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. 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

Until recently, economists have predominantly modeled the household as a single decision-making unit. This so-called “unitary" framework assumes that household demands satisfy the Slutsky conditions, so that household preferences can be represented by a standard utility function.[1] However, many empirical studies have shown that household demands are not consistent with the unitary model. In particular, Slutksy symmetry is often rejected in the data (see, e.g., Blundell et al. (1993)). Moreover, the “income pooling" implication of the unitary model, which requires relative incomes across spouses be immaterial to household decision making, is consistently rejected.[2] In line with this empirical evidence, economists have developed several alternative models of household behavior that relax the restrictive assumptions of the unitary framework.

One such alternative is the collective model of Chiappori (1988, 1992) and Apps and Rees (1988). The collective model treats the household as a group of individuals with their own distinct preferences, and assumes that household decisions are Pareto efficient. Unlike the unitary framework, the collective model recognizes that prices, wages, and relative incomes matter in the bargaining process, and factors that shift power within the household can affect household behavior. The flexibility of the model has enabled economists to better examine the design of policies and programs that have the potential to affect the inner-workings of the household, such as laws governing marriage, cash transfer programs (e.g., the importance of who in the household receives the transfer), and the relative merits of joint versus individual taxation. The ability of the collective model to examine these topics has resulted in its widespread use as a framework for analyzing the inner-workings of the household.

Another important factor in its growing popularity is that the collective model is falsifiable. Despite Pareto efficiency being a mild assumption, the collective model generates several testable implications (Browning and Chiappori, 1998; Bourguignon et al., 2009). However, these tests (which we discuss shortly) are often difficult to implement due to data limitations or insufficient statistical power. In this paper, we provide a novel setting to test collective rationality that overcomes these obstacles.

There are two main methods for testing the collective model. The first relies on *distribution factors*, which are variables that do not affect preferences or the household budget constraint, but do affect the allocation of resources through intra-household bargaining. Examples of distribution factors include transfers targeted a specific household member, sex ratios, or divorce laws that favor a particular spouse (Chiappori et al., 2002; Attanasio and Lechene, 2014). 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.,

[1] See Browning et al. (2006) for detailed discussions on the definition of the unitary model.

[2] Thomas (1990) provides an early test of the income pooling hypothesis. See Strauss et al. (2000) for a more comprehensive review of studies that have tested the income pooling assumption in developing countries.

excluded from individual preferences and the budget constraint).[3] 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 household demands satisfy a symmetry and rank condition on the Slutksy matrix. The central obstacle to this test is that it requires price variation and at least five consumption goods.[4] 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, as the labor supply of husband and wife, together with a Hicksian consumption comprise just three goods for the household. Indeed, Browning and Chiappori (1998) note the infeasibility of testing the collective model with typical labor supply data:[5]

> *"Since there is no cross-section variation in prices for goods, we can only define a single composite commodity, consumption, and then analyze the three "good" system for male and female labor supply and consumption. The cross-section variation in wages gives the (relative) "price" variation that we have exploited in this paper. ... however, we see that without further restrictions, the collective setting does not have any implications for price responses in a three-good model. Any Slutsky response in a three-good model are consistent with the collective setting."*

That is, the standard three-good labor supply setting for couples is sufficient to test the unitary model, but not the collective model's requirement of Pareto efficiency. 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.

Our main innovation is to identify a labor supply setting where there are five goods: multiple job holding. We model the labor supply decisions of individuals who are engaged in 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. Therefore, we will be able to test the collective model just by using labor supply data. 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. Therefore, unlike previous tests that rely on detailed household consumption data, we do not need long time series of datasets to generate sufficient price variation.

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

[3]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.

[4]More generally, given the homogeneity assumption, for N decision-maker households, $2(N-1)$ goods are required to test the collective model using price variation.

[5]See also Proposition 4 in Browning and Chiappori (1998).

in low-income countries. As a result, we conduct our tests in rural Bangladesh where 43% percent of men and 31% of women are employed in multiple occupations (see Figure 1 in Section 3). The need to focus on multiple job holders makes the scope of our analysis somewhat limited. Nonetheless, having a robust test for a smaller population complements (arguably) less robust tests that can be conducted more broadly.

The results of the study do not provide evidence against the collective model for nuclear families. However, we do find strong evidence against the unitary model, which assumes that the household behaves as a single decision-making unit. The results are robust to accounting for endogeneity in wages, as well as selection into multiple job holding.

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 symmetry and rank condition on the Slutsky matrix (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 on 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 essential, especially since there is some evidence against the Pareto efficiency assumption for 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 provide background information on multiple job holding in rural Bangladesh. In Section 4 we discuss the collective model and how it can be tested. We then discuss the application of the test in Section 5, describe our data in 6, and provide the results in Section 7. Section 8 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 add to the literature on multiple job holding in a developing-country context.

A large body of research 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.[6] 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.[7] We discuss the theory behind these tests in more detail in Section 4, 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

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

[7] 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).

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 a one-dimensional way, which restricts demand responses to variation in the distribution factors.[8] 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.

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.[9] However, recent work by Dauphin et al. (2018) has cast doubt on these results as their tests do not satisfy the so-called *all or nothing* condition, which requires that each demand function be affected by all or none of the distribution factors. Indeed, this condition is often not satisfied.

