification results. First, by incorporating the marriage decision in the collective model, we are able to generate two independent sets of estimates of the sharing rule: one from labor supplies and one from marriage decisions. As a result, our framework generates overidentifying restrictions that allow us to test whether the sharing rule which clears the marriage market is consistent with the sharing rule that determines labor supplies in households where both spouses work. Since the two different ways of estimating the determinants of the sharing rule are based on different identifying assumptions and data, depending on circumstances, one way may be more advantageous than the other.

Second, in the case where one spouse does not work, the sharing rule cannot be identified in the CFL framework as is well known.[3] If the spouses who do not work are ex-ante identical to individuals who chose to remain unmarried and have positive labor supply, then we can identify the sharing rule using marriage data on couples in which one spouse does not work and on unmarried men and women.[4]

Our new results are due to the integration of the collective model with a marriage matching model. The standard collective model does not imply any *a priori* restriction on the sharing rule. The restrictions on the sharing rule in this paper are due to an *additional* assumption that the sharing rule clears the marriage market. If our marriage matching assumption is incorrect, then the sharing rule restrictions in this paper will be invalid.

We estimate the collective matching model for non-specialized couples using a sample of young adults from the 2000 United States Census. As pointed out by Blundell, Browning, and Crawford (2003) in a related context, a rejection of the collective framework using parametric tests could arise due to a failure of the collective model itself or to a misspecified functional form for preferences. To this end, we estimate a semiparametric version of the model. In general, the marriage market estimates are much more consistent with the theory than are the labor supply estimates. As expected, individuals are more likely to marry when economic opportunities are better for married couples. With few exceptions, increases in wages and incomes for married couples tend to increase the odds of marriage and increases in the wages and incomes for singles tend to reduce the odds of marriage.

From the reduced form estimates, we compute two independent estimates

[3] Blundell, Chiappori, Magnac, and Meghir (2007) establish identification of the collective model from labor supply data in the case where the labor supply decision of one spouse is discrete and of the other spouse is continuous.

[4] Our result can be generalized to any discrete choice of hours, including zero hours, part-time and full-time work.

of the partial derivatives of the sharing rule, one from the log odds marriage estimates and one from household labor supplies. In general, it is the case that the sharing rule derivatives computed from the marriage estimates are more consistent with the theoretical predictions of the model: 7 out of 8 derivatives from the marriage estimates have the correct sign while only 4 out of 8 derivatives from the labor supply estimates are consistent with the theory. The sharing rule estimates derived from the marriage equations, in particular, predict that increases in marital nonlabor income are shared by the husband and the wife: of an increase in marital nonlabor income of one dollar, approximately 60 cents goes to the wife. Increases in the husband's (wife's) wage serves to increase (decrease) transfers to wives as higher own wages within marriage make marriage more attractive than remaining single. By the same reasoning increases in the wages and nonlabor incomes of single men and women are found to have opposing effects (relative to the wages of married men and women, respectively) on intra-household transfers.

After estimating the model, we test the restrictions on labor supplies and marriage decisions implied by the collective marriage matching model. We formulate a semi-parametric test of our collective matching model which involves comparing the partial derivatives of the sharing rule from labor supplies to those from marriage decisions.[5] Equality of the sharing rule derivatives from the marriage and labor supply estimates cannot be rejected; however, the strength of this conclusion is severely limited by the imprecision of many of the estimates.

The remainder of the paper is organized as follows. We survey the related literature in Section 2. In Section 3, we describe our benchmark version of the collective model and the marriage market. In Section 4, we establish

[5]It should be emphasized that our identification results are still parametric in the sense that some assumptions on the functional form of preferences are imposed, namely that preferences are egotistic. Chiappori (1988) develops nonparametric identification results for the collective model. In recent work, Cherchye, De Rock, and Vermeulen (2007) extend the results of Chiappori to a collective framework with externalities and public goods.

conditions under which the structural parameters of the model (preference parameters and the sharing rule) are identified. In Section 5 we show how the restrictions of our model can be tested. We estimate our model using data from the 2000 Census and present the estimation results in Section 7. Section 8 concludes.

2 Related Literature

We are indebted to several literatures. The study of intra-household allocations began with, among others, Becker (1973, 1974; summarized in 1991), the bargaining models of Manser and Brown (1980) and McElroy and Horney (1981), McElroy (1990) and the collective model of Chiappori (1988, 1992). A related literature, encompassing a diverse set of models, has studied the link between marriage market conditions and marriage rates. Becker (1973) was the first to consider the relationship between sex ratios and marriage rates. Brien (1997) tests the ability of several measures of marriage market conditions to explain racial differences in marriage rates. The link between sex ratios and household outcomes was also extended to the labor supply decision. Grossbard-Schectman (1984) constructs a model where more favorable conditions in the marriage market improve the bargaining position of individuals within marriage. One implication of Grossbard-Schectman and related models that has been tested extensively in the literature is that, for example, an improvement in marriage market conditions for women translates into a greater allocation of household resources towards women, which has a direct income effect on labor supply. Tests of this hypothesis have received support in the literature (see among others, Becker, 1991; Grossbard-Schectman, 1984, 1993; Grossbard-Schectman and Granger, 1998; Chiappori, Fortin, and Lacroix, 2002; Seitz, 2004; Grossbard and Amuedo-Dorantes, 2007).[6] Our

[6] A number of studies have shown that the negative correlation between female labor supply and the sex ratio may not hold outside the US, for example the recent studies by Fukuda (2006) and Emery and Ferrer (2008).

empirical work considers the link between the sex ratio and both marriage and labor supply decisions in a general version of the collective model with matching.

Several important predecessors of our work integrate the collective model and the marriage market (Becker and Murphy, 2000; Browning, Chiappori and Weiss, 2003) and extend the integrated model to consider pre-marital investments (Chiappori, Iyigun, and Weiss, 2006; Iyigun and Walsh, 2007). In these integrated collective models and in our work the sharing rule arises endogenously in the marriage market. Our paper differs from this recent work in focus. Our goal is to develop an empirical framework that minimizes *a priori* restrictions on marriage matching and labor supply patterns. In this respect, our empirical framework can be used to test some of the qualitative predictions of the existing integrated models.

Our treatment of discrete labor supply choices within the collective model, while different in formulation, was influenced by the work of Blundell, Chiappori, Magnac, and Meghir (2007). Blundell, et al. (2007) establish identification of the collective model in the case where the labor supply decision of one spouse is discrete and of the other spouse is continuous. In contrast to Blundell et al. (2007), information on marriage behavior can be used to identify the sharing rule in our framework, even in the case where both household members are not working.

Our work is complementary to the recent literature that estimates search and matching models of marriage. The vast majority of papers in this literature are parametric and dynamic (e.g., Brien, Lillard, and Stern, 2006; Del Boca and Flinn, 2006a, 2006b; Seitz, 2004; Wong, 2003). Del Boca and Flinn (2006a, 2006b), Jacquement and Robin (2008), and Seitz (2004) incorporate both time allocation within the household and marriage decisions. Hitsch, Hortacsu, and Ariely (2006) use novel data from an online dating service to estimate mate preferences.

We assume spouses have access to binding marital agreements and there is no divorce. There is an active empirical literature studying dynamic intra-household allocations and marital behavior. Mazzocco and Yamaguchi (2006) study savings, marriage, and labor supply decisions in a collective framework in which an individual's weight in the household's allocation process depends on the outside options of each spouse, in this case, divorce. As pointed out by Lundberg and Pollak (2003), bargaining within marriage may not lead to efficient outcomes in the absence of binding commitments. Del Boca and Flinn (2006a, 2006b) estimate models of household labor supply where the household members can choose to interact in either a cooperative or a noncooperative fashion. Seitz (2004) estimates a dynamic model of marriage and employment decisions where intra-household allocations are inefficient. Our focus here is on developing and estimating an empirical model of intrahousehold allocations and matching that imposes a minimal set of assumptions. To this end, Pareto efficiency is a maintained assumption.

Finally, Choo and Siow (2006a) developed the basic CS framework. Choo and Siow (2006b) and Brandt, Siow and Vogel (2008) are applications. CSS and the paper here develop and apply the collective marriage matching model. Choo and Siow (2005) develop a dynamic nonparametric matching model. Incorporating dynamics in our framework in the spirit of Choo and Siow (2005) is an important extension left to future work. Siow (2008) surveys this research program.

3 The Collective Marriage Matching Model

Consider a society that is composed of many segmented marriage markets. For expositional ease, assume there is one type of man and one type of woman within each society. We extend our analysis to multiple types in the empirical analysis described in Section 5. All men and women within the same market have the same ex-ante opportunities and preferences. Let m be the number of men and f be the number of women within a market.

Although this is a simultaneous model of intrahousehold allocations and marriage matching, it is pedagogically convenient to discuss the model as if decisions are made in two stages. In the first stage, individuals choose whether to marry and whether the wife works within the marriage. Wages and assets are known for every possible marital choice, and the distribution of spousal bargaining power is determined in equilibrium as described in detail below. In the second stage, labor supply decisions for working spouses and consumption allocations are chosen to realize the indirect utilities which were anticipated by their first stage choices.

We refer to marriages in which the wife does not work in the labor market as specialized marriages (s) and marriages in which both spouses work as non-specialized marriages (n). The index k, $k \in \{n, s\}$ describes whether a married couple is non-specialized or specialized. For simplicity, all men and all unmarried women are assumed to have positive hours of work.[7]

3.1 Preferences

Let C and c be the private consumption of women and men, respectively, and H and h denote their respective labor supplies. Preferences are described by:

$$U_k(C, 1 - H) + \Gamma_k + \varepsilon_k$$

for married women and

$$u_k(c, 1 - h) + \gamma_k + \epsilon_k$$

for married men. For both spouses, the first term is defined over consumption and leisure and affects the intrahousehold allocation. The last two terms, as in CS, affect marriage behavior but do not directly influence the intrahousehold allocation.

[7] It is straightforward to extend our model to allow for zero hours of work for all single and married men and women.

The parameters Γ_k and γ_k capture invariant gains to a marriage of type k for wives and husbands, respectively and are assumed to be separable from consumption and leisure. As in CS, invariant gains to marriage allow the model to fit the observed marriage matching patterns in the data.

For each man and woman, idiosyncratic independent and identically distributed type I extreme value preference shocks (ε_k and ϵ_k, respectively) are realized before marriage decisions are made. It is assumed that the preference shocks do not depend on the specific identity of the spouse, but are specific to the individual and the type of match. As will be shown later, since different individuals of the same gender get receive different preference shocks, they will make different marital choices.

3.2 Intrahousehold allocations

We begin by considering the second stage intrahousehold decision process. This is the familiar setting of the collective model, first developed by Chiappori (1988, 1992). We first describe the second stage problem for unmarried individuals. Next, we consider the intrahousehold allocation problem for non-specialized and specialized couples.

3.2.1 Singles

The problem facing a single woman is:

$$\max_{\{C,H\}} U_0(C, 1-H) + \Gamma_0 + \varepsilon_0 \tag{S}$$

subject to the budget constraint

$$C \leq W_0 H + A_0$$

and likewise for a single man:

$$\max_{\{c,h\}} u_0(c, 1-h) + \gamma_0 + \epsilon_0$$

subject to the budget constraint

$$c \leq w_0 h + a_0$$

3.2.2 Non-specialized couples

Consider a husband and wife in a couple where both partners work. Total nonlabor family income, denoted A_n, and wages for the husband (w_n) and wife (W_n) are realized before marriage decisions are made. The social planner's problem for the household is:

$$\max_{\{c,C,h,H\}} U_n(C, 1-H) + \Gamma_n + \varepsilon_n + \omega_n \Big[u_n(c, 1-h) + \gamma_n + \epsilon_n \Big] \tag{PN}$$

subject to the family budget constraint:

$$c + C \leq A_n + W_n H + w_n h,$$

where the Pareto weight on the husband's utility in non-specialized marriages is ω_n and the Pareto weight on the wife's utility is normalized to one.

