Are Households Pareto Efficient? A Test Based on Multiple Job Holding

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Abstract

The collective household model requires that household decisions result in Pareto efficient outcomes. While this assumption is falsifiable, these tests are often difficult to implement due to data limitations or insufficient statistical power. We identify a novel setting–multiple job holding–where these issues are less of an obstacle. Using data from Bangladesh, we estimate the leisure demand of households where members are engaged in multiple occupations and use the parameter estimates to test the collective model following Browning and Chiappori (1998). We are unable to reject Pareto efficiency but do find evidence against the unitary model. The results support the use of the collective model as a framework to study the inner workings of the household.

JEL Codes: D1, J12, J22, Q12.

Keywords: collective model, Pareto efficiency, multiple job holding, labor supply.

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1 Introduction

The collective model has become the workhorse framework for analyzing the inner workings of the household (Chiappori, 1988; Apps and Rees, 1988; Chiappori, 1992). The basic version of the model requires only that allocation decisions within the household are Pareto efficient. Importantly, the model is falsifiable; several testable predictions arise solely from assuming Pareto efficiency (Browning and Chiappori, 1998). Despite the existence of these tests (which we discuss shortly), in practice, they are often difficult to implement due to data limitations or insufficient statistical power (Browning et al., 2014; Dauphin et al., 2018). In this paper, we overcome these limitations and provide a novel setting to test collective rationality.

There are two main methods for testing the collective model. The first, and more common type of test, relies on *distribution factors*, which are variables that do not affect preferences or the household budget constraint, but do affect the allocation of resources.[1] The general idea behind these tests is that distribution factors can only enter the model in a limited way, which then imposes restrictions on how consumption and labor supply respond to variation in these variables. Specifically, distribution factors cannot have an effect on the set of feasible Pareto efficient allocations, but rather only the location of the final allocation on the Pareto frontier. A growing body of research has employed distribution factors to test collective rationality, and the results are largely positive as the model is rarely rejected. Nonetheless, Dauphin et al. (2018) have noted the potential weakness of these tests. The central problem relates to finding satisfactory distribution factors; they have to simultaneously be important enough to the household's decision-making process to affect demand, but also must be valid distribution factors (i.e., excluded from individual preferences and the budget constraint).[2] This data challenge is one we wish to avoid.

We focus our analysis on the second, less commonly used test of collective rationality pertaining to the Slutsky matrix (Browning and Chiappori, 1998). The collective model requires that this matrix be the sum of a symmetric, negative semidefinite matrix, and an additional matrix of rank one (i.e., the *SR1 property*). The central obstacle to this test is that it requires price variation and at least five consumption goods.[3] These two data requirements are often overly burdensome. The challenge when using consumption data is having enough price variation, which rules out the use of cross-sectional data. With labor supply, the (to this point) insurmountable obstacle is having five goods. Nonetheless, there is a considerable amount of price variation in wages, even with only cross-sectional data, which makes it attractive to use in testing collective rationality.

[1]Examples of distribution factors include transfers targeted a specific household member, sex ratios, or divorce laws that favor a particular spouse. See Chiappori et al. (2002) and Attanasio and Lechene (2014), for example.

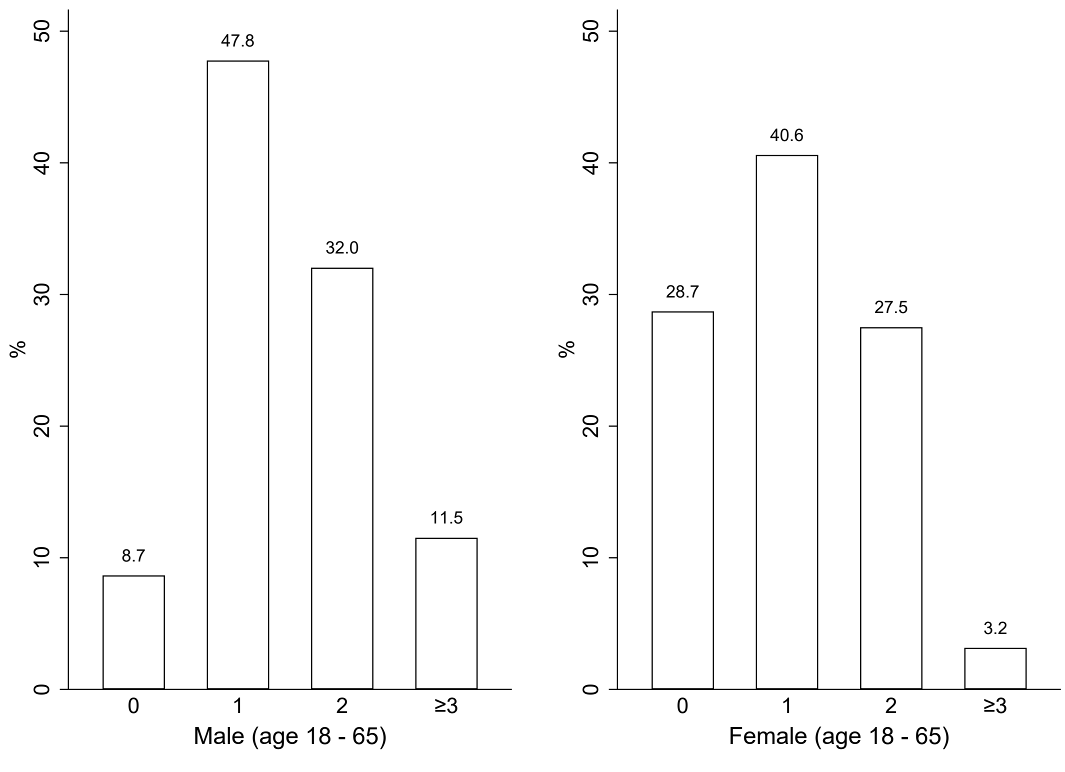
[2]Many empirical tests of the collective model based on distribution factors do not satisfy the underlying theoretical restrictions provided by Bourguignon et al. (2009) and Dauphin et al. (2018). Specifically, if there are two valid distribution factors, each household demand has to either respond to both distribution factors or none of them. This requirement is especially burdensome when the tests are based on disaggregated demand systems.

[3]For N decision-maker households, $2(N-1)$ goods are required to test the collective model using price variation.

Our main innovation is to identify a labor supply setting where there are five goods: multiple job holding. We model individual labor supply decisions similar to Choe et al. (2018). Individuals may work multiple jobs at different wages. Thus, in a couple where each spouse is employed in two occupations, there will be five goods: two quantities of hours worked for each spouse, and a composite consumption good. This setting allows us to avoid the pitfalls of existing tests, as we do not need to identify valid distribution factors. Moreover, the labor supply setting has significant cross-sectional variation in prices.