Finally, our study is more related to research that has examined the symmetry and rank condition on the Slutsky matrix. 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, and find that price responses are consistent with the collective model for couples, while the unitary model is not rejected for singles. 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.[10] Both of these studies rely on long time series of cross-sectional 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 only cross-sectional price variation as we do in our analysis. Interestingly, Kapan (2009) relies only a single year to provide a test of the symmetry and rank condition on the Slutsky matrix for households in Turkey. However, he uses twelve waves of monthly household expenditure data during a year in which a financial crisis resulted in substantial inflation, generating enough price variation. Unlike these studies, we do not rely on detailed household consumption and time series price variation, as our test is based on substantial individual-level variation

[8]Distribution factors can also be used to test the number of decision makers in the household (Dauphin and Fortin, 2001; Dauphin et al., 2011).

[9]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.

[10]In particular, their test results provide evidence in favor of a collective model with three decision-makers for nuclear families with working children.

in wages. This allows us to provide a robust price-based test to Pareto efficiency in household decisions.

Not all studies fail to reject Pareto efficiency and a growing literature has identified unique settings to conduct alternative test procedures. Seminal work by Udry (1996) examines productive efficiency across male and female agricultural plots in rural Burkina Faso. He finds that households are not optimally allocating labor and fertilizer across plots, which violates productive efficiency. Additional work has provided evidence of inefficient behavior by identifying instances of income hiding (Ashraf, 2009), imperfect information between spouses Ashraf et al. (2014), and the use of domestic violence in household bargaining (Bloch and Rao, 2002; Calvi and Keskar, 2021). These rejections all occur in developing countries, which suggests that the validity of the collective model, and of assuming collective rationality is still an open question that merits further research.

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. 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. Note that unlike previous studies in this literature, we do not aim to explain or model the extensive margin of multiple job holding decisions. Instead, we focus on multiple job holders and use their intensive margin decisions to provide a novel, labor supply-based test to the collective model.

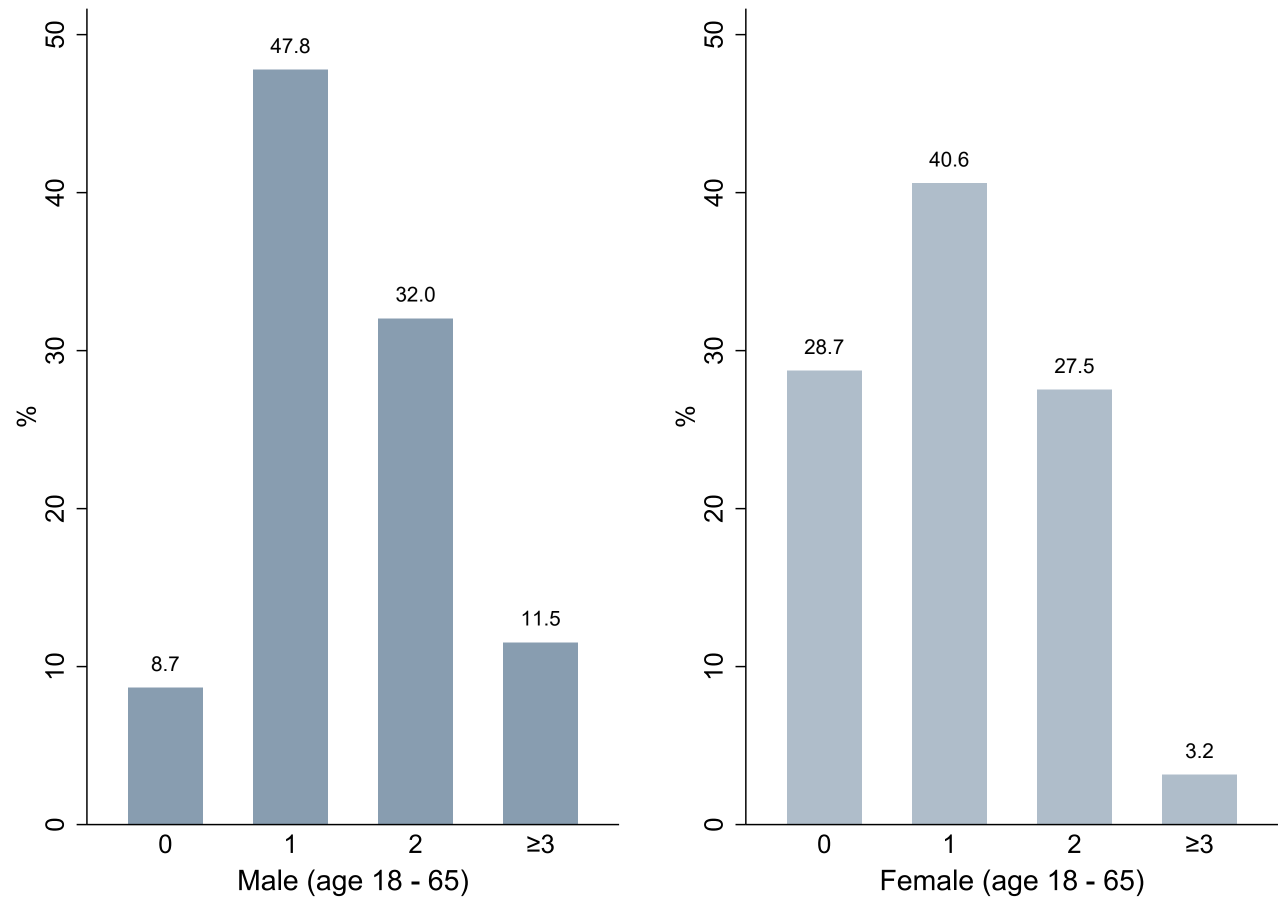
3 Multiple Job Holding in Rural Bangladesh