A major insight of Chiappori (1988) is that, if household decisions are Pareto efficient, the above program can be decentralized into each spouse solving an individual maximization problem with their own private budget constraint. The wife's budget constraint is characterized by her earnings and a lump sum transfer or sharing rule, denoted τ_n $(W_n, w_n, A_n, \omega_n)$. The husband's budget constraint is characterized by his earnings and household nonlabor income net of the sharing rule $A_n - \tau_n(W_n, w_n, A_n, \omega_n)$. The sharing rule is a known function: given W_n, w_n, A_n, and ω_n, the planner constructs $\tau_n(W_n, w_n, A_n, \omega_n)$. Then, the spouses solve separate individual optimization problems in the second stage.

The decentralized problem for the wife in the second stage is:

$$\max_{\{C,L\}} U_n(C, 1-H) + \Gamma_n + \varepsilon_n$$
$$\text{subject to } C \leq W_n H + \tau_n(W_n, w_n, A_n, \omega_n)$$

and the problem facing husbands in the second stage is:

$$\max_{\{c,l\}} u_n(c, 1-h) + \gamma_n + \epsilon_n$$
$$\text{subject to } c \leq w_n h + A_n - \tau_n(W_n, w_n, A_n, \omega_n).$$

The sharing rule in the decentralized problem and the Pareto weights in the social planner's problem are treated as pre-determined at the point consumption and leisure allocations are chosen. The large literature on collective models is, with few exceptions, agnostic regarding the origins of the sharing rule. A central focus of our paper is to derive a sharing rule from marriage market clearing.

3.2.3 Specialized couples

For households in which the wife does not work, the social planner's problem is:

$$\max_{\{c,C,h\}} U_s(C, 1) + \Gamma_s + \varepsilon_s + \omega_s \Big[u_s(c, 1-h) + \gamma_s + \epsilon_s \Big] \tag{PS}$$

subject to the family budget constraint:

$$c + C \leq A_s + w_s h,$$

where the Pareto weight on the husband's utility in specialized marriages is ω_s and the wife's Pareto weight is again normalized to one. The decentralized problem for the husband is

$$\max_{\{c,l\}} u_s(c, 1-h) + \gamma_s + \epsilon_s$$
$$\text{subject to } c \leq w_s h + A_s - \tau_s(w_s, A_s, \omega_s)$$

and the wife simply receives

$$Q_s(\tau_s) = U_s(C, 1) + \Gamma_s + \varepsilon_s,$$

where

$$C = \tau_s(w_s, A_s, \omega_s).$$

Since the wife is not working, the husband's Pareto weight in specialized marriages only depends on the husband's wage, nonlabor income, and the distribution factors.[8]

3.3 The marriage decision

In the first period, agents decide whether to marry and whether to specialize. Once the idiosyncratic gains from marriage, ε_k and ϵ_k, are realized, individuals choose the household structure that maximizes utility. Individuals have three alternatives: remain single, enter a specialized marriage, or enter a non-specialized marriage. For women, the indirect utility from remaining single is:

$$V_0(\varepsilon_0) = Q_0[W_0, A_0] + \Gamma_0 + \varepsilon_0,$$

from entering a specialized marriage is:

$$V_s(\varepsilon_s) = Q_s[\tau_s] + \Gamma_s + \varepsilon_s,$$

[8]Although individual types have been suppressed here for convenience, the sharing rule will in general depend on characteristics of both spouses and also on the society in which the couple resides.

and from entering a non-specialized marriage is:

$$V_n(\varepsilon_n) = Q_n[W_n, \tau_n] + \Gamma_n + \varepsilon_n.$$

The functions $Q_0[W_0, A_0]$, $Q_s[\tau_s(\cdot)]$, and $Q_n[W_n, \tau_n(\cdot)]$ are the indirect utilities resulting from the second stage consumption and labor supply decisions. Given the realizations of ε_0, ε_n, and ε_s, she will choose the marital choice which maximizes her utility. The utility from her optimal choice will satisfy:

$$V^*(\varepsilon_0, \varepsilon_s, \varepsilon_n) = \max[V_0(\varepsilon_0), V_s(\varepsilon_s), V_n(\varepsilon_n)]. \tag{1}$$

The problem facing men in the first stage is analogous to that of women. Given the realizations of ϵ_0, ϵ_n, and ϵ_s, he will choose the marital choice which maximizes utility. The indirect utility from remaining single is:

$$v_0(\epsilon_0) = q_0[w_0, a_0] + \gamma_0 + \epsilon_0$$

from entering a specialized marriage is:

$$v_s(\epsilon_s) = q_s[w_s, A_s - \tau_s] + \gamma_s + \epsilon_s$$

and from entering a non-specialized marriage is:

$$v_n(\epsilon_n) = q_n[w_n, A_n - \tau_n] + \gamma_n + \epsilon_n,$$

where $q_0[w_0, a_0]$, $q_s[w_s, A_s - \tau_s(\cdot)]$, and $q_n[w_n, A_n - \tau_n(\cdot)]$ are the husband's second stage indirect utilities for remaining single, entering a specialized marriage, and entering a nonspecialized marriage, respectively. The utility from his optimal choice satisfies:

$$v^*(\epsilon_0, \epsilon_s, \epsilon_n) = \max[v_0(\epsilon_0), v_s(\epsilon_s), v_n(\epsilon_n)]. \tag{2}$$

3.4 The Marriage Market

In this section, we construct supply and demand conditions in the marriage market and define an equilibrium for this market. Our model of the marriage market closely follows CS. Assume that there are many women and men in the marriage market, each woman is solving (1) and each man is solving (2). Under the assumption ε_k and ϵ_k are *i.i.d.* extreme value random variables, McFadden (1974) shows that, within a market, the number of marriages relative to the number of females can be expressed as the probability women prefer entering a type k marriage relative to all other alternatives, including remaining single:

$$\frac{\Pi_k}{f} = \frac{\exp\Big(\Gamma_k + Q_k[\cdot]\Big)}{\sum_{l\in\{0,s,n\}} \exp\Big(\Gamma_l + Q_l[\cdot]\Big)} \tag{3}$$

where Π_k is the number of marriages of type k. Similarly, for every man

$$\frac{\pi_k}{m} = \frac{\exp\Big(\gamma_k + q_k[\cdot]\Big)}{\sum_{l\in\{0,s,n\}} \exp\Big(\gamma_l + q_l[\cdot]\Big)} \tag{4}$$

where π_k is the number of marriages of type k.

Equations (3) and (4) imply the following supply and demand equations:

$$\ln \Pi_k - \ln \Pi_0 = (\Gamma_k - \Gamma_0) + Q_k[\cdot] - Q_0[W_0, A_0] \tag{5}$$

where Π_0 is the number of females who choose to remain unmarried, and

$$\ln \pi_k - \ln \pi_0 = (\gamma_k - \gamma_0) + q_k[w_k, A_k - \tau_k] - q_0[w_0, a_0] \tag{6}$$

and π_0 is the number of males who choose to remain unmarried. CS call the left hand side of (5) the net gains to a k type marriage relative to remaining unmarried for women and the left hand side of (6) the net gains to a k type marriage relative to remaining unmarried for men.

Marriage market clearing requires the supply of wives to be equal to the demand for wives for each type of marriage:

$$\Pi_k = \pi_k = \Pi_k^* \; \forall \; k. \tag{7}$$

The following feasibility constraints ensure that the stocks of married and single agents of each gender and type do not exceed the aggregate stocks of agents of each gender in the market:

$$f = \Pi_0 + \sum_k \Pi_k^* \tag{8}$$

$$m = \pi_0 + \sum_k \Pi_k^*. \tag{9}$$

We can now define a rational expectations equilibrium for our version of the collective marriage matching model. An equilibrium is defined and a proof of existence for a more general version of the collective matching model is provided in CSS. There are two parts to the equilibrium, corresponding to the two stages at which decisions are made by the agents. The first corresponds to decisions made in the marriage market; the second to the intra-household allocation. In equilibrium, agents make marital status decisions optimally, the sharing rules clear each marriage market, and conditional on the sharing rules, agents choose consumption and labor supply optimally. Formally:

Definition 1 *A rational expectations equilibrium consists of a distribution of males and females across marital status and type of marriage* $\{\hat{\Pi}_0, \hat{\pi}_0, \hat{\Pi}^*{}_k\}$, *a set of decision rules for marriage* $\{\widehat{V}^*(\varepsilon_{0G}, \varepsilon_{sG}, \varepsilon_{nG}), \widehat{v}^*(\varepsilon_{0g}, \varepsilon_{sg}, \varepsilon_{ng})\}$, *a set of decision rules for spousal consumption and leisure* $\{\hat{C}_0, \hat{C}_k, \hat{c}_0, \hat{c}_k, \hat{L}_0, \hat{L}_n, \hat{l}_0, \hat{l}_k\}$, *exogenous marriage and labor market conditions* W_n, W_0, w_k, w_0, A_k, A_0, a_0, m, f, *the sharing rules* $\{\widehat{\tau}_k(\cdot)\}$, *and a set of Pareto weights* $\{\widehat{\omega}_k\}$, $k \in \{n, s\}$, *such that:*

1. *The decision rules* $\{\widehat{V}^*(\cdot), \widehat{v}^*(\cdot)\}$ *solve (1) and (2);*

2. *All marriage markets clear implying (7), (8), (9) hold;*

3. *For a type n marriage, the decision rules $\{\hat{C}_n, \hat{c}_n, \hat{L}_n, \hat{l}_n\}$ solve (PN);*

4. *For a type s marriage, the decision rules $\{\hat{c}_s, \hat{l}_s\}$ solve (PS).*

Theorem 2 *A rational expectations equilibrium exists.*

Proof: See CSS. In general, the equilibrium Pareto weights will depend on all the exogenous variables in society.

The equilibrium stocks of marriages of each type, as well as the stocks of singles of each type, will depend on wages and nonlabor incomes, as well as labor and marriage market conditions across all alternatives, summarized by $\mathbf{R}$, $\mathbf{R} = \{W_n, w_k, W_0, w_0, A_k, A_0, a_0, m, f\}$ and are denoted:

$$\Pi_k^*(\mathbf{R})$$
$$\Pi_0^*(\mathbf{R})$$
$$\pi_0^*(\mathbf{R})$$

Let $\mathbf{R}_n = \{w_s, W_0, w_0, A_s, A_0, m, f\}$ and $\mathbf{R}_s = \{W_n, w_n, W_0, w_0, A_n, A_0, m, f\}$. In the collective literature, $\mathbf{R}_k$ is known as a set of distribution factors, factors that only influence the allocation through the Pareto weight for marriages of type k, $k \in \{n, s\}$. Equilibrium transfers will therefore be

$$\widehat{\tau}_n(W_n, w_n, A_n, \mathbf{R}_n) = \tau_n(W_n, w_n, A_n, \widehat{\omega}_n(\mathbf{R}))$$
$$\widehat{\tau}_s(w_s, A_s, \mathbf{R}_s) = \tau_s(w_s, A_s, \widehat{\omega}_s(\mathbf{R})).$$

4 Identification

In this section, we demonstrate how information on spousal labor supplies and on marriage decisions can be used to identify the preferences of individual household members as well as the sharing rule.

4.1 Non-specialized couples

4.1.1 Marriage matching restrictions

Denote the log odds ratio for choosing to be in a non-specialized marriage $\hat{P}_n$ relative to being single $\hat{P}_0$, respectively for women and $\hat{p}_n$ and $\hat{p}_0$ for men. We can express this log odds ratio as:

$$\frac{\hat{P}_n}{\hat{P}_0} = \frac{\exp(Q_n[W_n, \widehat{\tau}_n(W_n, w_n, A_n, \mathbf{R}_n)] + \Gamma_n)}{\exp(Q_0[W_0, A_0] + \Gamma_0)} \tag{10}$$

for women and

$$\frac{\hat{p}_n}{\hat{p}_0} = \frac{\exp(q_n[w_n, A_n - \widehat{\tau}_n(W_n, w_n, A_n, \mathbf{R}_n)] + \gamma_n)}{\exp(q_0[w_0, a_0] + \gamma_0)} \tag{11}$$

Denote $P_k = \ln \hat{P}_k - \ln \hat{P}_0$ and $p_k = \ln \hat{p}_k - \ln \hat{p}_0$. It is helpful to express the choice probabilities in this form, as the marriage choice only depends on the characteristics of the current match and the value of remaining single, not on all other potential matches. One advantage of the logit specification assumption is that it is possible to estimate the model with a subset of marriages, as can be observed from the above log odds ratios.