The downside of our tests is that they are limited to a select population, since we must restrict the sample to couples where both spouses are employed in at least two occupations. In high-income countries, this is a constraining restriction. For example, in the United States, only 7.8 percent of employed individuals worked in multiple jobs (Bailey and Spletzer, 2021). However, multiple job holding is widespread in low-income countries where self-employment is common. As a result, we conduct our tests in rural Bangladesh where around 43% percent of men and 31% of women are employed in multiple occupations (see Figure 1 below). The need to focus on multiple job holders make the scope of our analysis somewhat limited. Nonetheless, having a robust test for a small population complements (arguably) less robust tests that can be conducted more broadly.

Figure 1: Multiple Job Holding in Bangladesh



Notes: Bangladesh Integrated Household Survey (2011/12, 2015, 2018/19). Number of jobs held for all adults aged 18-65.

Our analysis uses three waves of the Bangladesh Integrated Household Survey. This survey was conducted by the International Food Policy Research Institute (IFPRI) and was designed to study issues pertaining to inequality within the household, and thus has been employed by several papers to study questions related to the collective household framework (Brown et al., 2021; Lechene et al., 2022; Lewbel and Pendakur, 2022). We estimate the model using the Quadratic Almost Ideal Demand System of Banks et al. (1997). The results do not provide evidence against the collective model as we fail to reject the *SR1* property. We do find evidence against the unitary model, which assumes that the household behaves as a single unit. The results are robust to accounting for endogeneity in wages and selection.

Our study has several contributions. First, we provide a new setting to test the collective model using multiple job holders. We, therefore, add to work that has tested the *SR1* property (Browning and Chiappori, 1998; Kapan, 2009; Dauphin et al., 2011). Second, we add to research on multiple job holding, which is becoming increasingly important as alternative forms of work become more common (Katz and Krueger, 2019). Finally, with our empirical application in rural Bangladesh, we contribute to the literature regarding modeling household decisions in developing countries. The collective model is increasingly used to understand intra-household inequality and poverty in these contexts (Dunbar et al., 2013; Calvi, 2020; Bargain et al., 2022; Lechene et al., 2022). Tests of the collective model are thus essential, especially since the Pareto efficiency assumption has often been rejected in developing-country households (Udry, 1996; Dercon and Krishnan, 2000; Duflo and Udry, 2004; Robinson, 2012).

The rest of the paper is organized as follows. In Section 2 we provide an overview of the literature. In Section 3 we discuss the collective model and how it can be tested. We then discuss the application of the test and provide the results in Section 4. Section 5 concludes.

2 Literature Review

This study contributes to two separate strands of research. First, we contribute to work that tests the collective model of the household. Second, we study multiple job holding in a developing-country context.

A large literature has conducted tests that provide evidence against the unitary model rather than evidence in support of the collective model. These tests are conducted by either demonstrating that distribution factors affect household choice variables (which would not be the case if the unitary model held), or they show that the Slutsky matrix is not symmetric.[4] Of more interest to this paper are tests on the restrictions of the collective model rather than those of the unitary alternative. Again, one can delineate between tests involving distribution factors from those that examine the form of the Slutsky matrix.[5] We discuss the theory behind these tests in more detail in Section 3, and focus here instead on summarizing applications of these tests and their results.

There are several ways in which distribution factors can be used to test the collective model. The first way involves the *proportionality property*, which requires that the ratio of the marginal effects of the distribution factors on demand must be proportional across all goods (Browning and Chiappori, 1998; Bourguignon et al., 2009). The idea behind this test is that the Pareto weights can affect demand in only

[4]See Browning et al. (2014) for a summary of tests of the unitary model, particularly those that test the income pooling hypothesis.

[5]An alternative strand of research uses revealed preference methods to study household behavior. Studies in this literature that have tested the collective model include Cherchye et al. (2007) and Cherchye et al. (2011).

a one-dimensional way, which restricts demand responses to variation in the distribution factors.[6] This test has been employed notably by Bourguignon et al. (1993) and Chiappori et al. (2002), and the results in each study fail to reject the collective model. In Bangladesh, both Bargain et al. (2022) and Brown et al. (2021) conduct the proportinality test and also find evidence in support of the collective model. Importantly, we use the same data as Brown et al. (2021), though we use different sample restrictions so our results are not directly comparable.[7]

An alternative approach that also relies on distribution factors is the *z-conditional demand* test. The theoretical basis for this test again relies on the idea that distribution factors can only affect demand in a one dimensional way. The demand for a particular good, once conditioning on the demand for a single other good and the substituting out a particular distribution factor, is independent of all other distribution factors (Bourguignon et al., 2009). Applications of this test include Bobonis (2009) and Attanasio and Lechene (2014). Both studies use the random assignment of a cash transfer program in Mexico (PROGRESA) that was provided to women as a distribution factor. Bobonis (2009) additionally uses rainfall shocks, while Attanasio and Lechene (2014) uses family network size. The results of both studies support the collective model.[8] However, recent work by Dauphin et al. (2018) has cast doubt on these results as their tests do not satisfy the *all or nothing* condition, which requires that each demand function needs to be affected by all or none of the distribution factors. Indeed, this condition is rarely satisfied in previous tests based on the distribution factors.

Our study is more related to research that has examined the $SR1$ condition. To our knowledge, the only studies to have employed this test are Browning and Chiappori (1998), Kapan (2009), and Dauphin et al. (2011). Browning and Chiappori (1998) use seven waves of the Canadian Family Expenditure Survey to estimate the model and test the $SR1$ condition. They find that the price responses are consistent with the collective model as the $SR1$ condition is not rejected. Canada provides an ideal setting for their analysis because there is both inter-temporal and spatial variation in prices. Dauphin et al. (2011) provide a similar test in the United Kingdom using twelve waves of UK Family Expenditure Survey, and fail to reject the collective model. Both of these studies rely on long panel datasets for price variation. This data requirement is especially burdensome for developing countries where household datasets are in general collected less frequently and span shorter time periods. Again, this highlights the need to identify a setting with cross-sectional price variation as we do in our analysis. Interestingly, Kapan (2009) relies only a single year to provide a test of the $SR1$ condition in Turkey. However, he uses twelve waves of monthly household expenditure data during a year in which a financial crisis resulted in substantial

[6] We focus here on tests of collective rationality. Distribution factors, however, can also me used to test the number of decision makers in the household (Dauphin and Fortin, 2001; Dauphin et al., 2011).

[7] Recent work by Lewbel and Pendakur (2022), also in Bangladesh, does not explicitly test the collective model, but rather allows for inefficiency and finds that certain types of households are, in fact, efficient. Their model imposes conditional efficiency, in the sense that the households may choose an inefficient consumption technology function, but conditional on that choice, are inefficient.