A distinct feature of employment in rural Bangladesh is the prevalence of multiple job holding. That is, it is very common for people to be engaged in more than one economic activity. These activities are mostly in agriculture, and they can be either self or wage employment.[11] Unlike in developed countries where jobs can be categorized as full-time or part-time with specific hours constraints, in rural Bangladesh we observe a wide range of hours. Moreover, the reasons for multiple job holding are likely to be different in this context than urban settings in developed countries. Although our data does not provide information regarding the reasons of taking a second job, income diversification is likely to be an important reason for multiple job holding in rural parts of low-income countries (Reardon, 1997; Barrett et al., 2001).

Figure 1 shows the prevalence of multiple job holding in rural Bangladesh. Around 43% of adult men and 31% of adult women are engaged in more than one occupation. This frequency contrasts sharply with developed countries, and suggests multiple job holding is quite typical in our context. These numbers for rural Bangladesh are comparable with a previous study by Unni (1996), which documents that more than 50% of working adults hold more than one job in rural Gujarat, India. Importantly, these numbers correspond to simultaneous multiple job holding as the survey we use in our analysis collects employment

[11] Note that employment is very broadly defined here; any positive hours of work in an income generating activity is considered as a job. For example, raising poultry is considered as a job while unpaid family work or household chores are not.

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.

information for individuals during the previous week. Therefore, if there is seasonality in employment activities, the pervasiveness multiple job holding may even be understated in the data.

Tables A1 and A2 in Appendix A show the most common occupations for adult men and women in each survey round of the Bangladesh Integrated Household Survey (BIHS).[12] For men, raising livestock is the most common occupation. Moreover, the percentage of men who raise livestock increased from 19.20% in 2011/12 to 24.76% in 2018/19. Working on one's own farm and agricultural day labor are the second and third most common occupations for men, respectively. Share cropper/tenant, trader (medium or small), and rickshaw/van pulling are the next most common economic activities for men in rural Bangladesh.

For women, raising poultry and livestock are by far the most common occupations. Around half of the women are engaged in raising poultry, while more than 30% of women raise livestock. Other economic activities, such as handicrafts, agricultural day labor, other wage labor, tailor, or working one's own farm, are done by less than 2% of working women in rural Bangladesh.

Finally, to see the spatial heterogeneity in these economic activities we provide the most common occupations (combined for men and women) separately for each seven divisions of Bangladesh in Table A3 of the Appendix. Livestock and poultry raising are the most common economic activities in every part of the country. Except for Chittagong, working on one's own farm is the third most common occupation in all regions. The geography of the divisions inevitably affects the economic activities. For example, raising fish is the seventh most common activity in Khulha, which is a region by the Indian Ocean, while we do not observe this activity in the landlocked region of Sylhet. However, overall, we do not observe significant spatial heterogeneity across the rural parts of Bangladesh in terms of economic activities.

[12] Note that these occupations are not only for multiple job holders, but all individuals observed in the BIHS.

For our main results, we use the labor supply decisions of multiple job holders in rural Bangladesh to test Pareto efficiency in household decisions. One particular issue pertaining to the economic activities we see in this context is that many of them can be categorized as self-employment. On the one hand, this situation makes our tests more robust as individuals can more flexibly make labor supply decisions compared to the case with salary jobs with strict constraints on hours. On the other hand, these jobs might require fixed costs (or investments) and non-labor inputs initially. For example, in the case of livestock raising, households buy animals, which are then raised by household members. Moreover, marginal earnings can be a decreasing function of hours worked.[13] Therefore, such self-employment-type economic activities can be more accurately modeled as agricultural production (or household enterprise in other examples) where investments on the assets, time inputs, and profits generated are explicitly considered. We do not take this approach; instead, we look at the short-term labor supply (or leisure) preferences of household members considering the average earnings from this activity as the value of time (i.e., wage/price), and assuming away the long-term decisions regarding non-labor inputs or fixed costs for these occupations. Individuals supply different hours of labor for these occupations and have different hourly earnings from each. The main innovation of our paper is to use the short-term labor supply decisions of multiple job holders to test Pareto efficiency, which cannot be tested using labor supply preferences in general (Browning and Chiappori, 1998).

4 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 5.

We model households that consist of N members, indexed by $i = 1, ..., N$.[14] 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 in the household.[15] 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 the vector $\mathbf{h_i} = (h_{i1}, \dots, h_{iK})$ describes his or her employment. So, 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 the vector $\mathbf{w_i} = (w_{i1}, \dots, w_{iK})$ shows hourly earnings of person i in each job.[16] Each individual has preferences over the private consumption and labor supply of all members, as well as the household public consumption. This allows for altruism, as well as externalities or any other preference interaction. Let $\mathbf{h} = (\mathbf{h_1}, \dots, \mathbf{h_N})$ and $\mathbf{c} = (\mathbf{c_1}, \dots, \mathbf{c_N})$. The utility function of member i is given by $u_i(-\mathbf{h}, \mathbf{c}, \tilde{\mathbf{c}})$, which is assumed to be strictly increasing in $-\mathbf{h_i}$ (or decreasing in $\mathbf{h_i}$) and $\mathbf{c_i}$, strongly concave and twice

[13] We partially address this problem using an instrumental variable approach. See Section 7 for details.