The following proposition shows that the structure of the marriage choice probabilities imposes testable restrictions on marriage behavior that allow us to uncover the partial derivatives of the sharing rule without using information on labor supplies:

Proposition 3 *Take any point such that $P_{nA} \cdot p_{nA} \neq 0$. Then, the following results hold: (i) If there exists exactly one distribution factor such that $p_{nR_1} P_{nA} \neq P_{nR_1} p_{nA}$, the following conditions are necessary for any pair (P_n, p_n) to be consistent with marriage market clearing for some sharing rule*

$\tau_n(W_n, w_n, A_n, \mathbf{R}_n)$:

$$\begin{aligned} \frac{\partial}{\partial j}\widehat{\tau}_{ni} &= \frac{\partial}{\partial i}\widehat{\tau}_{nj}, \quad i, j, \in \{W_n, w_n, A_n, \mathbf{R_n}\} \\ \textit{and} \quad \frac{P_{nR_l}}{p_{nR_l}} &= \frac{P_{nR_1}}{p_{nR_1}}, \quad l \in \{w_s, W_0, w_0, A_s, A_0, a_0, m, f\}. \end{aligned}$$

(ii) Under the assumption that the conditions in (i) hold, the sharing rule is defined up to an additive constant ρ. The partial derivatives of the sharing rule are given by:

$$\begin{aligned} \widehat{\tau}_{nA_n} &= \frac{p_{nR_1}P_{nA}}{p_{nR_1}P_{nA} - P_{nR_1}p_{nA}}, \\ \widehat{\tau}_{nR_l} &= \frac{P_{nR_1}p_{nR_l}}{p_{nR_1}P_{nA} - P_{nR_1}p_{nA}}, \quad R_l \in \{w_s, A_s, m, f\} \\ \widehat{\tau}_{ni} &= \frac{P_{nR_1}p_{ni}}{p_{nR_1}P_{nA} - P_{nR_1}p_{nA}}, \quad i \in \{W_n, W_0, A_0\} \\ \widehat{\tau}_{nj} &= \frac{P_{nj}p_{nR_l}}{p_{nR_1}P_{nA} - P_{nR_1}p_{nA}}, \quad j \in \{w_n, w_0, a_0\}. \end{aligned}$$

Proof: See Appendix A.1. Thus, information on marriage decisions allows us to identify the partial derivatives of the sharing rule independently of the partial derivatives identified from labor supplies.

4.1.2 Labor supply restrictions

Consider couples in which both partners work strictly positive hours. Assume that the unrestricted labor supplies for husbands and wives are continuously differentiable. The Marshallian labor supply functions associated with the collective framework are related to the reduced form according to:

$$\begin{aligned} H_n(W_n, & w_n, A_n, \mathbf{R}_n) \\ & = \tilde{H}_n[W_n, \widehat{\tau}_n(W_n, w_n, A_n, \mathbf{R}_n)] \qquad (12) \\ h_n(W_n, & w_n, A_n, \mathbf{R}_n) \\ & = \tilde{h}_n[w_n, A_n - \widehat{\tau}_n(W_n, w_n, A_n, \mathbf{R}_n)]. \qquad (13) \end{aligned}$$

This is exactly the setting of CFL. As in CFL, it is straightforward to show that the partial derivatives of the sharing rule can be recovered from labor supplies. For completeness, we reproduce the identification results of CFL here. Let R_1 be the 1^{st} element of $\mathbf{R}_n$. The following proposition outlines the necessary and sufficient conditions for identification of the sharing rule.

Proposition 4 *Take any point such that $H_{nA} \cdot h_{nA} \neq 0$. If R_1 is such that $h_{nR_1} H_{nA} \neq H_{nR_1} h_{nA}$, the sharing rule is defined up to an additive constant κ. The partial derivatives of the sharing rule are given by:*

$$\begin{aligned} \widehat{\tau}_{nA} &= \frac{h_{nR_1} H_{nA}}{h_{nR_1} H_{nA} - H_{nR_1} h_{nA}}, \\ \widehat{\tau}_{nj} &= \frac{h_{nR_1} H_{nj}}{h_{nR_1} H_{nA} - H_{nR_1} h_{nA}}, \\ \textit{where} \quad j &\in \{w_s, A_s, W_0, w_0, A_0, a_0, m, f\}, \\ \widehat{\tau}_{nW_n} &= \frac{h_{nW} H_{nR_1}}{h_{nR_1} H_{nA} - H_{nR_1} h_{nA}}, \\ \textit{and} \quad \widehat{\tau}_{nw_n} &= \frac{h_{nR_1} H_{nw}}{h_{nR_1} H_{nA} - H_{nR_1} h_{nA}} \end{aligned}$$

Proof: See Proposition 3 and the Appendix in CFL. Identification from labor supplies is identical to that in CFL in the case where both partners work.

Propositions 3 and 4 provide us with a set of over-identifying restrictions. In particular, the partial derivatives of the sharing rule from the household labor supplies are equal to the partial derivatives of the sharing rule derived from the marriage log odds equations if the collective model is to be consistent with market clearing.

4.2 Specialized couples

4.2.1 Marriage

The indirect utilities for wives and husbands in specialized marriages are:

$$\begin{aligned} V_s[\varepsilon_{sG}] &= Q_s[\widehat{\tau}_s(w_s, A_s, \mathbf{R_s})] + \Gamma_s + \varepsilon_{sG} \\ v_s[\varepsilon_{sg}] &= q_s[w_s, A_s - \widehat{\tau}_s(w_s, A_s, \mathbf{R_s})] + \gamma_s + \varepsilon_{sg}. \end{aligned}$$

Denote the probability of choosing to be in a specialized marriage $\hat{P}_s$ for women and $\hat{p}_s$ for men. The ratio of choice probabilities for specialized marriage relative to remaining single is:

$$\frac{\hat{P}_s}{\hat{P}_0} = \frac{\exp(Q_s[\widehat{\tau}_s(w_s, A_s, \mathbf{R_s})] + \Gamma_s)}{\exp(Q_0[W_0, A_0] + \Gamma_0)}$$

for women and

$$\frac{\hat{p}_s}{\hat{p}_0} = \frac{\exp(q_s[w_s, A_s - \widehat{\tau}_s(w_s, A_s, \mathbf{R_s})] + \gamma_s)}{\exp(q_0[w_0, a_0] + \gamma_0)}$$

for men. As is the case for non-specialized marriages, the following proposition shows that it is straightforward to derive the partial derivatives of the sharing rule from marriage decisions. Then

Proposition 5 *Take any point such that $P_{nA} \cdot p_{nA} \neq 0$. Then, the following results hold: (i) If $p_{sR_1} P_{sA} \neq P_{sR_1} p_{sA}$, the following conditions are necessary for any pair (P_s, p_s) to be consistent with marriage market clearing for some* *sharing rule* $\widehat{\tau}_s(w_s, A_s, \mathbf{R_s})$*:*

$$\begin{aligned}
\widehat{\tau}_{sA} &= \frac{p_{sR_1} P_{sA}}{p_{sR_1} P_{sA} - P_{sR_1} p_{sA}}, \\
\widehat{\tau}_{sR_l} &= \frac{p_{sR_1} P_{sR_l}}{p_{sR_1} P_{sA} - P_{sR_1} p_{sA}}, \quad R_l \in \{W_n, w_n, A_n, m, f\}, \\
\widehat{\tau}_{si} &= \frac{p_{sR_l} P_{si}}{p_{sR_1} P_{sA} - P_{sR_1} p_{sA}}, \quad i \in \{w_s, w_0, a_0\}, \\
\textit{and} \quad \widehat{\tau}_{sj} &= \frac{P_{sR_l} p_{sj}}{p_{sR_1} P_{sA} - P_{sR_1} p_{sA}}, \quad j \in \{W_0, A_0\}.
\end{aligned}$$

Proof: See Appendix A.2. Thus, it is possible to identify the sharing rule, up to an additive constant, for specialized couples if we observe changes in marriage behavior in response to changes in wages, nonlabor incomes, or population supplies.[9] A conclusion that immediately follows from the above is that it is always possible to identify the sharing rule from marriage decisions in the absence of data on labor supply.

4.2.2 Labor supply

Consider couples in which only the husband works in the labor market. The Marshallian labor supply function for husbands in specialized marriages is:

$$h_s(w_s, A_s, \mathbf{R_s}) = \tilde{h}_s(w_s, A_s - \widehat{\tau}_s(w_s, A_s, \mathbf{R_s})).$$

The partial derivatives of the labor supply function are

$$\begin{aligned}
h_{sw} &= \tilde{h}_{sw} - \tilde{h}_{sy} \widehat{\tau}_{sw}, \\
h_{sA} &= \tilde{h}_{sy}(1 - \widehat{\tau}_{sA}), \\
\text{and} \quad h_{sj} &= -\tilde{h}_{sy} \widehat{\tau}_{sj}, \quad j \in \{W_0, w_0, A_0, a_0, W_n, w_n, A_n, m, f\}.
\end{aligned}$$

[9] As is the case for non-specialized couples, the indirect utilities and the sharing rules can both be identified up to an additive constant. Once the partial derivatives of the sharing rule are known, it is straightforward to recover the partial derivatives of the Marshallian labor supply function for husbands $\tilde{h}_y$ and $\tilde{h}_w$.

The above system has 11 equations and 13 unknowns. It is clear that if we only observe variation in the husband's labor supply it is not possible to uncover preferences and the sharing rule.

5 Econometric Specification and Model Tests

In this section, we outline our strategy for estimating and testing the collective matching model. We start by describing the data used to estimate our model. We next describe our estimation strategy and outline how we test whether the restrictions in Propositions 4 and 3 hold for nonspecialized couples.

5.1 Data

We use data from the 2000 US Census to estimate our model. For the purposes of our empirical analysis, we allow for the presence of many segregated marriage markets and many discrete types of men and women, where i denotes the male's type and j the female's types. The type of each individual is defined by the combination of race, education, and age. There are four race categories (black, white, Hispanic, other) and three education types (less than high school, high school graduate and/or some college, college graduate). To ensure that labor supply decisions are closely linked to marriage decisions, we focus primarily on young couples aged 21 to 30, grouped into two five-year age categories. There are thus 24 potential types of women and men in the marriage market. As in CFL, we further assume that each state constitutes a separate marriage market r. Our unit of observation is (ijr) and there are a total of $28,800$ possible cells or categories.

Our goal is to test the over-identifying restrictions implied by the collective matching model for nonspecialized couples. To this end, we limit our sample to couples in which both spouses work strictly positive hours and unmarried individuals who work strictly positive hours.[10]

The marital choice for women (men) is defined as the log of the ratio of the number ijr marriages to the number of jr single women (ir single men). Table 1 presents summary statistics on marriage for the age groups in our sample. The proportion of women between 21 and 25 years of age that are married is around 23% and is roughly twice as high for the 26 to 30 year old group. Women are working in the majority of marriages for this age range and time period; only one-third of marriages are specialized. Men tend to be within the same age range or slightly older than their wives; the proportion of women marrying men above the age of 30 is 46% for 26 to 30 year old women, while the proportion of 21 to 25 year old women marrying men below the age of 21 is only 2%.

Many types of matches, for example across ethnic or education categories are relatively uncommon. Statistics on the ethnic and education composition of marriages are presented in Tables 2 and 3, respectively. As is well known from previous studies, the vast majority of marriages (98%) are between men and women of the same race, with marriages between white men and white women comprising 94% of all marriages. With respect to education, individuals are also very likely to match within own-education categories (78% of marriages) but not to the same extent as for race.

We impose the following additional restrictions on the sample used in estimation. We eliminate cells with less than five observations and observations for which nonlabor income is negative. We restrict our sample to couples without children. We also limit the sample used in estimation to same race and same education marriages due to the limited number of mixed

[10]We also estimate a sharing rule for specialized couples. As outlined in Section 4.2, the collective matching framework allows us to identify the derivative of the sharing rule for specialized couples using only information on marriage decisions, as outlined in Proposition 5. Our specialized sample is limited to couples where only the husband works strictly positive hours and the wife works zero hours. The estimation results are presented in Appendix C.

race and education marriages as described above. Finally we trim the top and bottom 2% of the wage, nonlabor income and sex ratio distributions to eliminate outliers in the non-specialized sample.[11] Our final non-specialized sample contains 390 categories.