[8] Angelucci and Garlick (2016) and De Rock et al. (2022) test the collective model using similar methods focusing on the same conditional cash transfer program. Angelucci and Garlick (2016) find that only a set of households (older couples) are efficient, while others (younger couples) are not. De Rock et al. (2022) shows that household decisions are compatible with the collective model at the beginning of the program, but not later on.

inflation, generating enough price variation.

Our study also relates to work on multiple job holding. Seminal work by Shishko and Rostker (1976) incorporates multiple job holding into a standard labor supply model. Subsequent theoretical and empirical contributions include Paxson and Sicherman (1996), who add a dynamic element to the model, and Choe et al. (2018) who focus on hours constraints. Other empirical work in this area has identified several reasons for multiple job holding, including financial pressure (Wu et al., 2009), hour constraints in the main job (Conway and Kimmel, 1998; Choe et al., 2018), job mobility (Paxson and Sicherman, 1996), self-insurance (or income diversification) (Guariglia and Kim, 2004), or a preference for heterogeneous work (Wu et al., 2009). Finally, Krishnan (1990) studies the intra-household aspects of multiple job holding by modeling the husband's decision to moonlight jointly with the wife's decision to work.

Research on multiple job holding in low-income countries typically focus on the decisions of rural farming households to supply off-farm labor (Reardon, 1997; Barrett et al., 2001). In rural Bangladesh, the most common occupations are in agriculture (see Table A3) and multiple job holding decisions are more likely to be consistent with the income diversification motive. Given our context, many of the issues studied in relation to multiple job holding in high-income countries (e.g., hour constraints in wage employment) are less relevant.

3 Model

We set out a collective model following Browning and Chiappori (1998) and Chiappori and Ekeland (2006). The key modification of the model is that we incorporate multiple job holding into the household's problem. Our goal is to derive the pseudo-Slutsky matrix resulting from the household's problem, as that will generate restrictions on household behavior that we will test in Section 4.

We model nuclear households that consist of N household members, indexed by $i = 1, ..., N$. There may be children present, but we assume that they have no say in household decisions.[9] Let $\mathbf{c_i}$ denote the vector of private consumption of member i, with $\mathbf{c} = (\mathbf{c_1}, \dots, \mathbf{c_N})$. Let $\tilde{\mathbf{c}}$ denote the vector of public consumption of the household.[10] The price vectors associated with the private and public goods are given by $\mathbf{p}$ and $\tilde{\mathbf{p}}$, respectively. Each member can be employed in multiple jobs. The labor supply of individual i in job k is given by h_{ik} for $k = 1, \dots, K$, and $\mathbf{h_i} = (h_{i1}, \dots, h_{iK})$. So, for example if the individual has a single job, then $h_{ik'} = 0$ for $k' > 1$. The wage rate of person i at job k is given by w_{ik}, and $\mathbf{w_i} = (w_{i1}, \dots, w_{iK})$. Let T_{ik} be the maximum possible hours i can work at job k. Then, $l_{ik} = T_{ik} - h_{ik}$ is the part of i's leisure generated by not working the full potential hours at job k, with $\mathbf{l_i} = (l_{i1}, \dots, l_{iK})$.[11] Therefore the price of leisure l_{ik} is w_{ik}. Each individual has preferences over the private consumption and leisure of all members,

[9] In line with the legal framework regarding the employment of children, in the empirical application we select households with children below 12 as they are not allowed to work legally while those children aged 12 and above can. See subsection 4.2 for details.

[10] Consumption of any commodity can be partly private and partly public as in Browning et al. (2013).

[11] This is similar to the multiple job holding model by Choe et al. (2018). Each T_{ik} in their model correspond to a boundary parameter of the Stone-Geary utility function of individual i.

as well as the household public consumption. This allows for altruism, as well as externalities or any other preference interaction. Let $\mathbf{l} = (\mathbf{l_1}, \ldots, \mathbf{l_N})$ and $\mathbf{c} = (\mathbf{c_1}, \ldots, \mathbf{c_N})$. The utility function of member i is given by $U_i(\mathbf{l}, \mathbf{c}, \tilde{\mathbf{c}})$, which is assumed to be strictly increasing in $\mathbf{l_i}$ and $\mathbf{c_i}$, strongly concave and twice differentiable in all arguments.[12] Denote the vector of all prices household members face by $\pi = (\mathbf{p}, \tilde{\mathbf{p}}, \mathbf{w_1}, \ldots \mathbf{w_N})$. Finally, let y denote the household's non-labor income.

Under Pareto efficiency, the household maximizes a weighted sum of individual utilities,

$$\max_{\mathbf{l_1},\ldots\mathbf{l_N},\mathbf{c_1},\ldots\mathbf{c_N},\tilde{\mathbf{c}}} \sum_{i=1}^{N} \lambda_i(\pi, y, \mathbf{z}) U_i(\mathbf{l}, \mathbf{c}, \tilde{\mathbf{c}})$$

where $\lambda_i \geq 0$ is the Pareto weight for household member i, which is a function of prices, non-labor income, and distribution factors $\mathbf{z}$. We normalize the Pareto weights so that $\sum_{i=1}^{N} \lambda_i = 1$. The household solves the above problem subject to a budget constraint:

$$\sum_{i=1}^{N} (\mathbf{p}'\mathbf{c_i} + \mathbf{w_i'}\mathbf{l_i}) + \tilde{\mathbf{p}}'\tilde{\mathbf{c}} = \sum_{i=1}^{N} \mathbf{w_i'}\mathbf{T_i} + y$$

and each spouse's time constraint for each occupation:

$$l_{ik} = T_{ik} - h_{ik} \text{ for } k = 1, \ldots, K \text{ and } n = 1, \ldots, N.$$

The resulting bundle of labor supplies and consumption will be Pareto efficient by assumption.

Let $\mathbf{f}(\pi, y, \lambda(\pi, y, z))$ denote the vector of Marshallian demand functions (or labor supplies) resulting from the household's problem. Each demand depends on prices, wage rates, the household's non-labor income, and the Pareto weights. Moreover, the Pareto frontier is determined by prices, wages, and non-labor income, and the Pareto weights determine where on the Pareto frontier the optimal demands are located.