[14] We provide the theoretical idea behind our test for the most general case, i.e., for arbitrary number of decision-makers in the household. In our empirical application we focus on nuclear households with two decision-maker members, husband and wife, with or without children aged at most 11. These children are not very likely to be decision-makers (in the sense of the collective model) considering the legal framework about their employment. See Section 6 for details about our sample selection.

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

[16] Note that this vector shows potential hourly earnings for non-participating, or single job holding individuals. However, we do not model the extensive margin decision in our empirical application. We just write the theoretical model here in the most general way.

differentiable in all arguments.[17,18] Denote the vector of all prices (and wages) household members face by $\boldsymbol{\pi} = (\mathbf{p}, \tilde{\mathbf{p}}, \mathbf{w_1}, ...\mathbf{w_N})$. Finally, let y denote the household's non-labor income.

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

$$\max_{\mathbf{h}_1,...\mathbf{h}_N,\mathbf{c}_1,...\mathbf{c}_N,\tilde{\mathbf{c}}} \sum_{i=1}^{N} \lambda_i(\boldsymbol{\pi}, y, \mathbf{z}) u_i(-\mathbf{h}, \mathbf{c}, \tilde{\mathbf{c}}), \tag{1}$$

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

$$\tilde{\mathbf{p}}'\tilde{\mathbf{c}} + \sum_{i=1}^{N} \mathbf{p}'\mathbf{c_i} = \sum_{i=1}^{N} \mathbf{w_i'}\mathbf{h_i} + y, \tag{2}$$

and each member's time constraint:

$$\sum_{k=1}^{K} h_{ik} + l_i = T \text{ for } i = 1, ..., N. \tag{3}$$

For each individual, we do not make any hours restriction on the labor supply for a particular job h_{ik}, as long as the total labor supply does not exceed T. This is in line with our context, rural Bangladesh, where hours constraints are less likely to be the reason for multiple job holding compared to the case of non-agricultural jobs in urban contexts, especially in developed countries (Choe et al., 2018). Furthermore, while we do not do so here, it is possible to generalize the model so that the total available time for market work T varies across people.

Let $\mathbf{f}(\boldsymbol{\pi}, y, \boldsymbol{\lambda}(\boldsymbol{\pi}, y, \mathbf{z}))$ denote the vector of Marshallian demand functions (or labor supplies) resulting from the household's problem. Each demand depends on prices, non-labor income, and the Pareto weights. Let $\boldsymbol{\eta}(\boldsymbol{\pi}, u, \boldsymbol{\lambda})$ denote the vector of Hicksian demand functions resulting from the household's dual problem. Similar to the Marshallian demands, $\boldsymbol{\eta}$ 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,

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

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

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

for any goods j and j'. In matrix notation,

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

[17]Minus labor supply notation is particularly useful for the Slutsky matrix, which is negative semi-definite when considered together with other private and public consumption goods. Also we will be estimating the leisure demand of households in our empirical application.

[18]Note that $u_i(-\mathbf{h}, \mathbf{c}, \tilde{\mathbf{c}})$ is not necessarily increasing in $-\mathbf{h_j}$ or $\mathbf{c_j}$ for $j \neq i$, and thus, selfishness or negative consumption externalities may exist between household members.

where $\mathbf{f}_\pi$ is the Jacobian matrix of partial derivatives of $\mathbf{f}$ with respect to π, $\mathbf{f}_y$ is a vector of partial derivatives of $\mathbf{f}$ with respect to y, and η_π is the Jacobian matrix of partial derivatives of η with respect to π. 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, the usual Slutsky equation does not hold.

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. Instead, 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 $\xi(\pi, y, z)$ are defined as:

$$\xi(\pi, y, z) = \mathbf{f}(\pi, y, \lambda(\pi, y, z)). \tag{4}$$

Following Browning and Chiappori (1998), we define the pseudo-Slutsky matrix S for the observable demands $\xi(\pi, y, z)$ as:

$$S(\pi, y, \mathbf{z}) = \xi_\pi + \xi_\mathbf{y}\xi', \tag{5}$$

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 (4) 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 (they add up to one). 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 in Browning and Chiappori (1998)). 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).

To explain the intuition behind this point, Figure 2 graphically illustrates the impact of price changes on household allocations for couples ($N = 2$). Let the shaded area shows the utility possibility set under an initial price vector π and non-labor income y. The boundary of this area shows the Pareto optimal allocations for the household. Suppose the set of distribution factors, $\mathbf{z}$, are such that the household chooses the allocation given at point I.[19] Suppose prices change to π', altering the set of feasible allocations for the household. Under new prices, the Pareto frontier is shown with the dashed curve. If the Pareto weights are unaffected to price changes (as in the unitary model), the final allocation will be at point II, where the tangent line to point I will be parallel to the line tangent to point II. The movement from point I to II is captured by Σ. If instead, changes in prices also alter the Pareto weights (as in the collective model), then in addition to changes in feasible allocations, there will also be a movement along the Pareto frontier, where the total effect is captured by S. Under the collective setting, a possible final allocation is shown with point III. Note that the utility of a member can be less than his/her initial utility due to changes in bargaining positions.[20] In both cases (unitary and collective), efficiency requires that the outcomes are on the frontier. However, price changes might result in inefficient household allocations as well; if the final allocation is somewhere inside the (dashed) frontier, then there will be room for Pareto improvement. Therefore, the way household demands change with prices (or wages in the labor supply setting) allows us to test the restrictions of the unitary model, which predicts λ to be unaffected, as well as the collective model, which postulates Pareto efficiency only.