Our measure of labor supply is annual hours of work. Wages are measured by average hourly earnings, constructed by dividing total labor income by annual hours. Nonlabor income is measured as the sum of several income sources including social security income, supplementary security income, welfare, interest, dividend and rental income, and other income. Wages, hours of work and nonlabor income are subsequently aggregated up to the cell level using the household sampling weights.[12] The sex ratio ijr in each sample is defined as the total number of men of type i divided by the total number of women of type j in market r. Table 4 contains descriptive statistics for our nonspecialized sample. On average, married men work more hours per year and have higher wages than married women, as expected. The same trend can be observed upon comparison of single men and women. While nonlabor incomes are similar across single men and women, married couples tend to have higher nonlabor income than singles. The average value of the sex ratio across cells indicates that there are slightly fewer men to women in our 21 to 30 year old sample.

5.2 Econometric Specification

Our tests of the collective matching model do not rely upon any particular functional form for preferences, thus it is desirable to impose as few parametric assumptions on preferences as possible in our empirical analysis. The goal of this section is to outline a strategy for obtaining semi-parametric estimates of the collective matching model. The reduced form marriage and

[11]For the specialized sample, a more conservative trim of the top and bottom 1% was used to maintain a reasonable sample size.

[12]Note that measurement error in earnings and hours at the individual level is reduced when the data are aggregated up to the cell level.

labor supply equations are:

$$
\begin{aligned}
P^r_{ij}(W^r_{ij}, & w^r_{ij}, A^r_{ij}, W^r_{0j}, w^r_{i0}, A^r_{0j}, a^r_{i0}, R^r_{ij}) \\
&= \tilde{P}_{ij}[W^r_{ij}, \tau_{ij}(W^r_{ij}, w^r_{ij}, A^r_{ij}, W^r_{0j}, w^r_{i0}, A^r_{0j}, a^r_{i0}, R^r_{ij}), W^r_{0j}, A^r_{0j}] \\
p^r_{ij}(W^r_{ij}, & w^r_{ij}, A^r_{ij}, W^r_{0j}, w^r_{i0}, A^r_{0j}, a^r_{i0}, R^r_{ij}) \\
&= \tilde{p}_{ij}[w^r_{ij}, A^r_{ij} - \tau_{ij}(W^r_{ij}, w^r_{ij}, A^r_{ij}, W^r_{0j}, w^r_{i0}, A^r_{0j}, a^r_{i0}, R^r_{ij}), w^r_{i0}, A^r_{i0}]
\end{aligned}
$$

and

$$
\begin{aligned}
H^r_{ij}(W^r_{ij}, & w^r_{ij}, A^r_{ij}, W^r_{0j}, w^r_{i0}, A^r_{0j}, a^r_{i0}, R^r_{ij}) \\
&= \tilde{H}_{ij}[W^r_{ij}, \tau_{ij}(W^r_{ij}, w^r_{ij}, A^r_{ij}, W^r_{0j}, w^r_{i0}, A^r_{0j}, a^r_{i0}, R^r_{ij})] \\
h^r_{ij}(W^r_{ij}, & w^r_{ij}, A^r_{ij}, W^r_{0j}, w^r_{i0}, A^r_{0j}, a^r_{i0}, R^r_{ij}) \\
&= \tilde{h}_{ij}[w^r_{ij}, A^r_{ij} - \tau_{ij}(W^r_{ij}, w^r_{ij}, A^r_{ij}, W^r_{0j}, w^r_{i0}, A^r_{0j}, a^r_{i0}, R^r_{ij})],
\end{aligned}
$$

respectively. In theory, the full set of distribution factors includes all wages, nonlabor incomes, and population supplies for men and women of every potential type and marital status. It is not feasible to estimate a model with so many distribution factors. Furthermore, it would be difficult to precisely estimate the effect of each factor due to multicollinearity. Therefore, we assume the vector of distribution factors is summarized by the match-specific sex ratio R^r_{ij}, the ratio of men of type i to women of type j, as this is a measure of marriage market conditions commonly adopted in the literature.

We introduce subscripts for the match type (ij) and the state of residence r to highlight two points. The first is that our framework (and our empirical analysis) is general enough to accommodate heterogeneity in preferences and sharing rules by match type. The second point we wish to highlight is that we are imposing the identifying assumption that preferences can vary across different types of matches, but not across locations. Thus, the partial derivatives of the marriage log odds ratios and the labor supplies (and therefore the sharing rules) will be identified off cross-state variation in marriage rates and hours worked within match type. Estimation entails two stages:

Stage 1: Estimate a semiparametric partially linear version of the model:

$$
\begin{aligned}
&P_{ij}^r(W_{ij}^r, w_{ij}^r, A_{ij}^r, W_{0j}^r, w_{i0}^r, A_{0j}^r, a_{i0}^r, R_{ij}^r) \\
&\quad = \tilde{P}[W_{ij}^r, \tau_{ij}(W_{ij}^r, w_{ij}^r, A_{ij}^r, W_{0j}^r, w_{i0}^r, A_{0j}^r, a_{i0}^r, R_{ij}^r), W_{0j}^r, A_{0j}^r] + \alpha_{ij}^P + e_{ij}^{Pr} \\
&p_{ij}^r(W_{ij}^r, w_{ij}^r, A_{ij}^r, W_{0j}^r, w_{i0}^r, A_{0j}^r, a_{i0}^r, R_{ij}^r) \\
&\quad = \tilde{p}[w_{ij}^r, A_{ij}^r - \tau_{ij}(W_{ij}^r, w_{ij}^r, A_{ij}^r, W_{0j}^r, w_{i0}^r, A_{0j}^r, a_{i0}^r, R_{ij}^r), w_{i0}^r, A_{i0}^r] + \alpha_{ij}^p + e_{ij}^{pr}
\end{aligned}
$$

and

$$
\begin{aligned}
&H_{ij}^r(W_{ij}^r, w_{ij}^r, A_{ij}^r, W_{0j}^r, w_{i0}^r, A_{0j}^r, a_{i0}^r, R_{ij}^r) \\
&\qquad = \tilde{H}[W_{ij}^r, \tau_{ij}(W_{ij}^r, w_{ij}^r, A_{ij}^r, W_{0j}^r, w_{i0}^r, A_{0j}^r, a_{i0}^r, R_{ij}^r)] + \alpha_{ij}^H + e_{ij}^{Hr} \\
&h_{ij}^r(W_{ij}^r, w_{ij}^r, A_{ij}^r, W_{0j}^r, w_{i0}^r, A_{0j}^r, a_{i0}^r, R_{ij}^r) \\
&\qquad = \tilde{h}[w_{ij}^r, A_{ij}^r - \tau_{ij}(W_{ij}^r, w_{ij}^r, A_{ij}^r, W_{0j}^r, w_{i0}^r, A_{0j}^r, a_{i0}^r, R_{ij}^r)] + \alpha_{ij}^h + e_{ij}^{hr}.
\end{aligned}
$$

Our econometric specification differs from the most general version of our model in two respects. First, we restrict the match type ij so that it only affects the marriage log odds ratios and the labor supplies through an intercept. This allows differences in match-specific characteristics to affect individual marriage market decisions and labor supply, albeit in a limited way. Second, we introduce *iid* cell-specific error terms (e_{ij}^{Pr}, e_{ij}^{pr}, e_{ij}^{Hr}, e_{ij}^{hr}) that are independent of wages, other incomes, and the sex ratio.

We estimate the above specification model using a combination of Robinson (1988) and Speckman (1988) estimators and local linear estimation (Ruppert and Wand, 1994).[13] Details are presented in Appendix B.

Stage 2: Construct semi-parametric estimates of the partial derivatives of the sharing rule from the first stage estimates and test the equality of the model restrictions.

[13]See Li and Racine (2007) for a full description of both methods.

Recall, we are interested in a test of whether the sharing rule that is consistent with market clearing is also consistent with household labor supplies. The set of restrictions associated with this test are

$$
\begin{aligned}
\tau_{nA} &= \frac{h_{nR}H_{nA}}{h_{nR}H_{nA} - H_{nR}h_{nA}} = \frac{p_{nR}P_{nA}}{p_{nR}P_{nA} - P_{nR}p_{nA}}, \\
\tau_{nR} &= \frac{h_{nR}H_{nR}}{h_{nR}H_{nA} - H_{nR}h_{nA}} = \frac{p_{nR}P_{nR}}{p_{nR}P_{nA} - P_{nR}p_{nA}}, \\
\tau_{nW} &= \frac{h_{nW}H_{nR}}{h_{nR}H_{nA} - H_{nR}h_{nA}} = \frac{p_{nW}P_{nR}}{p_{nR}P_{nA} - P_{nR}p_{nA}}, \\
\tau_{nw} &= \frac{h_{nR}H_{nw}}{h_{nR}H_{nA} - H_{nR}h_{nA}} = \frac{p_{nR}P_{nw}}{p_{nR}P_{nA} - P_{nR}p_{nA}}, \\
\tau_{ni} &= \frac{h_{ni}H_{nR}}{h_{nR}H_{nA} - H_{nR}h_{nA}} = \frac{p_{ni}P_{nR}}{p_{nR}P_{nA} - P_{nR}p_{nA}}, \quad i \in \{W_0, A_0\}, \\
\text{and} \quad \tau_{nj} &= \frac{h_{nR}H_{nj}}{h_{nR}H_{nA} - H_{nR}h_{nA}} = \frac{p_{ni}P_{nR}}{p_{nR}P_{nA} - P_{nR}p_{nA}}, \quad j \in \{w_0, a_0\}.
\end{aligned}
$$

Our semi-parametric procedure computes an estimate of the partial derivatives of the marriage and labor supply equations for each observation in the sample. We then compute the sharing rule estimates at each point. The point estimates of the sharing rule and the partial derivatives presented below represent the weighted average of the point estimates, where the weights are the household sampling weights from the Census.

The standard errors for all the estimates and test statistics are generated using bootstrap methods. For example, consider the derivative estimates with respect to R from the male labor supply in the non-specialized case, $\widehat{h}_{nR}$. Let the sample size be N and let B denote the number of bootstrap replications, each of which is of size N. For all the reported standard errors, B is set to 1499. For each replication, we compute the weighted average point estimate $\widehat{h}^*_{nR1}, \ldots, \widehat{h}^*_{nRB}$ and the bootstrap variance estimate for $\widehat{h}_{nR}$

using the standard formula

$$s^2_{\widehat{h}_{nR}B} = \frac{1}{B-1}\sum_{b=1}^{B}(\widehat{h}^*_{nRb} - \bar{\widehat{h}}^*_{nR}), \qquad \text{where } \bar{\widehat{h}}^*_{nR} = B^{-1}\sum_{b=1}^{B}\widehat{h}^*_{nRb}.$$

Let $\hat{\tau}^L_{nR}$ and $\hat{\tau}^M_{nR}$ be the weighted point estimates of the sharing rule derivatives with respect to R from the labor and marriage market, respectively, for non-specialized couples. To test the hypothesis that $H_0 : \tau^L_{nR} = \tau^M_{nR}$, we use the test statistic

$$t = \frac{\hat{\tau}^L_{nR} - \hat{\tau}^M_{nR}}{s_{\widehat{d}_{nR}B}} = \frac{\widehat{d}_{nR}}{s_{\widehat{d}_{nR}B}}.$$

To compute the bootstrap standard error, $s_{\widehat{d}_{nR}B}$, we compute the weighted point estimate for each bootstrap replication $\widehat{d}^*_{nR1}, \ldots, \widehat{d}^*_{nRB}$. The variance of the difference in the sharing rule estimates is calculated according to

$$s^2_{\widehat{d}_{nR}B} = \frac{1}{B-1}\sum_{b=1}^{B}(\widehat{d}^*_{nRb} - \bar{\widehat{d}}^*_{nR}), \qquad \text{where } \bar{\widehat{d}}^*_{nR} = B^{-1}\sum_{b=1}^{B}\left(\hat{\tau}^{*L}_{nRb} - \hat{\tau}^{*M}_{nRb}\right).$$

6 Comparative Statics for a Special Case

To provide intuition for the interpretation of the empirical results, consider a society where there is one type of man and one type of woman, and only one type of marriage, nonspecialized marriages. Then each individual simply chooses whether to enter a nonspecialized marriage or not. In this case, the net gains equations become:

$$\begin{aligned} N(W, w, A, W_0, w_0, A_0, a_0, R) &= \ln\mu(W, w, A, W_0, w_0, A_0, a_0, R) \\ &\quad - \ln\Big[F - \mu(W, w, A, W_0, w_0, A_0, a_0, R)\Big] \\ &= \Gamma - \Gamma_0 + Q\Big[W, \tau(W, w, A, W_0, w_0, A_0, a_0, R)\Big] - Q_0[W_0, A_0] \end{aligned}$$

for women and

$$
\begin{aligned}
n(W, w, A, W_0, w_0, A_0, a_0, R) &= \ln \mu(W, w, A, W_0, w_0, A_0, a_0, R) \\
&\quad - \ln\Big[M - \mu(W, w, A, W_0, w_0, A_0, a_0, R)\Big] \\
&= \gamma_k - \gamma_0 + q\Big[w, A - \tau(W, w, A, W_0, w_0, A_0, a_0, R)\Big] - q_0[w_0, a_0]
\end{aligned}
$$

for men.