Let $\eta(\pi, u, \lambda)$ denote the vector of Hicksian demand functions resulting from the household's dual problem. Similar to the Marshallian demands, η is a function of the Pareto weights which will have implications for the structure of the Slutsky matrix. Using standard duality results, we have that,

$$\mathbf{f}(\pi, E(\pi, u), \lambda) = \eta(\pi, u, \lambda)$$

where $E(\pi, u)$ is the non-labor income necessary to reach utility u. Differentiating with respect to any price in π results in the canonical Slutsky equation:

$$\frac{\partial f_j}{\partial \pi_{j'}} + \frac{\partial f_j}{\partial y} f_{j'} = \frac{\partial \eta_j}{\partial \pi_{j'}},$$

[12] $U_i(\mathbf{l}, \mathbf{c}, \tilde{\mathbf{c}})$ is not necessarily increasing in $\mathbf{l_j}$ or $\mathbf{c_j}$ for $j \neq i$, and thus, selfishness or negative consumption externalities may exist between household members.

or in matrix notation,

$$\mathbf{f}_\pi + \mathbf{f}_y \mathbf{f}' = \eta_\pi.$$

The above relationship holds when both utility *and the Pareto weights* are fixed, which corresponds to the standard unitary case. In the collective setting, the Pareto weights vary with prices. Therefore, this usual Slutsky equation does not hold.

Note that the vector of structural demand functions $\mathbf{f}(\pi, y, \lambda(\pi, y, z))$, which shows the independent variations of household demand with prices, non-labor income, and Pareto weights, is not observable as we cannot observe the Pareto weights. What we can observe is the changes in demand with prices, non-labor income, and distribution factors. Therefore, the vector of observable demand functions given by $\xi(\pi, y, z)$ is defined as:

$$\xi(\pi, y, z) = \mathbf{f}(\pi, y, \lambda(\pi, y, z)). \tag{1}$$

Following Browning and Chiappori (1998), we define the pseudo-Slutsky matrix S for the observable demands as

$$S(\pi, y, \mathbf{z}) = \xi_\pi + \xi_{\mathbf{y}} \xi' \tag{2}$$

where ξ_π is the Jacobian matrix of partial derivatives of ξ with respect to π, and $\xi_{\mathbf{y}}$ is a vector of partial derivatives of ξ with respect to y. Then using Equation (1) and rearranging, we can write the pseudo-Slutsky matrix as,

$$\begin{aligned} S(\pi, y, \mathbf{z}) &= \xi_\pi + \xi_{\mathbf{y}} \xi' \\ &= \mathbf{f}_\pi + \mathbf{f}_\lambda \lambda'_\pi + (\mathbf{f}_y + \mathbf{f}_\lambda \lambda_y)\mathbf{f}' \\ &= \mathbf{f}_\pi + \mathbf{f}_y \mathbf{f}' + \mathbf{f}_\lambda (\lambda'_\pi + \lambda_y \mathbf{f})' \\ &= \Sigma(\pi, y, \mathbf{z}) + R(\pi, y, \mathbf{z}), \end{aligned}$$

where $\Sigma(\pi, y, \mathbf{z}) = \mathbf{f}_\pi + \mathbf{f}_y \mathbf{f}'$ is a symmetric, negative definite matrix and $R(\pi, y, \mathbf{z}) = \mathbf{f}_\lambda (\lambda'_\pi + \lambda_y \mathbf{f})'$ is a matrix of rank no more than $N-1$. In words, when the price of good j changes, its effect on the demand for good j' can be decomposed into two effects: First, holding utility and the Pareto weights constant, there will be a reallocation of consumption given by Σ. Second, and specific to the collective model, the price change will induce a change in the Pareto weights, which comprise R.

The matrix $R(\pi, y, \mathbf{z})$ being at most rank $N-1$ has important implications for the tests we conduct. The reason behind this restriction is that any effect of prices on the Pareto weights will be at most $N-1$ dimensional as there are $N-1$ free Pareto weights. With two decision-makers there is a single Pareto weight, and thus a one-dimensional movement along the Pareto frontier when prices change. In this case, the pseudo-Slutksy matrix is a sum of a symmetric, negative definite matrix, and an additional matrix of rank one (the $SR1$ property). Any price change will first induce a change in the Pareto frontier. This change is given by the Slutsky matrix Σ. Second, the price change will then result in a movement along the new Pareto frontier. This change is given by the matrix R. Therefore, the rank of R is informative about the decision-making process in the household. If $rank(R) = 0$, then the pseudo-Slutsky matrix $S(\pi, y, \mathbf{z})$ is symmetric and negative definite, which means that the household decisions are compatible with the unitary model. If, on the other hand, $rank(R) = n$, for $n \neq 0$, then the household behavior is compatible with the collective model with $n+1$ decision-makers (with non-zero Pareto weights).

While the rank of $R(\pi, y, \mathbf{z})$ is informative about the decision-making process in the household, the matrix R is unobservable as we cannot observe the changes in the vector of Pareto weights as a result of price changes. Instead, we observe $S(\pi, y, \mathbf{z})$. Following Browning and Chiappori (1998) we define a matrix,

$$M(\pi, y, \mathbf{z}) = S(\pi, y, \mathbf{z}) - S(\pi, y, \mathbf{z})', \tag{3}$$

which is observable, with rank at most $2(N-1)$. Note that $M(\pi, y, \mathbf{z})$ is anti-symmetric, therefore its rank has to be even.[13] Our empirical test of the collective model using price variations is based on this matrix, $M(\pi, y, \mathbf{z})$. If its rank is zero, i.e., $S(\pi, y, \mathbf{z})$ is symmetric, we cannot reject the unitary model. In the case of a collective model with two decision-makers, the $rank(M)$ can be at most 2. Therefore, for 2-member households, if we reject both cases, i.e., $rank(M) = 0$ and $rank(M) = 2$, then we reject the collective rationality. Thus, the validity of the collective model will be based on determining the rank of the matrix M. We provide more details regarding the implementation of this test in the following section.

4 Analysis

4.1 Estimation

In the empirical application, we restrict our attention to households with a husband (m) and wife (f) (i.e., $N = 2$), where each spouse works in two occupations (i.e., $K = 2$).[14,15] Next, we use a single Hicksian composite good, C, with its price normalized to one as opposed to the full vector of individual consumption goods. Then the vector of prices faced by the household will contain five elements: $\pi = (w_{m1}, w_{m2}, w_{f1}, w_{f2}, 1)$, where, e.g., w_{m2} denotes the husband's wage in his second job.

The multiple job holding setting is not standard for a demand system estimation. As a result, we provide additional details regarding how we implement the estimation and conduct the test of the $SR1$ property. We first describe how we construct budget shares. We then describe the demand system that we use in the estimation. Finally, we describe how we test the rank of the matrix described in Equation (3).

Budget Share Construction We have five goods (and therefore five budget shares) in our empirical

[13] A matrix is anti-symmetric if $M' = -M$.

[14] Multiple job holding is not common among children, even for those who can be legally employed.

[15] We allow adults to work in more than two occupations. See subsection 4.2 for details.

application: two leisure goods for each spouse (one for each job), and a composite consumption good. The prices of the leisure goods are the wages for the corresponding job. We normalize the price of the composite good to one. Total expenditure (the denominator for the budget shares) is then determined by these wages, as well as the time endowments in each occupation and household non-labor income.