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

$$M(\pi, y, \mathbf{z}) = S(\pi, y, \mathbf{z}) - S(\pi, y, \mathbf{z})', \tag{6}$$

which is observable, with rank at most $2(N-1)$. Note that $M(\pi, y, \mathbf{z})$ is a real, anti-symmetric, therefore its rank has to be even.[21] 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 couples, if we reject both cases, i.e., $rank(M) = 0$ and $rank(M) = 2$, then we reject collective rationality, i.e., Pareto efficiency of the household. Thus, the validity of the Pareto efficiency assumption, and either of the household models 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.

5 Empirical Specification and Estimation

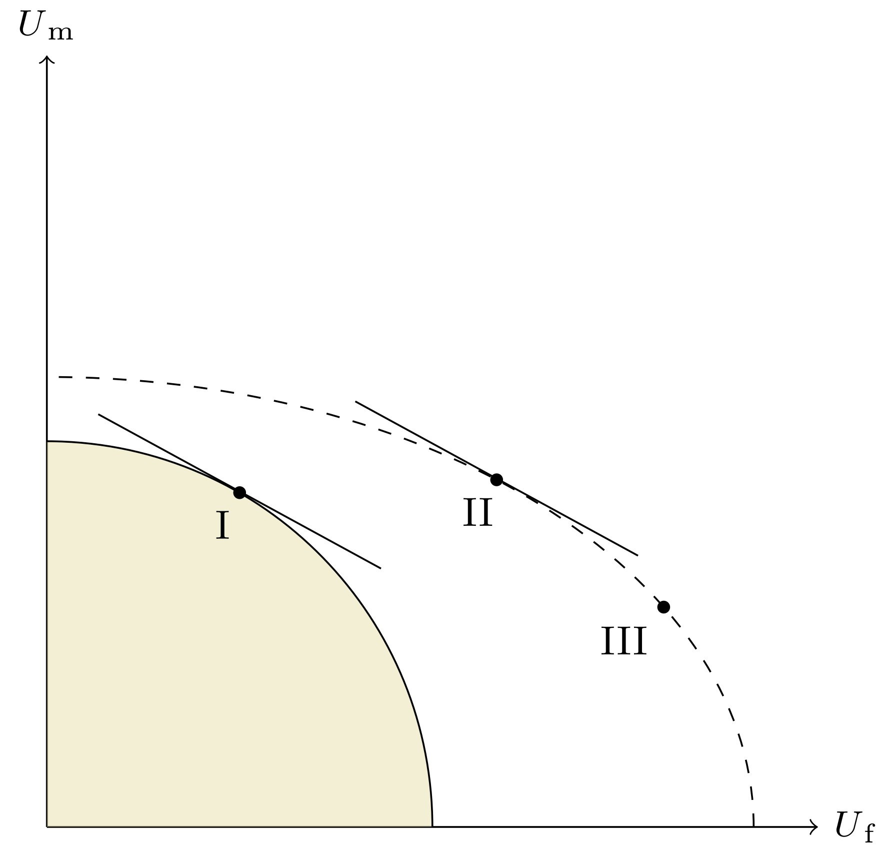
The main novelty of our approach is to test Pareto efficiency using labor supply decisions in the context of multiple job holding. We do not rely on either detailed, product-level consumption data, or aggregated

[19] Note that $\mathbf{z}$ has no impact on the set of feasible allocations; it only affects the final allocation on the Pareto frontier.

[20] Note also that not all points on the Pareto frontier are realistic outcomes for the household. Spouses might have reservation utilities, below which they would choose to be single.

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

Figure 2: Price Changes and Household Outcomes



Notes: Utility possibility set for couples under two different prices. The y-axis provides the husband's utility, while the x-axis provides the same for the wife. The shaded region gives the set of feasible utility levels under some initial price vector, and point I provides a possible initial allocation. The dashed line gives the Pareto frontier after a change in the price vector. A resulting allocation at point II would be consistent with the unitary model, while an additional change to point III would be consistent with the collective model.

consumption data with price variation. Instead, we consider a single Hicksian composite good, and use leisure demand and variation in individual-level wages for our test. Moreover, we do not need to observe any distribution factor.

We restrict our attention to households with a husband (m) and wife (f) (i.e., $N = 2$), and thus omit households with extended family members or older children.[22] While most individuals in our sample have exactly two jobs, some have three and even four occupations. For those individuals, we pool the non-primary jobs into a single occupation so that $K = 2$.[23] We then apply our test using the requisite five goods (given the homogeneity) to test the collective rationality of couples.

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. 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 (6).

Budget Share Construction We have five goods (and therefore five budget shares) in our empirical application: two leisure goods for each spouse (one for each job), and a composite consumption good. Leisure goods are defined as the difference between total available time and hours worked for each job. Specifically, let T_{ik} as the maximum possible hours individual $i = m, f$ can work at job $k = 1, 2$. Then, the leisure of member i associated with job k is defined as $l_{ik} = T_{ik} - h_{ik}$, where h_{ik} denotes the working

[22] Multiple job holding is not common among children, even for those who can be legally employed. Note that our test can be easily applied to extended households, given each decision-maker member engages in multiple jobs.