These are two equations that can be solved for the two unknowns, $\mu(\cdot)$ and $\tau(\cdot)$ and it is straightforward to derive a set of comparative statics for the net marital gains equations. The sign predictions for the comparative statics have implications for the signs of the reduced form log odds marriage equations, the reduced form labor supplies, and the sharing rules. A summary of the sign predictions is presented in Table 5. Columns 1 and 2 contain the sign predictions for the partial derivatives of the reduced form log odds marriage regressions for women and men, respectively. Columns 3 and 4 contain the sign predictions for the corresponding labor supply regressions. Finally, Column 5 of Table 5 contains the predicted signs of the sharing rule derivatives.

It is worth emphasizing that our restrictions on the sharing rule are due to the *additional* assumption that the sharing rule must clear the marriage market. These restrictions are not present in the standard collective model such as CFL.

The comparative statics for the net gains equations above are as follows.

$$
\begin{array}{ccccc}
\mu_W > 0 & \tau_W < 0 & N_W > 0 & n_W > 0 & h_W < 0 \\
\mu_w > 0 & \tau_w > 0 & N_w > 0 & n_w > 0 & H_w < 0
\end{array}
$$

An increase in wages for married women W makes marriage more attractive to women. To attract more men into marriage, τ falls and μ increases. A similar arguments applies to an increase in the wage of married men w.

We thus expect the sharing rule to be increasing in the husband's wage and, conversely, to be decreasing in the wife's wage. As a result, the model predicts labor supply is decreasing in the wage of the spouse. The own wage effect in the labor supply equation is ambiguous due to the standard income and substitution effects found in the unitary model.

Comparing our results to the collective model without marriage matching (i.e. CFL), we expect $\tau_W < 0$ whereas they expect and found $\tau_W > 0$. The main difference is that we hold W_0, the unmarried wage, constant when we increase W. Because in their empirical work, they do not hold W_0 constant, we interpret CFL's estimate of τ_W as the net change in the sharing rule in response to changes in the married and unmarried wages of women when the married wage is observed to increase marginally.

$$\mu_A > 0 \qquad 1 > \tau_A > 0 \qquad N_A > 0 \qquad n_A > 0 \qquad H_A < 0 \qquad h_A < 0$$

When A increases, the payoff to marriage increases, thus more individuals marry. Both husbands and wives can benefit from increases in marital non-labor income; thus it is expected that gains will be shared by both spouses, consistent with a sharing rule derivative between 0 and 1. Since $0 < \tau_A < 1$, both spousal labor supplies must decrease as A increases, a standard income effect.

$$\begin{array}{llllll}
\mu_{W_0} < 0 & \tau_{W_0} > 0 & N_{W_0} < 0 & n_{W_0} < 0 & H_{W_0} < 0 & h_{W_0} > 0 \\
\mu_{A_0} < 0 & \tau_{A_0} > 0 & N_{A_0} < 0 & n_{A_0} < 0 & H_{W_0} < 0 & h_{W_0} > 0 \\
\mu_{w_0} < 0 & \tau_{w_0} < 0 & N_{w_0} < 0 & n_{w_0} < 0 & H_{w_0} > 0 & h_{w_0} < 0 \\
\mu_{a_0} < 0 & \tau_{a_0} < 0 & N_{a_0} < 0 & n_{a_0} < 0 & H_{w_0} > 0 & h_{w_0} < 0
\end{array}$$

As W_0 or A_0 increase, women find it less attractive to enter marriage. To reduce the number of marriages, τ falls and μ also falls. A similar argument applies to increases in w_0 and a_0. Transfers to women within marriage are therefore predicted to rise if the wages and nonlabor incomes they face when single increase and are expected to fall with the nonlabor incomes and wages of single men, consistent with a bargaining interpretation. As a result, we expect the labor supply of married women to be increasing in the wages and nonlabor incomes of single men and decreasing in the wages and nonlabor incomes of single women, while the converse is true for married men.

$$
\begin{array}{llllll}
1 > \mu_F > 0 & \tau_F < 0 & N_F < 0 & n_F > 0 & H_F > 0 & h_F < 0 \\
1 > \mu_M > 0 & \tau_M > 0 & N_M > 0 & n_M < 0 & H_M < 0 & h_M > 0
\end{array}
$$

As F increases, more women want to marry. To attract more men into marriage, τ falls and μ increases but by less than the increase in F. This implies $N_F < 0$ and $n_F > 0$. A similar argument holds for the increase in M. As is standard in the literature, an increase in the sex ratio is expected to increase transfers to women within marriage as men face greater competition for spouses, resulting in a rise in labor supply for married men and a fall for married women.

7 Results

In this section, we present semi-parametric estimates of the collective matching model. We start by presenting estimates of the reduced form log odds marriage and labor supplies. We use these reduced form estimates to construct two independent sets of estimates of the sharing rule derivatives, presented in Section 5.2, and test the model restrictions discussed above. Finally, we consider the sensitivity of our estimates to several alternative model specifications.

7.1 Reduced form marriage and labor supply estimates

The estimates of the marriage and labor supply regressions for our benchmark specification are presented in Table 6. In all of the following tables, instances where the estimated signs are consistent with the theoretical predictions from Table 5 are denoted by †. The first two columns contain semi-parametric estimates of the reduced form log odds marriage regressions for women and men. The third and fourth columns contain semi-parametric estimates of the reduced form labor supply equations for wives and husbands in non-specialized marriages, respectively.

The results for the log odds marriage regressions are very consistent with the theoretical sign predictions. Column 1 of Table 6 contains the estimation results for women, while Column 2 contains the corresponding estimates for men. As expected, an increase in the number of type i men relative to type j women increases the log odds of an ij marriage for women and reduces the odds of an ij marriage for men. In general, increases in wages and incomes for married couples tend to increase the odds of marriage and increases in wages and incomes for singles tend to reduce the odds of marriage. In particular, increases in the wages of single men have a statistically significant and negative effect on the log odds of marriage for both men and women, as do increases in the nonlabor income of single females. Only one set of estimates differs in sign from the theoretical prediction. An increase in the wages of married women is expected to increase the log odds of marriage, whereas the estimated effect is negative.

Turning to the labor supply estimates, an increase in nonlabor income has the expected negative effect on labor supply for both married men and married women. The effect of an increase in the sex ratio on the husband's labor supply is also consistent with the theory: a 10% increase in the sex ratio is predicted to result in a 26 hour (or 1.2%) increase in annual labor supply for married men. In contrast to the marriage estimates, however, the labor supply estimates often have different signs than those predicted by the theory. There is no clear pattern, for example, in the effect of male and female wages on household labor supply: it is often the case that increases in wages or nonlabor incomes have the same effect on the husband's and wife's labor supply when the theory predicts the effects should be opposite in sign.

7.2 Estimates of the sharing rule from marriage and labor supply decisions

Previous work on the collective model (for example, CFL) generated estimates of the sharing rule from labor supplies or from consumption demands. We make two original contributions to the empirical literature on the collective model. First, we produce new and independent estimates of the sharing rule from marriage decisions. Second, since we can also produce estimates of the sharing rule from household labor supply as done in previous studies, we assess the extent to which our estimates of the sharing rule from labor supplies are consistent with our sharing rule estimates derived from marriage decisions.

The marriage estimates and the labor supply estimates presented in Table 6 are subsequently used to generate two independent sets of estimates of the sharing rule. These estimates are presented in columns 1 and 2 of Table 12, respectively. Column 1 contains estimates of the partial derivatives of the sharing rule with respect to each argument from the log odds of non-specialized marriages versus remaining single for men and women. Column 2 contains corresponding estimates from the labor supply estimates for non-specialized couples. The former sharing rule can be interpreted as the sharing rule that is consistent with marriage market clearing; the latter can be interpreted as the intra-household allocation that is consistent with family labor supply.

The estimates presented in Table 12 highlight many similarities across the marriage and labor supply sharing rules. Nonlabor income for married couples is the only sharing rule determinant that was precisely estimated in both specifications, and the parameter estimates are both positive and less than one, consistent with our theoretical predictions. An increase in other income for married couples is predicted to increase transfers to wives by 84 cents based on the labor supply estimates and 60 cents based on the marriage estimates.

The effect of increases in the sex ratio on the sharing rule is negative, counter to our theoretical predictions, in both specifications. However, with the exception of the sex ratio, the sharing rule estimated from the marriage log odds regressions is entirely consistent with the theory. The sharing rule is increasing in the wages of married men and decreasing in the wages of married women, as predicted by the theory. Increases in the wages and nonlabor incomes of unmarried men and women have the opposite effect. In contrast to the marriage estimates, one half of the sharing rule estimates from labor supplies are opposite in sign to the theoretical predictions.

Figures 1 and 2 present the partial derivatives of each determinant of the sharing rule from the marriage regressions. Pointwise 95% confidence bands are drawn at the 5%, 10%, 25%, 50%, 75%, 90%, and 95% percentiles. In all cases, and as expected, the partial derivatives are less precise at the lowest and highest percentiles. With the exception of nonlabor income for married couples and unmarried individuals, the figures demonstrate the substantial nonlinearity in the sharing rule derivatives.

The t-statistic for a test of equality of the sharing rule estimates from the labor supply and marriage regressions is presented in Column 3. Despite the many sign differences across specifications, the test statistics cannot reject the equality of the sharing rule derivatives from the marriage and labor regressions. It is important to note that most of the partial derivatives of the sharing rule are not precisely estimated. Thus, we cannot draw any strong conclusions regarding the consistency of the separate sets of sharing rule estimates from our estimation results.

The estimation results presented here suggest that estimation of the collective model from marriage decisions as opposed to labor supply might be a promising direction for future research. It is perhaps not surprising that marriage decisions appear to be more consistent with the predictions of the model: it is likely that bargaining power is most responsive to changes in wages and nonlabor incomes at the point the marriage decision is made. After forming a match, the presence of divorce costs and marriage-specific investments likely reduce the effects of outside conditions in the marriage market on intra-household allocations.

7.3 Selection and Alternative specifications

In this section, we consider two alternative specifications to assess the robustness of the estimation results from the benchmark specification. First, we try and assess the importance of unobserved heterogeneity in wages across married and unmarried individuals. Recall, our benchmark specification defines wages at the match level. In particular, the wage of a type i man married to a type j woman is computed as the average wage of husbands in ij matches in the data. The wage of an unmarried type i male is the average wage of all unmarried type i males, by state of residence. That wages for married and unmarried men of the same type differ in the data may be indicative of selection into marriage on unobserved characteristics that also determine wages. In this instance, the wage faced by unmarried men may not be representative of the wage a married man of the same type would face were he to remain unmarried. Unfortunately, our framework does not allow us to readily incorporate such unobserved heterogeneity.