The household's budget constraint is given by:

$$C + w_{m1} l_{m1} + w_{m2} l_{m2} + w_{f1} l_{f1} + w_{f2} l_{f2} = \underbrace{w_{m1} T_{m1} + w_{m2} T_{m2} + w_{f1} T_{f1} + w_{f2} T_{f2} + y}_{\text{Total Expenditure}} \tag{4}$$

where $l_{ik} = T_{ik} - h_{ik}$ for $i = m, f$ and $k = 1, 2$. Similar to Choe et al. (2018), we calculate T_{ik} as the maximum weekly hours of worked observed in our sample for individual type $i = m, f$ in job $k = 1, 2$ plus 1. We compute non-labor income as the difference between total household consumption and wage income. This expenditure-based approach to calculate non-labor income reduces measurement error (Blundell et al., 2007; Lise and Seitz, 2011).[16]

We can then construct the following budget shares:

$$\omega_1 = \frac{w_{m1} l_{m1}}{g}, \quad \omega_2 = \frac{w_{m2} l_{m2}}{g}, \quad \omega_3 = \frac{w_{f1} l_{f1}}{g}, \quad \omega_4 = \frac{w_{f2} l_{f2}}{g}, \quad \omega_5 = \frac{C}{g},$$

where total expenditure is defined as the right-hand side of Equation (4), with $g = w_{m1} T_{m1} + w_{m2} T_{m2} + w_{f1} T_{f1} + w_{f2} T_{f2} + y$.

Demand System We assume individuals have indirect utility functions given by the Quadratic Almost Ideal Demand System (QUAIDS) of Banks et al. (1997).[17] Let ω and π be the vector of budget shares and log prices (or wages) respectively. The system of demand functions is then given by,

$$\omega = \alpha + \boldsymbol{\Gamma}\pi + \beta[\ln g - a(\pi)] + \zeta \frac{[\ln g - a(\pi)]^2}{b(\pi)} + \epsilon, \tag{5}$$

where

$$a(\pi) = \alpha_0 + \alpha'\pi + \frac{1}{2}\pi'\boldsymbol{\Gamma}\pi, \quad b(\pi) = \exp(\beta'\pi). \tag{6}$$

To impose the adding up constraint, we omit the Hicksian consumption good from the estimation. Homogeneity is imposed as the price of the Hickisan consumption good is normalized to one. Thus, ω and π are 4×1 vectors of the budget shares and log wages respectively and $\boldsymbol{\Gamma}$ is a 4×4 matrix of parameters. Similar to previous studies (Banks et al., 1997; Cherchye et al., 2015), we model the parameter α as a linear function of observed household characteristics (preference factors). We then estimate the non-linear system provided in Equation (5) by iterative feasible generalized least squares, allowing errors to be

[16] Savings are minimal in rural Bangladesh, and are therefore ignored.

[17] The indirect utility function takes the following form: $V(\pi, g) = \left(\frac{b(\pi)}{\ln g - a(\pi)} - \zeta(\pi)\right)^{-1}$ where $\zeta(\pi) = \sum_{j=1}^{k} \zeta_i \pi_i$ and $\sum_{j=1}^{k} \zeta_i = 0$.

correlated across equations (seemingly unrelated regression model). This is equivalent to estimating the system by maximum likelihood. This specification assumes that wages are exogenous, which is standard in the literature. As an auxiliary analysis, we instrument wages with leave-one-out wage instruments to address a potential endogeneity due to measurement error or non-standard employment. Specifically, we use second degree polynomial, village-level, leave-one-out average wage and estimate the system by generalized method of moments (GMM).

The pseudo-Slutsky matrix given in Equation (2) can be written in budget share form as,

$$S = \omega_\pi + \omega_g \omega'$$

where ω_π is the Jacobian matrix of partial derivatives of the budget shares with respect to log wages, and ω_g is the gradient of the budget shares with respect to $\ln g$. From Equation (5), the pseudo-Slutsky matrix is then,

$$S = \Gamma - (\beta + 2\frac{\tilde{g}}{b(\pi)}\zeta)\pi'(\Gamma - \Gamma') + \tilde{g}(\beta\beta' + \frac{\tilde{g}}{b(\pi)}(\zeta\beta' + \beta\zeta') + 2\Big(\frac{\tilde{g}}{b(\pi)}\Big)^2\zeta\zeta') \tag{7}$$

where $\tilde{g} = \ln g - a(\pi)$. As demonstrated in Browning and Chiappori (1998), a particular convenience for QUAIDS is that testing the rank of $M = S - S'$ is equivalent to testing the rank of $\Gamma - \Gamma'$. Therefore, we implement our rank tests for the matrix $\Gamma - \Gamma'$.

Rank Test Recall that the restriction imposed by the collective model is that the rank of the anti-symmetric matrix $M = S - S'$ is at most two for two-member households. Therefore, there are two cases to consider. If $rank(M) \equiv rank(\Gamma - \Gamma') = 0$, then we cannot rule out the unitary model. Note that this case corresponds to testing whether the matrix Γ is symmetric, which is testing the equality of $4(4-1)/2 = 6$ linear constraints. If instead the rank of M were two, then we conclude that the collective model is not rejected. Following Browning and Chiappori (1998), we test the case $rank(M) \equiv rank(\Gamma - \Gamma') = 2$ as follows. Assume without loss of generality that $m_{12} \neq 0$. Then M has rank 2 if and only if,

$$m_{34} = \frac{m_{13}m_{24} - m_{14}m_{23}}{m_{12}} \tag{8}$$

where m_{ik} is the ik^{th} element of M. We use Wald test to test the symmetry of Γ and the non-linear equality given by Equation (8). The rejection of both the symmetry of Γ and the Equation (8) implies the rejection of the collective rationality.

4.2 Data

We use data from three waves of the Bangladesh Integrated Household Survey (BIHS) which were conducted in 2011/12, 2015, and 2018/19. The survey was designed to analyze intra-household dynamics and thus has been previously used to study nutrional inequality (D'Souza and Tandon, 2019), consumption inequality (Brown et al., 2021; Botosaru et al., 2021; Lechene et al., 2022), consumption inefficiency (Lewbel and Pendakur, 2022), and economics of scale in consumption (Calvi et al., 2021).

We rely primarily on the labor supply and expenditure modules in our analysis. The labor supply module includes information on the activities of all individuals in the household over the previous week. This data includes the type of occupation, hours worked in that occupation, and the income (both cash and in-kind) for each activity. We calculate hourly wages by dividing income to hours worked in each occupation. When income is missing, we rely on occupation-specific village-level averages.[18] An important feature of employment in Bangladesh is the prevalence of multiple job holding. More than 43% of men and more than 30% of women are engaged in multiple occupations (see Figure 1). The BIHS provides hours and income information for all occupations of each individual. We distinguish between primary and secondary occupations by whichever job the individual devoted more hours to in the previous week. Since some indiviudals work more than two occupations, we pool hours worked in jobs two and higher into a single occupation. Wages for this job are then a weighted average of the wages in each individual occupation, where the weights are the hours worked.[19] The most common occupations are in agriculture (see Table A3).