[23] See subsection 6 for details regarding how we construct wages for the secondary occupation for individuals with more than two jobs.

hours. That is, l_{ik} is the leisure generated from not working full (possible) hours.[24] The prices of the leisure goods are the wages for the corresponding job. We normalize the price of the composite good to one. The vector of prices faced by the household then contains 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. Total expenditure (the denominator for the budget shares) is determined by these wages, as well as the time endowments in each occupation and household non-labor income.[25] Similar to Choe et al. (2018), we calculate T_{ik} as the maximum weekly hours of work observed in our sample for individual type $i = m, f$ in job $k = 1, 2$ plus 1, which ensures that leisure budget shares are non-negative.[26] Since we consider a sample of households where couples are multiple job holders, this hours constraint is not binding. More precisely, it is binding only for a single observation that corresponds to the maximum observed hours for each gender and for each job. As a result, $l_{ik} > 0$ for each $i = m, f$ and $k = 1, 2$. Then, the household's budget constraint is given by:

$$C + w_{m1}l_{m1} + w_{m2}l_{m2} + w_{f1}l_{f1} + w_{f2}l_{f2} = w_{m1}T_{m1} + w_{m2}T_{m2} + w_{f1}T_{f1} + w_{f2}T_{f2} + y \tag{7}$$

where the left-hand side is the total household expenditure (including leisure expenditure) and the right-hand side is the full potential income of the household. Each $w_{ik}l_{ik}$ corresponds to leisure expenditure of the household associated with person i and job k. We compute non-labor income as the difference between total household consumption and labor income. This expenditure-based approach to calculate non-labor income reduces measurement error (Blundell et al., 2007; Lise and Seitz, 2011).[27] We then construct the budget shares as follows:

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

where total expenditure in the denominator is the right-hand side of Equation (7) (i.e., full potential income), with $g = w_{m1}T_{m1} + w_{m2}T_{m2} + w_{f1}T_{f1} + w_{f2}T_{f2} + y$. Then, for example, ω_2 corresponds to the budget share associated with husband's secondary job. Note that household leisure demand in the setting of multiple job holding is similar to disaggregated household consumption demand, as leisure demand of household members are partitioned.

Demand System To estimate the leisure demand of households, we use the Quadratic Almost Ideal Demand System (QUAIDS) of Banks et al. (1997).[28] This functional form allows flexible relative price effects and has been used in previous price-based tests of the collective rationality (Browning and Chiappori, 1998; Dauphin et al., 2011). Our preliminary analyses show that leisure Engel curves are non-linear in log total (potential) income, and therefore a quadratic logarithmic model like QUAIDS is needed.[29] Note that, although preferable, non-parametric alternatives are not feasible given our sample

[24] We could use labor supply when constructing budget shares. In that case, budget shares would become negative and add up to non-labor income. From an empirical point of view, a particular difficulty of this approach arises when non-labor income is zero (Stern, 1986).

[25] The individual utility functions we defined in the most general way in Section 4 simplify to $u_i(l_{m1}, l_{m2}, l_{f1}, l_{f2}, C)$ for $i = m, f$ in our five-good setting empirical application.

[26] Choe et al. (2018) use T_{ik}'s for jobs that are either constrained or unconstrained in terms of hours. Our model assumes away hours constraints.

[27] Savings are minimal in rural Bangladesh.

[28] 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 $\sum_{j=1}^{k} \zeta_i = 0$.

[29] Previously, Ray (1982) and Kooreman and Kapteyn (1986) use the linear version of this demand system, AIDS by Deaton and Muellbauer (1980), to estimate the leisure demand of households. Focusing on individuals separately, Choe et al. (2018) uses Linear Expenditure System based on Stone-Geary utility function to model leisure demand with multiple job holding.

size.

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,

$$\omega = \alpha + \boldsymbol{\Gamma}\pi + \beta[\ln g - a(\pi)] + \zeta \frac{[\ln g - a(\pi)]^2}{b(\pi)} + \epsilon, \tag{8}$$

where,

$$a(\pi) = \alpha_0 + \alpha'\pi + \frac{1}{2}\pi'\boldsymbol{\Gamma}\pi, \quad b(\pi) = \exp(\beta'\pi). \tag{9}$$

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), including the husband's age, household size, and an indicator for the household residing in the Dhaka division. Our sample is quite homogeneous, so we include a limited number of preference factors.[30] We then estimate the non-linear system provided in Equation (8) by iterative feasible generalized least squares, allowing errors to be correlated across equations (non-linear seemingly unrelated regression model). Finally, although the parameter α_0 is formally identified, it is not well-determined. Following previous studies (Deaton and Muellbauer, 1980; Banks et al., 1997; Browning and Chiappori, 1998), we choose a constant less than the minimum observed lng in our data.[31]

The pseudo-Slutsky matrix given in Equation (5) 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 (8), the pseudo-Slutsky matrix is then,

$$S = \Gamma - (\beta + 2\frac{\tilde{g}}{b(\pi)}\zeta)\pi'(\Gamma - \Gamma') + \tilde{g}(\beta\beta' + \frac{\tilde{g}}{b(\pi)}(\zeta\beta' + \beta\zeta') + 2\Big(\frac{\tilde{g}}{b(\pi)}\Big)^2 \zeta\zeta') \tag{10}$$

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. 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

[30] Considering our sample size and the non-linearity of the model, including a large number of observable characteristics is computationally difficult as well.