As a robustness check, we consider an alternative specification where we define type-specific (as opposed to match-specific) wages as follows. Denote the wage of a type i male as w_i, where w_i is the average wage of all men, married and unmarried, of type i. Similarly, denote the average of wage for all type j females as W_j. To capture the availability of other types of spouses that are available in marriage, define w_{-i} to be the weighted average of the wages for men of all types except type i, where the weights reflect the proportions of the types in the population. Similarly, define W_{-j} to be the weighted average of the wages for women of all types except type j. We substitute w_i (W_j) for w_{ij} (W_{ij}) and w_{-i} (W_{-j}) for w_{i0} (W_{0j}) and re-estimate the model.

The results for the log odds marriage regressions are presented in Columns 2 and 5 of Table 8 for wives and husbands, respectively. Columns 1 and 4 contain the estimation results for the benchmark specification for comparison purposes. The results are very robust across specifications in terms of both sign and magnitude. The corresponding results for the labor supply regressions are presented in Table 9. The effect of the single woman's wage has a positive effect on both the labor supply of the husband and wife in the benchmark specification. In our alternative wage specification an increase in the alternative wage reduces male and female labor supply. Thus, the labor supply estimates are sensitive to the measure of the alternative wage while the marriage estimates are not.

A primary goal of our model and empirical results is to test whether the sharing rule that clears the marriage market is also consistent with household labor supplies. To this end, we expect the model to provide a better description of behavior in younger households, as the current labor supply decisions in younger households is likely closer, temporally, to their marriage decisions. For older households, the distribution of marriages is more likely to have been determined further in the past. If preferences, populations supplies, wages, or marital technologies changed over time, the sharing rule that was faced by an older couple *at the time of marriage* may likely be different than the sharing rule that determines current household labor supplies. Our final specification explores this issue. We estimate the model on a sample of individuals aged 21 to 60 years of age. The estimation results for wives and husbands are presented in Columns 3 and 6, respectively of Table 8 for the log odds of marriage and Table 9 for labor supply.

Regarding the labor supply results, the coefficient on the sex ratio for wives changes sign and for men moves closer to zero in the older sample relative to the benchmark specification. This result suggests the current sex ratio may not be a good measure of outside marriage opportunities for the older sample. The effect of single male wages also gets much smaller and the effect of single female wages changes sign for the husband's labor supply. Thus the labor supply estimates seem somewhat sensitive to the age range of the sample. As expected, the marriage results are also more sensitive to the choice of age range: the effects of the wife's wage and also the sex ratio change sign between our benchmark specification and the older sample.

A comparison of the estimates of the sharing rule for all three specifications is presented in Table 10. The estimate of the sharing rule with respect to other income tends to be precisely estimated and roughly consistent across all of the specifications, although the magnitude of the effect of nonlabor income on the sharing rule tends to be smaller in the older sample. The effect of wages tends to vary widely across specifications, and equality of the sharing rule estimates from the labor supply and marriage estimates is rejected for the husband's wage and the single female's wages for the older sample. In general, more of the derivatives of the sharing rule from the marriage regressions are significant. Very few of the estimates from the labor supply regressions are precisely estimated. Taking advantage of data on marriage decisions may be a more attractive in general than using data on household labor supply or consumption for married couples in general. Since all individuals in the data make marriage decisions, data on both singles and married couples can be used to estimate the sharing rule which has two advantages: (i) it allows the researcher to utilize a larger sample, and (ii) it reduces the potential for sample selection bias as it is no longer necessary to restrict the analysis to observations on married couples.

8 Conclusion

In this paper, we develop an empirical collective matching model that embeds the collective model of Chiappori, Fortin, and Lacroix (2002) in the nonparametric matching model of Choo and Siow (2006). We show that the matching model generates an equilibrium sharing rule used to allocate resources in the intra-household problem of married couples. Further, we show that this sharing rule can be independently identified from commonly available labor supply and marital sorting data.

We estimate semiparametric sharing rules from 2000 US data and test the restrictions on labor supplies and marriage decisions implied by our collective matching model. For a sample of young adults, we find that the sharing rule consistent with household labor supplies is also consistent with marriage market clearing. The estimates provide evidence in favor of integrating the collective model and our non-transferable utility model of marriage, although the results should be interpreted with caution, as many of the estimates are imprecisely estimated. In general, the estimates of the collective model from marriage data are more robust and more consistent with the theory, suggesting a fruitful avenue for future research.

Our framework abstracts from two additional important issues which are beyond the scope of the current paper. The first is dynamics. As we mention in Section 2, Choo and Siow (2005), Seitz (2004), Mazzocco and Yamaguchi (2006) and others make important first steps in this direction. The second is unobserved heterogeneity and how this heterogeneity might influence marriage and labor supply decisions. How to resolve the latter issue is an open question in the literature. In this paper, we provide a framework that allows for rich observed individuals heterogeneity and show how observed heterogeneity might influence matching and labor supply decisions.

Table 1: **Summary Statistics on Marriages**

	Women	
	age 21 to 25	**age 26 to 30**
Proportion of women that are married	23.42	56.85
Proportion of marriages:		
that are specialized	33.11	34.38
where spouse is younger than 21	1.74	00.09
where spouse is older than 30	11.77	46.07

Table 2: **Ethnic Distribution of Marriages**

		Non-specialized couples				
		Husbands				
		White	**Black**	**Hispanic**	**Other**	**Total**
	White	94.27	0.00	0.79	0.14	95.20
	Black	0.06	2.21	0.00	0.00	2.27
Wives	**Hispanic**	0.64	0.00	1.68	0.00	2.32
	Other	0.11	0.00	0.03	0.07	0.22
	Total	95.08	2.21	2.50	0.21	100.00
Number of couples		894,252				

Table 3: **Education Distribution of Marriages**

		Non-specialized couples			
		Husbands			
		< High School	**High School**	**College**	**Total**
	< High School	0.01	0.42	0.01	0.45
Wives	**High School**	0.02	49.54	14.25	63.82
	College	0.00	7.31	28.42	35.73
	Total	0.03	57.28	42.68	100.00
Number of couples		894,252			

Table 4: **Household Characteristics**

	Nonspecialized couples	
	Husbands	**Wives**
Annual hours	2186.88	1862.41
	(134.77)	(154.55)
Average hourly wage	16.20	13.62
	(3.84)	(3.56)
Nonlabor income	1043.45	
	(849.52)	
Sex Ratio	0.9829	
	(0.1923)	
# of types ijr	390	
# weighted married couples	710,601	

	Single Males	**Single Females**
Annual hours	1930.93	1687.68
	(221.18)	(240.58)
Average hourly wage	14.80	12.58
	(3.45)	(3.06)
Nonlabor income	722.19	716.53
	(416.17)	(289.91)

Table 5: **Theoretical sign predictions of the marriage choices, labor supplies, and sharing rule partial derivatives for non-specialized couples**

	Marriage		Labor Supply		Sharing Rule
	Women	Men	Wives	Husbands	
Other income	+	+	-	-	(0,1)
Husband's wage	+	+	-	?	+
Wife's wage	+	+	?	-	-
Sex ratio	+	-	-	+	+
Single male wage	-	-	+	-	-
Single male income	-	-	+	-	-
Single female wage	-	-	-	+	+
Single female income	-	-	-	+	+

Table 6: **Semi-parametric marriage and labor supply estimates for non-specialized couples**

	Marriage		Labor Supply	
	Women	Men	Wives	Husbands
Other income	0.0001†	0.0001†	-0.0363†	-0.0093†
	(1.2212)	(1.1441)	(1.5302)	(0.3717)
Sex ratio	0.6568†	-0.4788†	92.6772	255.9506†
	(1.4166)	(1.0716)	(0.9827)	(2.8832)
Husband's wage	0.0180†	0.0193†	-0.4019†	-8.0883†
	(0.8025)	(0.8649)	(0.0747)	(1.5357)
Wife's wage	-0.0363	-0.0307	7.6926†	0.5554
	(1.2672)	(1.0858)	(1.3175)	(0.0965)
Single male wage	-0.1875†	-0.1774†	9.1098†	14.1518
	(3.7076)	(3.5096)	(0.7248)	(1.1893)
Single male income	-0.0002†	-0.0002†	0.0418†	-0.0232†
	(0.7358)	(0.7336)	(0.7398)	(0.3911)
Single female wage	-0.0890†	-0.0939†	8.7338	13.6085†
	(1.6359)	(1.7727)	(0.7868)	(1.1856)
Single female income	-0.0004†	-0.0004†	-0.1549†	-0.1360
	(1.0981)	(1.2110)	(2.3802)	(1.8320)
Observations		390		

Notes: Absolute value of t-statistic in parentheses. † denotes an estimated sign that is consistent with the theory.

Table 7: **Sharing rule estimates for non-specialized couples**

	Marriage	Labor Supply	t-statistic
Other income	0.5993†	0.8424†	-0.6106
	(1.7415)	(3.9943)	
Sex ratio	-480.3270	-1803.3200	0.5194
	(0.2083)	(1.4320)	
Husband's wage	96.3306†	70.8551†	0.1914
	(0.9757)	(0.8478)	
Wife's wage	-1.9760†	16.8349	-0.1556
	(0.0190)	(0.2764)	
Single male wage	-200.1350†	-256.4570†	0.1579
	(0.6469)	(1.5111)	
Single male income	-0.0348†	0.0512	-0.0651
	(0.0329)	(0.0643)	
Single female wage	46.9794†	-57.1923	0.4010
	(0.1992)	(0.6962)	
Single female income	0.8993†	0.7133†	0.9192
	(0.8155)	(0.9045)	
Observations	390		

Notes: Absolute value of t-statistics in parentheses. † denotes an estimated sign that is consistent with the theory.

Table 8: **Alternative marriage log odds estimates**

	Women			Men		
	Benchmark	Substitute Wages	Ages 21-60	Benchmark	Substitute Wages	Ages 21-60
Other income	$0.0001^\dagger$	$0.0001^\dagger$	$0.0001^\dagger$	$0.0001^\dagger$	$0.0001^\dagger$	$0.0001^\dagger$
	(1.2212)	(1.2255)	(6.6842)	(1.1441)	(1.0900)	(6.2500)
Sex ratio	$0.6568^\dagger$	$0.5648^\dagger$	$1.3225^\dagger$	$-0.4788^\dagger$	$-0.5769^\dagger$	0.1311
	(1.4166)	(0.9798)	(7.7339)	(1.0716)	(1.0496)	(0.7488)
Husband's wage	$0.0180^\dagger$	$0.0062^\dagger$	$0.0351^\dagger$	$0.0193^\dagger$	$0.0064^\dagger$	$0.0344^\dagger$
	(0.8025)	(0.1555)	(4.8536)	(0.8649)	(0.1616)	(4.4890)
Wife's wage	-0.0363	-0.0358	$0.0131^\dagger$	-0.0307	-0.0213	$0.0090^\dagger$
	(1.2672)	(0.7481)	(1.1283)	(1.0858)	(0.4643)	(0.7211)
Single male wage	$-0.1875^\dagger$		$-0.0523^\dagger$	$-0.1774^\dagger$		$-0.0509^\dagger$
	(3.7076)		(4.2740)	(3.5096)		(4.0268)
Single male income	$-0.0002^\dagger$	$-0.0001^\dagger$	$-0.00002^\dagger$	$-0.0002^\dagger$	$-0.0002^\dagger$	$-0.00003^\dagger$
	(0.7358)	(0.3828)	(0.4375)	(0.7336)	(0.5728)	(0.5200)
Single female wage	$-0.0890^\dagger$		$-0.0774^\dagger$	$-0.0939^\dagger$		$-0.0842^\dagger$
	(1.6359)		(5.7603)	(1.7727)		(5.9594)
Single female income	$-0.0004^\dagger$	$-0.0007^\dagger$	$-0.0001^\dagger$	$-0.0004^\dagger$	$-0.0008^\dagger$	$-0.0001^\dagger$
	(1.0981)	(1.9631)	(2.9091)	(1.2110)	(2.0743)	(3.1522)
Substitute male wage		$-0.0692^\dagger$			$-0.0571^\dagger$	
		(1.4900)			(1.2584)	
Substitute female wage		$-0.0410^\dagger$			$-0.0449^\dagger$	
		(1.3475)			(1.5415)	
Observations	390	390		390	390	

Notes: Absolute value of t-statistic in parentheses. † denotes an estimated sign that is consistent with the theory.