We infer non-labor income using the labor supply data in conjunction with the expenditure module. The expenditure module includes weekly expenditures on individual food items, monthly expenditures on non-durable goods, and a yearly recall of semi-durable consumption goods. We compute non-labor income as the difference between expenditure and labor income of the household.

As previously discussed, our tests apply to only a subset of households. We limit our sample to households with two married adults with children 12 or older. This age cutoff is imposed as children younger than 12 rarely work, and also due to the legal framework about the employment of children in Bangladesh.[20] As children aged 12 and above can legally work, they might have bargaining power within the household. This would then require us to model children as decision-makers with non-zero Pareto weights.[21] We then drop couples where either spouse works fewer than two jobs. As previously discussed, this would be a limiting restriction in a developed country, but less so in Bangladesh where work in multiple activities is common. To analyze how different our sample is from those households

[18] If the wage information for an activity is not available in a village, we use increasingly larger clusters, i.e., village, upazila and district.

[19] Under this categorization of jobs (primary vs. secondary) that is based on working hours, the wage rate in the secondary job can be higher than in the primary job.

[20] The principles regarding children's employment in Bangladesh are laid down by the Bangladesh Labour Act 2006, and the amendment in 2013. In line with the Minimum Age Convention of the International Labour Organization (ILO, C138), children aged 12 and above can be employed in non-hazardous, light work up to 42 hours a week. Also, note that we observe very few employed children below age 12 in the BIHS, and a noticeable increase in employment rate at age 12.

[21] This restriction on the household composition is common in the collective labor supply literature. See Sözbir (2022) for further discussions.

that are not included due to multiple job holding restriction, we conduct a mean difference test based on six household characteristics. The results are given in Table A4 in the appendix. We do not find any significant difference between these two groups of households in terms of household expenditure and the ages of spouses. The differences in the number of children and education of spouses are significant but not sizable. Nonetheless, we address this selection issue further using a Heckman selection specification which we discuss in 4.3. Finally, we omit any household with missing data for any variable given in Table 1. This results in a sample of 1,111 households.

Table 1: Descriptive Statistics

	Mean	**Median**	**Std. Dev.**
Husband:			
Primary Wage	38.58	30.28	31.90
Secondary Wage	56.36	37.27	64.49
Primary Hours	37.79	36.00	17.01
Secondary Hours	12.91	11.00	8.82
Wife:			
Primary Wage	27.04	16.67	30.36
Secondary Wage	16.06	8.33	20.78
Primary Hours	11.48	7.00	8.28
Secondary Hours	6.17	7.00	3.51
Preference factors:			
Age of Husband	40.84	37.00	12.27
Number of Children	1.50	1.00	1.04
$\mathbb{1}$(Dhaka)	0.29	0.00	0.46
Household:			
Weekly Consumption	2,472.99	2,177.69	1,307.85
Weekly Total Expenditure	7,667.72	6,521.38	4,201.20
Observations		1,111	

Note: Bangladesh Integrated Household Survey (2011/12, 2015, 2018/19). The table reports some descriptive statistics of the sample used in estimation. The distinction between the primary and secondary occupation is determined by which activity comprises a larger share of the individual's weekly time. All monetary values are measured in Bangladeshi Takas.

Descriptive statistics are provided in Table 1. Because of our sample restrictions, households are relatively small with 1.5 children on average. Thirty percent of households live in the Dhaka division. Husbands spend more time in market work (38 hours in the primary job and 13 hours in the secondary job per week) than their wives (11 hours in the primary job and 6 hours in the secondary job per week).[22] Moreover, husbands earn a higher wage for both their primary and secondary occupations.

4.3 Results

Table 2 provides the main results. Panel A presents the parameter estimates of the demand system originating from Equation (5). Columns 1 and 2 correspond to the leisure demand equations for the

[22] See figure A1 in the Appendix for the distribution of primary and secondary hours in our sample.

husband's first and second jobs, respectively. Columns 3 and 4 presents the analogous equations for the wife.

Table 2: Estimation Results

Panel A: Demand System	ω_1 (1)	ω_2 (2)	ω_3 (3)	ω_4 (4)
Husband's Primary Wage	11.85	-2.13	-5.07	-1.45
	(1.03)	(0.78)	(0.39)	(0.27)
Husband's Secondary Wage	1.91	8.59	-0.04	-0.82
	(0.83)	(1.00)	(0.53)	(0.24)
Wife's Primary Wage	-5.69	-1.61	8.77	-0.14
	(0.61)	(0.53)	(0.31)	(0.18)
Wife's Secondary Wage	-0.68	0.19	-0.39	2.98
	(0.20)	(0.17)	(0.10)	(0.12)
$\alpha_{intercept}$	-27.82	39.22	-0.69	1.30
	(3.31)	(3.20)	(2.62)	(0.99)
$\alpha_{husband\_age}$	0.07	0.01	-0.01	-0.01
	(0.02)	(0.02)	(0.02)	(0.01)
$\alpha_{children}$	-1.79	-0.41	-0.12	0.01
	(0.28)	(0.23)	(0.23)	(0.09)
α_{Dhaka}	-1.08	-0.42	0.50	0.29
	(0.54)	(0.54)	(0.43)	(0.19)
β	11.84	-18.40	5.13	0.16
	(1.86)	(0.95)	(1.10)	(0.42)
λ	-0.74	1.27	-0.26	-0.07
	(0.17)	(0.15)	(0.07)	(0.02)

Panel B: Rank Tests	Rank = 0	Rank = 2
χ^2	42.56	1.72
$p-value$	(0.00)	(0.19)

Note: Bangladesh Integrated Household Survey (2011/12, 2015, 2018/19). Panel A shows the coefficient estimates and standard errors (in parentheses) of the demand system; all values are multiplied by 100. Panel B shows the rank test results.

The results show that the slope of the Engel curves (β) are positive for leisure demand associated with primary jobs, and negative for husband's leisure associated with his secondary job. The parameter estimates for the quadratic term (λ) are significant for all budget shares. This supports our choice of QUAIDS. Considering the estimates for wage/price terms (the matrix Γ); own wage rates increases leisure consumption of both spouses, in their primary and secondary jobs. An increase in husband's primary wage decreases the budget shares for wife's leisure. Similarly, wife's primary wage rate has a negative impact on husband's leisure demand. The impact of secondary wages on the leisure demand of the other spouse are not always significant. Husband's secondary wage decreases the leisure demand associated with wife's secondary job; the leisure demand associated with husband's primary job decreases with wife's wage rate in her secondary job.