[31] We also experiment with alternatives constants; the main results do not change.

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,

$$m_{34} = \frac{m_{13}m_{24} - m_{14}m_{23}}{m_{12}} \tag{11}$$

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 (11). The rejection of both the symmetry of Γ and the Equation (11) implies the rejection of the collective rationality.

6 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.[32] As discussed in Section 3, a distinct feature of employment in Bangladesh is the prevalence of multiple job holding. 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. Note that 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. Finally, 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 below 12. This age cutoff is imposed considering the legal framework relating to the employment of children in Bangladesh.[33] As children aged 12 and above can legally work and earn income, they might have bargaining power within the household, regardless of

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

[33] The principles regarding children's employment in Bangladesh are provided 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.

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.

their actual work status. This would then require us to model these children as decision-makers with non-zero Pareto weights.[34] 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 that are not included due to multiple job holding restriction, we conduct a difference-in-means 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 Section 7. Finally, we omit any household with missing data for any preference factors given in Table 1. This results in a final sample of 1,111 households.

We provide descriptive statistics in Table 1. Because of our sample restrictions, households are relatively small with 1.5 children on average. Around 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).[35] Moreover, husbands earn a higher wage for both their primary and secondary occupations.

Variation in earnings (wages) is the source of identification and constitutes the basis of our test. Figure A1 in Appendix B shows the distribution of wages for husbands and wives, in their primary and secondary

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

[35] See figure A2 in Appendix B for the distribution of primary and secondary hours in our sample.

occupations, separately in each survey round. The main takeaway from this figure is that the variation we rely on is cross-sectional. That is, the price-adjusted wage distribution in each round almost exactly matches.[36] This is a distinct feature and important contribution of this study, as previous studies mainly rely on time variation and require observing long time series of cross-sections.

7 Empirical Results

7.1 Demand System Estimates

Before discussing the results of the rank tests which assess the validity of the collective model, we begin in Table 2 by presenting the parameter estimates of our demand system given by Equations (8) and (9). Columns 1 and 2 correspond to the leisure demand equations for the husband's first and second jobs, respectively. Columns 3 and 4 presents the analogous equations for the wife.

We find the parameter estimates for ζ, which correspond to the quadratic term, are significant for all budget shares. This suggests that the Engel curves are nonlinear in log full income and QUAIDS is needed. The signs of the coefficient estimates for β and ζ are the same for the primary jobs of both spouses; our estimates of β is significant and positive, while estimates of ζ is significant and negative. With regard to the secondary jobs, we find β estimate to be negative and significant for the husband, while insignificant for the wife. The estimate of ζ is positive only for husband's secondary job.

Our three preference factors are husband's age, number of children, and an indicator for living in the Dhaka division. These demographic controls affect the system in a non-linear way through the parameter α. The results show that the coefficient estimates corresponding to husband's age and Dhaka dummy is significant only for the budget share corresponding to husband's primary job only. The number of children seems to impact household budget shares for husband's both primary and secondary jobs. We would expect the number of children to affect wife's leisure. The insignificant estimates for this preference factor for budget shares corresponding to wife's labor supply might be due to homogeneity of our sample. Again, note that average number of children in nuclear families in our sample is less than two.

As discussed in Section 5, we are especially interested in the estimate of the Γ matrix, which is given by the first four rows and columns of Table 2. All diagonal elements $\Gamma_{i,i}$, for $i = 1, \ldots, 4$, are estimated to be positive and significant. The signs of the coefficient estimates corresponding to non-diagonal elements vary. Among twelve non-diagonal elements, nine of them are precisely estimated while we have insignificant estimates for $\Gamma_{4,2}, \Gamma_{2,3}, \Gamma_{3,4}$. To save space we do not report income or price elasticities. Our main interest is to test the rank of the non-symmetric component of the Pseudo-Slutsky matrix. And the estimates of the Γ matrix is sufficient for our purpose.

7.2 Rank Tests

In Panel B of Table 2 we provide our main results pertaining to the rank tests. Recall 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. Therefore, rejecting both cases would give evidence

[36] Only for wife's primary job, the location (mean) of the distribution seems to shift in the third round.

Table 2: Estimation Results

Panel A: Demand System	Husband's primary job ω_1 (1)	Husband's secondary job ω_2 (2)	Wife's primary job ω_3 (3)	Wife's secondary job 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)
α (intercept)	-27.82	39.22	-0.69	1.30
	(3.31)	(3.20)	(2.62)	(0.99)
α (husband's age)	0.07	0.01	-0.01	-0.01
	(0.02)	(0.02)	(0.02)	(0.01)
α (number of 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)
ζ	-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 for matrix M. If $rank(M) = 0$, that would indicate a failure to reject the unitary model. If $rank(M) = 2$, that would indicate a failure to reject the collective model.

against Pareto efficiency assumption. A particular convenience for QUAIDS specification is that the rank of $M = S - S'$ is equivalent to rank of $\Gamma - \Gamma'$. Therefore, we test the rank of $\Gamma - \Gamma'$.