Table 9: **Alternative labor supply estimates**

	Wives			Husbands		
	Benchmark	Substitute Wages	Ages 21-60	Benchmark	Substitute Wages	Ages 21-60
Other income	-0.0363†	-0.0764†	-0.0027†	-0.0093†	-0.0262†	-0.0055†
	(1.5302)	(2.8097)	(0.9446)	(0.3717)	(0.9023)	(2.0383)
Sex ratio	92.6772	430.0079	24.2459	255.9506†	111.1578†	-49.7308
	(0.9827)	(2.8478)	(0.8440)	(2.8832)	(0.7144)	(1.9147)
Husband's wage	-0.4019†	-3.1949†	-0.2844†	-8.0883†	-5.1690†	-4.6181†
	(0.0747)	(0.3228)	(0.2287)	(1.5357)	(0.5316)	(4.1518)
Wife's wage	7.6926†	23.6186†	0.0763†	0.5554	12.7186	1.1392
	(1.3175)	(2.0030)	(0.0364)	(0.0965)	(1.0873)	(0.5834)
Single male wage	9.1098†		2.9130†	14.1518		4.5312
	(0.7248)		(1.3322)	(1.1893)		(2.3705)
Single male income	0.0418†	-0.1290	0.0209†	-0.0232†	-0.0248†	-0.0153†
	(0.7398)	(1.3618)	(2.5477)	(0.3911)	(0.2405)	(1.9916)
Single female wage	8.7338		1.0477	13.6085†		-4.8273
	(0.7868)		(0.4465)	(1.1856)		(2.2759)
Single female income	-0.1549†	-0.0396†	-0.0250†	-0.1360	-0.1257	-0.0076
	(2.3802)	(0.4316)	(3.0020)	(1.8320)	(1.3788)	(0.9447)
Substitute male wage		18.1302†			2.7932	
		(1.6641)			(0.2398)	
Substitute female wage		-5.7448†			-0.2907	
		(0.7923)			(0.0365)	
Observations	390	390		390	390	

Notes: Absolute value of t-statistic in parentheses. † denotes an estimated sign that is consistent with the theory.

Table 10: **Alternative sharing rule estimates**

	Marriage			Labor Supply		
	Benchmark	Substitute Wages	Ages 21-60	Benchmark	Substitute Wages	Ages 21-60
Other income	0.5993†	0.4691†	0.1503*†	0.8424†	0.0848†	0.4394*†
	(1.7415)	(1.1837)	(1.2456)*	(3.9943)	(0.3767)	(4.8315)
Sex ratio	-480.3270	-4349.0500	-22288.09*	-1803.3200	1934.08†	-3609.6240*
	(0.2083)	(0.9371)	(12.2948)	(1.4320)	(1.5858)	(3.4997)
Husband's wage	96.3306†	345.3219*†	131.6737†	70.8551†	-7.6143*	-87.2119*
	(0.9757)	(1.9830)	(2.3981)	(0.8478)	(0.1054)	(1.4885)
Wife's wage	-1.9760†	-107.8040†	186.0725	16.8349	12.2972	84.2620
	(0.0190)	(0.6165)	(2.9475)	(0.2764)	(0.1843)	(1.6107)
Single male wage	-200.1350†		-102.3092†	-256.4570†		97.9159
	(0.6469)		(1.1907)	(1.5111)		(0.9791)
Single male income	-0.0348†	1.3866	156.6002	0.0512	-0.2254†	-1.6302†
	(0.0329)	(1.0402)	(1.5506)	(0.0643)	(0.3132)	(4.1678)
Single female wage	46.9794†		-1.1551*	-57.1923		-409.5318*
	(0.1992)		(3.5847)	(0.6962)		(6.8031)
Single female income	0.8993†	0.8462†	1.0047*†	0.7133†	-2.0102	-0.3081*
	(0.8155)	(0.3077)	(5.0582)	(0.9045)	(2.7875)	(1.3999)
Substitute male wage		-405.9320*†			137.2526*	
		(1.7313)			(1.1293)	
Substitute female wage		-48.9502			4.5412†	
		(-0.3078)			(0.0634)	
Observations	390	390		390	390	

Note: Absolute values of t-statistics in parentheses. Value of t-statistics of equality denoted by * for 10 percent significance. † denotes an estimated sign that is consistent with the theory.

Figure 1: Partial derivative of the sharing rule with respect to the sex ratio and wages and nonlabor incomes for married men and women

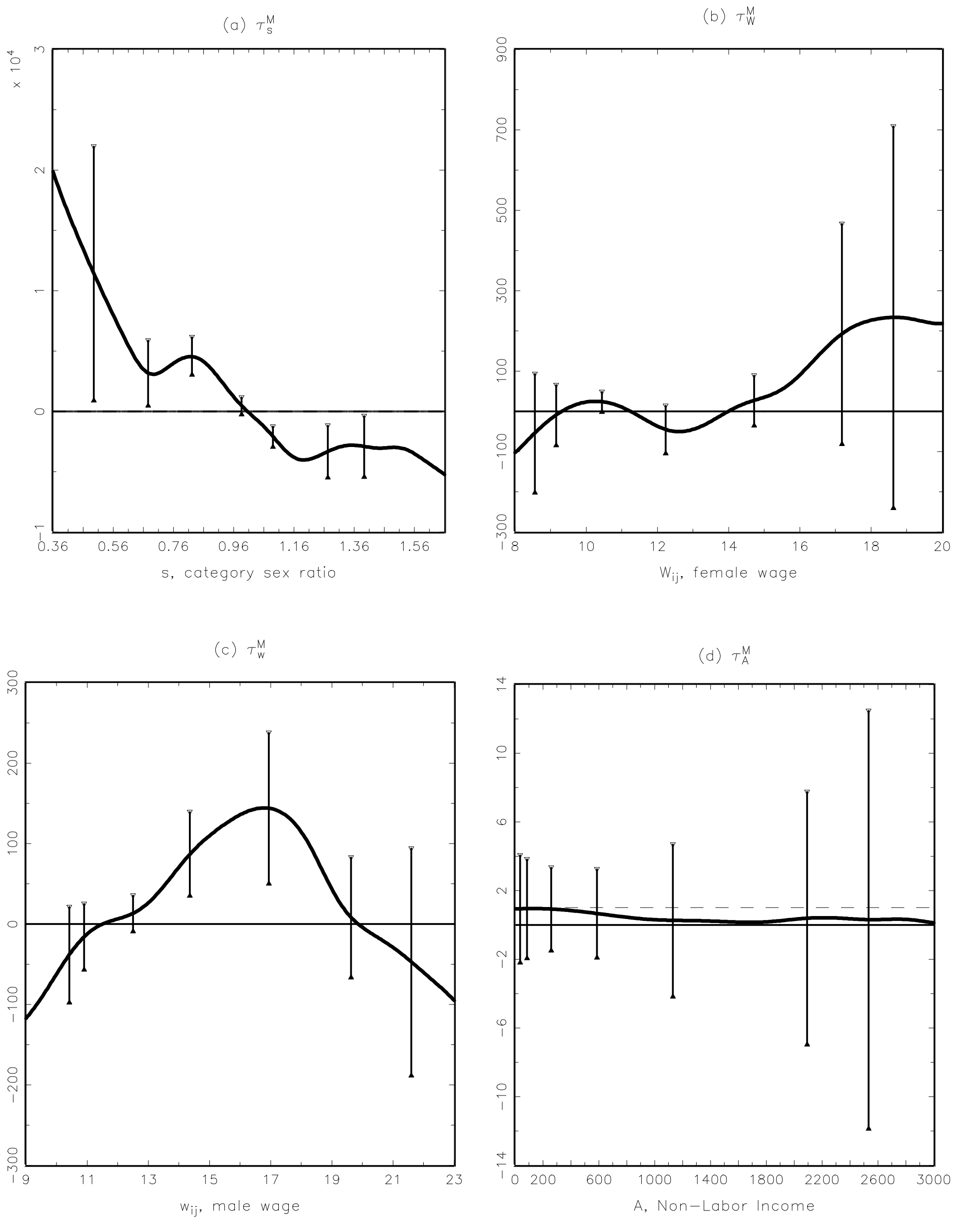
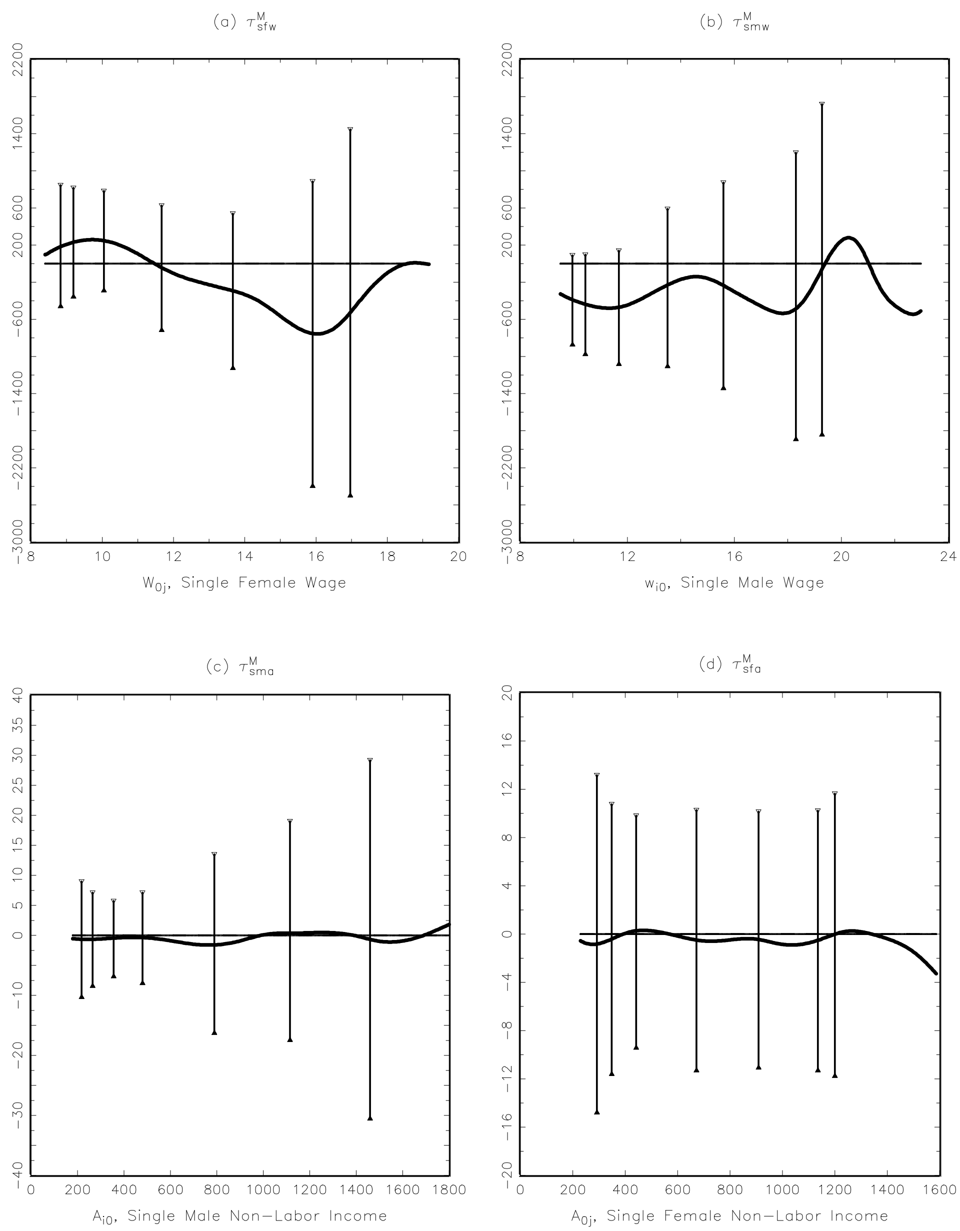


Figure 2: Partial derivative of the sharing rule with respect to the wages and nonlabor incomes for unmarried men and women