We use three preference factors, husband's age, number of children, and an indicator for Dhaka division in our estimation. These demographic controls affect the system in a non-linear way through the parameter α. The results show that leisure demand of the husband tends to increase with his age, while wife's leisure demand decreases. However, except for the first budget share, these estimates are not significant. Number of children has a significant negative effect on husband's leisure demand, with no significant impact on wife's leisure. This suggests that husbands work more when there are more children in their households.

In Panel B we provide the results of the rank test. Recall that the implication of the collective model is that the anti-symmetric matrix $M = S - S'$ is of most rank two. Moreover, if the household were unitary, the rank would be zero. We find strong evidence against the unitary model as the χ^2 statistic is 42.56, with a p-value of less than 0.01. This result is not surprising and consistent with the overwhelming majority of past studies that have tested the unitary model. Moving to the main result, we do not find evidence against the collective model. The χ^2 statistic is very low at 1.72, with a p-value 0.19. From this we conclude that Pareto efficiency is not an overly strong assumption in our context.

Our results are robust to treating wages as endogenous. For example, one may be worried that wages or expenditure are measured with error, and potentially bias the results. To account for this, we instrument for wages using a second degree polynomial, village-level, leave-one-out average wage. We estimate this specification via Hansen (1982)'s Generalized Method of Moments, and these instruments pass standard over-identification tests (with $\chi^2 = 10.45$ and p-value 0.84). The results are presented in Table A1 in the Appendix. Our results are less precise relative to the results presented in Table 2. Nonetheless, we again are able to reject the unitary model, but fail to reject the collective model.

Our failure to reject the model is specific to the subset of households where both the husband and wife work multiple jobs. Our focus on this sample results in a selection issue, which we deal with using a Heckman (1979) procedure. Specifically, we use all households with two married adults and children no older than 11, and select our estimation sample that satisfies the multiple job holding criterion based on the variables in Table A4. Then, we include the predicted inverse Mills' ratio from the selection equation to the demand system provided in Equation (5). The results are provided in Table A2 in the Appendix. Again, we reject the unitary model, but fail to reject the collective model.

The results of the present study are consistent with other studies that examine Bangladeshi households. Brown et al. (2021) test the collective model using the proportionality test, and their results, conducted on a less restrictive sample, are in line with our findings. However, note that our test is based on a more general model as we do not make assumptions of egoistic preferences or separability of household consumption and leisure (labor supply). Therefore, our test complements previous tests of the collective model, which are based on more restrictive assumptions but less restrictive sample selection criteria.

5 Conclusion

Testing the collective household model using price variation requires observing at least five goods. This requirement seemingly rules out the use of labor supply decisions of household members together with a Hicksian consumption good to test the collective model (Browning and Chiappori, 1998). However, in this study we identify a novel setting, multiple job holding, to overcome this obstacle. When couples are engaged in multiple occupations, they supply labor at different wage rates in their primary and secondary jobs. This results in five goods for the household: two leisure goods for each member and a Hicksian consumption good. Then, individual-specific wage rates provide sufficient price variation to test the model.

We apply this theoretical idea in rural Bangladesh where multiple job holding is prevalent. We test the collective model on a sample of nuclear households where both couples hold two or more jobs. Unlike much of the existing literature, our test does not require distribution factors. Moreover, unlike previous tests, which are based on region- (or country) level prices and use long panel datasets to generate sufficient price variation, we utilize individual-specific prices that exhibit considerable cross-sectional variation. This allows us to estimate the response of household demand to prices precisely.

The results show that household decisions are compatible with the collective model. We find strong evidence against the unitary model but fail to reject the restrictions of the collective model. Therefore, we cannot rule out the Pareto efficiency assumption for Bangladeshi households. Our results are based on a flexible specification for household demand and are robust to treating wages as endogenous. The findings are in line with previous tests that rely on more restrictive model assumptions (e.g., egoistic preferences, separability of leisure from consumption). The main limitation of our study is that it pertains to a select sample of married couples who work multiple occupations. Nonetheless, our study provides a robust test of Pareto efficiency for a small population and complements previous tests that can be conducted more broadly, but are based on more stringent model assumptions.

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A Additional Tables

Table A1: Estimation Results (Endogenous Wages)

Panel A: Demand System	ω_1 (1)	ω_2 (2)	ω_3 (3)	ω_4 (4)
Husband's Primary Wage	16.31	-15.30	30.22	10.22
	(5.51)	(9.96)	(12.87)	(6.46)
Husband's Secondary Wage	-5.69	-21.45	13.54	2.62
	(5.63)	(9.38)	(13.67)	(5.38)
Wife's Primary Wage	-21.68	-86.92	72.36	32.53
	(14.19)	(32.23)	(30.84)	(25.91)
Wife's Secondary Wage	1.30	1.37	5.60	-2.68
	(1.94)	(9.31)	(9.60)	(5.53)
$\alpha_{intercept}$	-10.61	-0.93	-75.03	13.98
	(22.94)	(19.06)	(42.51)	(9.81)
$\alpha_{husband\_age}$	-0.27	-0.08	-0.65	-0.01
	(0.13)	(0.09)	(0.65)	(0.06)
$\alpha_{children}$	2.62	0.74	4.87	-0.16
	(1.33)	(0.91)	(6.77)	(0.71)
α_{Dhaka}	-4.04	0.18	-25.84	0.48
	(4.19)	(2.80)	(15.28)	(2.49)
β	21.40	9.37	67.29	4.04
	(9.51)	(11.20)	(9.01)	(7.59)
λ	-63.18	-39.57	-136.53	-23.56
	(48.39)	(36.24)	(84.17)	(27.27)

Panel B: Rank Tests	Rank = 0	Rank = 2
χ^2	32.18	0.62
$p-value$	(0.00)	(0.43)

Note: Bangladesh Integrated Household Survey (2011/12, 2015, 2018/19). Panel A shows the coefficient estimates and standard errors (in parentheses) of the demand system; all values are multiplied by 100. Panel B shows the rank test results.