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A Identification

A.1 Marriage, non-specialized couples

Denote the probability of choosing to be in a non-specialized marriage $\hat{P}_n$ and the probability of being single $\hat{P}_0$, respectively for women and $\hat{p}_n$ and $\hat{p}_0$ for men. Under the extreme value assumption for we can express the ratio of the choice probabilities for non-specialized marriage relative to remaining single as:

$$\frac{\hat{P}_n}{\hat{P}_0} = \frac{\exp(Q_n[W_n, \tau_n(W_n, w_n, A_n, W_0, w_0, A_0, a_0, \mathbf{R}_n)] + \Gamma_n)}{\exp(Q_0[W_0, A_0] + \Gamma_0)}$$

for women and

$$\frac{\hat{p}_n}{\hat{p}_0} = \frac{\exp(q_n[w_n, A_n - \tau_n(W_n, w_n, A_n, W_0, w_0, A_0, a_0, \mathbf{R}_n)] + \gamma_n)}{\exp(q_0[w_0, a_0] + \gamma_0)}$$

Denote $P_n = \ln \hat{P}_n - \ln \hat{P}_0$ and $p_n = \ln \hat{p}_n - \ln \hat{p}_0$. Differentiating with respect to each argument yields:

$$\begin{aligned}
P_{nA} &= Q_{nY}\tau_{nA} \\
P_{nR_i} &= Q_{nY}\tau_{nR_i}, \qquad R_i \in \mathbf{R}_n \\
P_{nW} &= Q_{nW} + Q_{nY}\tau_{nW} \\
P_{nw} &= Q_{nY}\tau_{nw} \\
P_{nW_0} &= Q_{nY}\tau_{W_0} - Q_{0W_0} \\
P_{nw_0} &= Q_{nY}\tau_{w_0} \\
P_{nA_0} &= Q_{nY}\tau_{A_0} - Q_{0A_0} \\
P_{na_0} &= Q_{nY}\tau_{a_0}
\end{aligned}$$

for women and

$$
\begin{aligned}
p_{nA} &= q_{ny}(1 - \tau_{nA}) \\
p_{nR_i} &= -q_{ny}\tau_{nR_i}, \quad R_i \in \mathbf{R}_n \\
p_{nw} &= q_{nw} - q_{ny}\tau_{nw} \\
p_{nW} &= -q_{ny}\tau_{nW} \\
p_{nW_0} &= -q_{ny}\tau_{W_0} \\
p_{nw_0} &= -q_{ny}\tau_{w_0} - q_{0w_0} \\
p_{nA_0} &= -q_{ny}\tau_{A_0} \\
p_{na_0} &= -q_{ny}\tau_{a_0} - q_{0a_0}
\end{aligned}
$$

A.2 Marriage, specialized couples

Denote the probability of choosing to be in a specialized marriage $\hat{P}_s$ and the probability of being single $\hat{P}_0$, respectively for women and $\hat{p}_s$ and $\hat{p}_0$ for men. Under the extreme value assumption for we can express the ratio of the choice probabilities for specialized marriage relative to remaining single as:

$$\frac{\hat{P}_s}{\hat{P}_0} = \frac{\exp(Q_s[\tau_s(w_s, A_s, W_0, w_0, A_0, a_0, \mathbf{R}_s)] + \Gamma_s)}{\exp(Q_0[W_0, A_0] + \Gamma_0)}$$

for women and

$$\frac{\hat{p}_s}{\hat{p}_0} = \frac{\exp(q_s[w_s, A_s - \tau_s(w_s, A_s, W_0, w_0, A_0, a_0, \mathbf{R}_s)] + \gamma_s)}{\exp(q_0[w_0, a_0] + \gamma_0)}$$

for men. Denote $P_s = \ln \hat{P}_s - \ln \hat{P}_0$ and $p_s = \ln \hat{p}_s - \ln \hat{p}_0$. Differentiating with respect to each argument yields:

$$
\begin{aligned}
P_{sA} &= Q_{sY}\tau_{sA} \\
P_{sR_i} &= Q_{sY}\tau_{sR_i}, \quad R_i \in \mathbf{R}_s \\
P_{sw} &= Q_{sY}\tau_{sw} \\
P_{sW_0} &= Q_{sY}\tau_{W_0} - Q_{0W_0} \\
P_{sw_0} &= Q_{sY}\tau_{w_0} \\
P_{sA_0} &= Q_{sY}\tau_{A_0} - Q_{0A_0} \\
P_{sa_0} &= Q_{sY}\tau_{a_0}
\end{aligned}
$$

for women and

$$
\begin{aligned}
p_{sA} &= q_{sy}(1-\tau_{sA}) \\
p_{sR_i} &= -q_{sy}\tau_{sR_i}, \quad R_i \in \mathbf{R}_s \\
p_{sw} &= q_{sw} - q_{sy}\tau_{sw} \\
p_{sW_0} &= -q_{sy}\tau_{W_0} \\
p_{sw_0} &= -q_{sy}\tau_{w_0} - q_{0w_0} \\
p_{sA_0} &= -q_{sy}\tau_{A_0} \\
p_{sa_0} &= -q_{sy}\tau_{a_0} - q_{0a_0}
\end{aligned}
$$

B First stage estimation

The first stage estimation entails the following four steps:

Step 1: Take the conditional expectation of H_n with respect to the non-parametric part of the model. Let $\mathbf{s}$ denote a vector containing $W, w, A, \mathbf{R}$, where subscripts are eliminated for expositional convenience. Then

$$E[H_n|\mathbf{s}] = E[\mathbf{X}|\mathbf{s}]'\beta_H + H_n(\mathbf{s}) \tag{14}$$

and we difference from the labor supply equation to obtain:

$$H_n - E[H_n|\mathbf{s}] = [\mathbf{X} - E[\mathbf{X}|\mathbf{s}]]'\beta_H + \nu_H. \tag{15}$$

Step 2: Estimate $E[H_n|\mathbf{s}]$ and $E[\mathbf{X}|\mathbf{s}]$ by local linear regression. The local linear estimator of the conditional mean function at $\mathbf{s} = (W, w, A, \mathbf{R})$ is $\hat{\alpha}$ and the derivative at this point is $\hat{\rho}$. The local linear estimator for $E[H_n|\mathbf{s}]$ is:

$$\min_{\alpha,\rho} \sum_i \Big\{ H_{ni} - \alpha - \rho'(\mathbf{S}_i - \mathbf{s}) \Big\}^2 \prod_{h=1}^{4} K\Big(\frac{S_{ih} - s_h}{b_h} \Big) \tag{16}$$

where $K(\cdot)$ is a one-dimensional kernel function, the bandwidth for the i^{th} covariate is b_i and the kernel weight function is a product kernel. From standard weighted least squares theory, the local linear estimator for the conditional mean is

$$\hat{H}_n(\mathbf{s}) = e_1(\mathbf{S}_s'\mathbf{W}_s\mathbf{S}_s)^{-1}\mathbf{S}_s'\mathbf{W}_s\mathbf{H_n} \tag{17}$$

where e_1 is a $5+1$ vector with 1 for the first element and 0 everywhere else, $\mathbf{H_n} = (H_{n1}, H_{n2}, ...H_{nN})'$ where N is the number of observations,

$$\mathbf{W}_s = diag\Big\{ \prod_{i=1}^{4} K\Big(\frac{S_{i1} - s_{i1}}{b_i}\Big) \ \dots \ \prod_{i=1}^{4} K\Big(\frac{S_{iN} - s_{iN}}{b_i}\Big) \Big\} \tag{18}$$

and

$$S_s = \begin{pmatrix} 1 & (\mathbf{S}_1 - \mathbf{s})' \\ \vdots & \vdots \\ 1 & (\mathbf{S}_N - \mathbf{s})' \end{pmatrix} \tag{19}$$

To get an estimate of the derivative of $H_n(\mathbf{S})$ wrt to the $k-$th derivative,

$$\frac{\partial \hat{H_n}(\mathbf{s})}{\partial s_k} = e_{k+1}\big(\mathbf{S}_s'\mathbf{W}_s\mathbf{S}_s\big)^{-1}\mathbf{X}_s'\mathbf{W}_s\mathbf{H}_n \tag{20}$$

Currently the $i-$th covariate bandwidth is set according to a rule of thumb of $c\sigma_i/n^{d+4}$ where σ_i is the standard deviation of the $i-$th covariate and n is the sample size. Refer to Ruppert and Wand (1994) for expressions of the bias and variance on the derivative estimate.

Step 3: Estimate

$$H_n - \hat{E}[H_n|\mathbf{s}] = [\mathbf{X} - \hat{E}[\mathbf{X}|\mathbf{s}]]'\beta_H + \nu_H.$$

using OLS to obtain $\hat{\beta}_H$.

Step 4: We can obtain an estimate of $H_n(W, w, A, \mathbf{R})$ as

$$H_n(W, w, A, \mathbf{R}) = \hat{E}[H_n|\mathbf{s}] - \hat{E}[\mathbf{X}|\mathbf{s}]'\beta_H \tag{21}$$

C Specialized Couples

Labor supply and marriage estimates for specialized couples are presented in Table 11. As was the case for nonspecialized couples, the husband's own wage effect is negative and significant, suggesting the substitution effect is dominated by the income effect and the effect of the husband's wage on the sharing rule. An increase in the wage of single females has a significant negative effect on the husband's labor supply, counter to the predictions of the theory. For the log odds marriage regressions, increases in the sex ratio have the expected negative effect on the log odds of marriage for men. Although the results for specialized couples are quite mixed, it is again the case that the marriage estimates are much more consistent with the theoretical sign predictions than are the labor supply estimates.

Sharing rule estimates from marriage decisions for specialized couples are presented in Column 4 of Table 12. Columns 1 to 3 present the results for nonspecialized couples for comparison purposes. The estimates for specialized couples tend to be quite mixed and in most instances are not consistent with the theory. The only significant estimate is the effect of increases in marital nonlabor income on transfers to wives which is implausibly large: the estimates suggest women receive an additional \$1.93 in transfers as nonlabor income increases by \$1. The remaining estimates are statistically insignificant, likely due to the limited sample size for specialized couples in our data.

Table 11: **Semi-parametric labor supply and marriage estimates for specialized couples**

	Labor Supply	Marriage	
	Husbands	Women	Men
Other income	0.0094	-0.0001	-0.0001
	(0.4246)	(1.1833)	(1.4138)
Sex ratio	328.7304†	-1.3727	-2.5624†
	(0.8566)	(1.0458)	(2.0051)
Husband's wage	-19.0024†	-0.0042	-0.0017
	(2.9254)	(0.2240)	(0.0912)
Single male wage	52.2727	-0.1114†	-0.1171†
	(1.3646)	(0.9162)	(0.9601)
Single male income	0.1437	-0.0004†	-0.0003†
	(0.8176)	(0.8255)	(0.7463)
Single female wage	-64.3665	-0.1083†	-0.0921†
	(1.8400)	(1.0231)	(0.9124)
Single female income	-0.3480	-0.0008†	-0.0008†
	(1.2733)	(0.9885)	(1.0173)
Observations			268

Notes: Absolute value of t-statistic in parentheses. † denotes an estimated sign that is consistent with the theory.

Table 12: **Sharing rule estimates for non-specialized and specialized couples**

	Non-specialized Couples			Specialized Couples
	Labor Supply	Marriage	t-statistic	Marriage
Other income	0.8424†	0.5993†	-0.6106	1.9336
	(3.9943)	(1.7415)		(2.2927)
Sex ratio	-1803.3200	-480.3270	0.5194	-14760.5200
	(1.4320)	(0.2083)		(0.8512)
Husband's wage	70.8551†	96.3306†	0.1914	102.0021†
	(0.8478)	(0.9757)		(0.3947)
Wife's wage	16.8349	-1.9760†	-0.1556	
	(0.2764)	(0.0190)		
Single male wage	-256.4570†	-200.1350†	0.1579	1160.3420
	(1.5111)	(0.6469)		(1.0053)
Single male income	0.0512	-0.0348†	-0.0651	5.2082
	(0.0643)	(0.0329)		(0.7619)
Single female wage	-57.1923	46.9794†	0.4010	-282.6500
	(0.6962)	(0.1992)		(0.3505)
Single female income	0.7133†	0.8993†	0.9192	2.5212†
	(0.9045)	(0.8155)		(0.5173)
Observations	390			268

Notes: Absolute value of t-statistics in parentheses. † denotes an estimated sign that is consistent with the theory.