Table A2: Estimation Results (Selection-Corrected)

Panel A: Demand System	ω_1 (1)	ω_2 (2)	ω_3 (3)	ω_4 (4)
Husband's Primary Wage	11.74	-1.92	-5.12	-1.46
	(1.04)	(0.80)	(0.39)	(0.27)
Husband's Secondary Wage	2.15	8.23	0.07	-0.82
	(0.86)	(1.01)	(0.54)	(0.24)
Wife's Primary Wage	-5.74	-1.56	8.75	-0.15
	(0.61)	(0.53)	(0.31)	(0.18)
Wife's Secondary Wage	-0.70	0.20	-0.40	2.97
	(0.20)	(0.18)	(0.10)	(0.12)
$\alpha_{intercept}$	-26.82	49.96	6.28	3.05
	(6.07)	(6.88)	(4.79)	(1.82)
$\alpha_{husband\_age}$	0.07	0.01	-0.01	-0.01
	(0.02)	(0.02)	(0.02)	(0.01)
$\alpha_{children}$	-1.88	-0.83	-0.47	-0.08
	(0.40)	(0.34)	(0.29)	(0.12)
α_{Dhaka}	-1.07	-0.33	0.57	0.31
	(0.55)	(0.55)	(0.44)	(0.20)
β	11.87	-18.55	5.16	0.20
	(1.84)	(0.96)	(1.08)	(0.43)
λ	-0.71	1.23	-0.25	-0.07
	(0.16)	(0.14)	(0.07)	(0.02)
Inverse Mills' Ratio	(-1.99)	(-5.76)	(-5.62)	(-1.28)
	(4.36)	(3.50)	(2.95)	(1.14)

Panel B: Rank Tests	Rank = 0	Rank = 2
χ^2	42.08	1.69
$p-value$	(0.00)	(0.19)

Note: Bangladesh Integrated Household Survey (2011/12, 2015, 2018/19). Panel A shows the coefficient estimates and standard errors (in parentheses) of the demand system; all values are multiplied by 100. Panel B shows the rank test results.

Table A3: Most Common Occupations

Male		Female	
Occupation	**Percent**	**Occupation**	**Percent**
Raising livestock	21.47	Raising poultry	52.25
Working own farm (crop)	17.23	Raising livestock	33.07
Share cropper/tenant	10.16	Tailor/seamstress	1.72
Agricultural day labor	10.1	Handicrafts	1.54
Medium trader (shop or small store)	6.45	Working own farm (crop)	1.44

Note: Bangladesh Integrated Household Survey, round 2015. The most common occupations, focusing on adults aged 18-65.

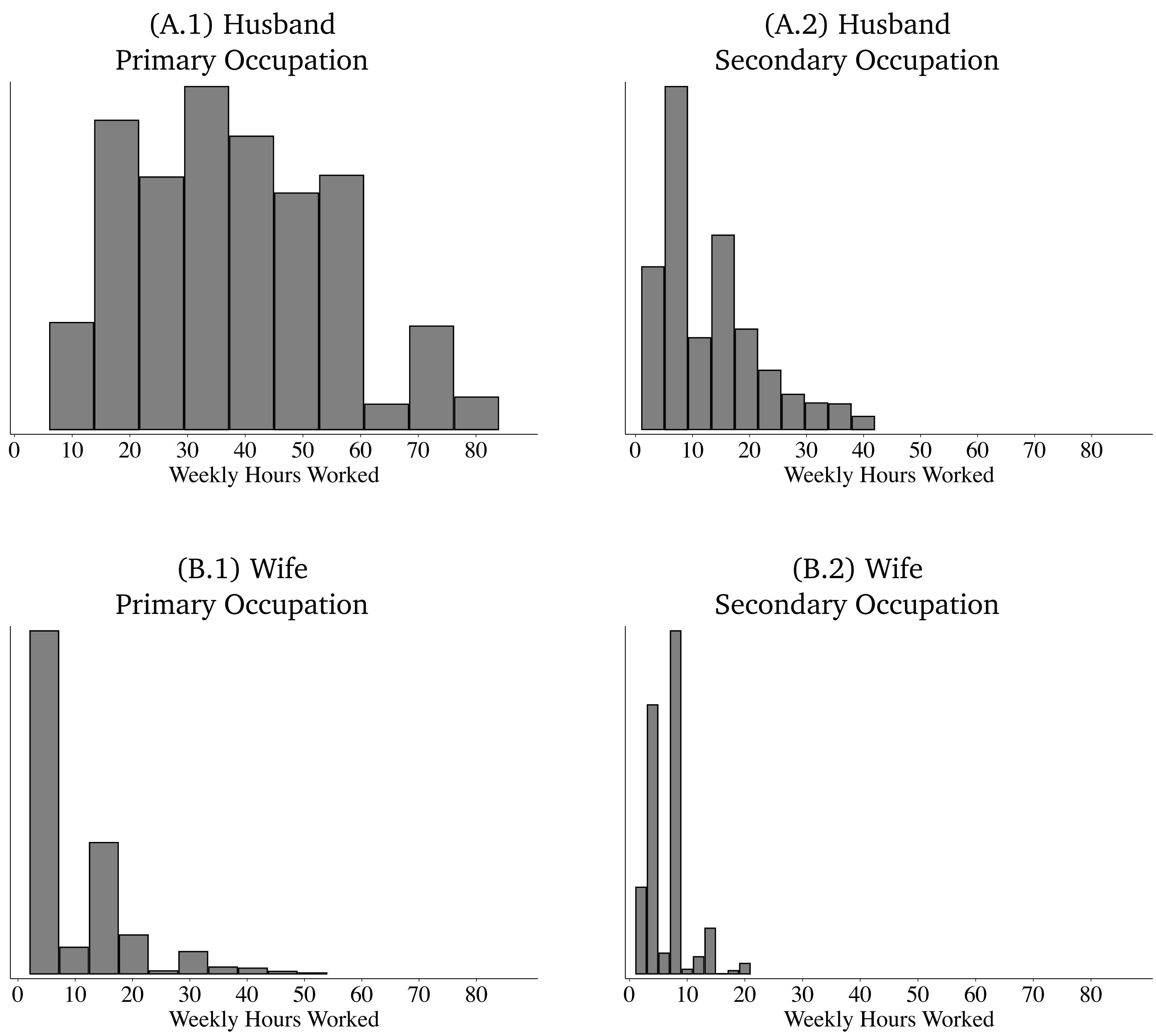
Table A4: Difference in Means: Estimation vs. Control Sample

	mean: control sample	**mean: estimation sample**	**difference:** t	**difference:** p
Household size	3.347	3.501	-4.275	0.000
Total expenditure	2,454.464	2,472.989	-0.341	0.733
Age of husband	41.624	40.841	1.531	0.126
Age of wife	33.826	33.246	1.315	0.189
Education of husband	1.845	1.932	-2.519	0.012
Education of wife	1.999	2.107	-3.363	0.001

Note: Bangladesh Integrated Household Survey (2011/12, 2015, 2018/19). Mean values of observed characteristics of (1,111) households in the estimation sample, and (3,521) households that are dropped due to multiple job holding restriction (control sample).

B Additional Figures

Figure A1: Hours Worked by Occupation



Notes: Bangladesh Integrated Household Survey (2011/12, 2015, 2018/2019). Weekly hours worked in primary and secondary occupations.