First, we test whether $rank(\Gamma - \Gamma') = 0$, i.e., the case of unitary model, which is equivalent to testing whether Γ is symmetric. 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 our test of the collective model, we are unable to reject that $rank(\Gamma - \Gamma') = 2$, as the χ^2 statistic is very low at 1.72, with a p-value 0.19.[37] From this we conclude that Pareto efficiency is not an overly strong assumption in our context.

These results 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

[37] We first check our assumption underlying the rank 2 case, which is $m_{12} \neq 0$. This is equivalent to testing $\Gamma_{1,2} = \Gamma_{2,1}$, and we reject the equality of $\Gamma_{1,2}$ and $\Gamma_{2,1}$.

Table 3: Estimation Results (Endogenous Wages)

Panel A: Demand System	Husband's primary job ω_1 (1)	Husband's secondary job ω_2 (2)	Wife's primary job ω_3 (3)	Wife's secondary job 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)
α (intercept)	-10.61	-0.93	-75.03	13.98
	(22.94)	(19.06)	(42.51)	(9.81)
α (husband's age)	-0.27	-0.08	-0.65	-0.01
	(0.13)	(0.09)	(0.65)	(0.06)
α (number of 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)
ζ	-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 for matrix M. We instrument for wages using a second degree polynomial, village-level, leave-one-out average wage. If $rank(M) = 0$, that would indicate a failure to reject the unitary model. If $rank(M) = 2$, that would indicate a failure to reject the collective model.

and leisure (labor supply). Also we do not rely on distribution factors. Therefore, our test complements previous tests of the collective model, which are based on more restrictive assumptions but less restrictive sample selection criteria.

Robustness Checks Our main specification assumes that wages are exogenous, which is standard in the literature. However, as discussed in detail in Section 3, many agricultural jobs in rural Bangladesh are not standard wage jobs, and might require fixed costs. Moreover, one may be worried that wages or expenditure are measured with error, and potentially bias the results. To address these issues, as an auxiliary analysis, we instrument wages with leave-one-out wage instruments. Specifically, we use second degree polynomial, village-level, leave-one-out average wages. We then estimate this specification via Hansen (1982)'s Generalized Method of Moments. The instruments pass standard over-identification tests (with $\chi^2 = 10.45$ and p-value 0.84). The results are presented in Table 3. Our results are less precise relative to the results presented in Table 2. Nonetheless, we again are able to reject the unitary

Table 4: Estimation Results (Selection-Corrected)

Panel A: Demand System	Husband's primary job ω_1 (1)	Husband's secondary job ω_2 (2)	Wife's primary job ω_3 (3)	Wife's secondary job 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)
α (intercept)	-26.82	49.96	6.28	3.05
	(6.07)	(6.88)	(4.79)	(1.82)
α (husband's age)	0.07	0.01	-0.01	-0.01
	(0.02)	(0.02)	(0.02)	(0.01)
α (number of 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)
ζ	-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 for matrix M. We account for selection by including a predicted inverse Mills' ratio in the demand system provided in Equation (8). If $rank(M) = 0$, that would indicate a failure to reject the unitary model. If $rank(M) = 2$, that would indicate a failure to reject the collective model.

model, but fail to reject the collective model. That is, we do not reject Pareto efficiency. Therefore, our results are robust to treating wages as endogenous.

Our failure to reject the collective rationality 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 the usual 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 Equations (8) and (9). The results are provided in Table 4. Again, we reject the unitary model, but fail to reject the collective model.

Finally, we check whether our results are robust to clustering standard errors. The price variation in our study (wages) is at the individual-level, and thus in our main specification we chose to use robust standard errors without any clustering. However, there might be village-level unobserved effects on wages. Also

Table 5: Estimation Results (Clustered Standard Errors)

Panel A: Demand System	Husband's primary job ω_1 (1)	Husband's secondary job ω_2 (2)	Wife's primary job ω_3 (3)	Wife's secondary job ω_4 (4)
Husband's primary wage	14.05	-5.62	-4.09	-1.37
	(0.60)	(0.61)	(0.29)	(0.27)
Husband's secondary wage	-2.75	13.82	-1.89	-1.02
	(0.59)	(0.68)	(0.28)	(0.22)
Wife's primary wage	-4.80	-2.59	9.10	-0.09
	(0.55)	(0.43)	(0.25)	(0.18)
Wife's secondary wage	-0.42	0.02	-0.30	3.00
	(0.15)	(0.14)	(0.08)	(0.12)
α (intercept)	0.44	0.23	10.95	0.66
	(2.85)	(2.85)	(2.12)	(0.72)
α (husband's age)	0.07	0.00	-0.01	-0.01
	(0.02)	(0.02)	(0.02)	(0.01)
α (number of children)	-1.75	-0.48	-0.12	0.00
	(0.28)	(0.25)	(0.23)	(0.09)
α (Dhaka)	-1.07	-0.21	0.51	0.30
	(0.56)	(0.53)	(0.44)	(0.19)
β	8.80	-11.75	4.29	-0.25
	(1.66)	(0.99)	(1.26)	(0.34)
ζ	-1.34	2.31	-0.60	-0.14
	(0.37)	(0.35)	(0.22)	(0.06)

Panel B: Rank Tests	Rank = 0	Rank = 2
χ^2	41.14	0.29
$p-value$	(0.00)	(0.59)

Note: Bangladesh Integrated Household Survey (2011/12, 2015, 2018/19). Panel A shows the coefficient estimates and standard errors (in parentheses) clustered at the village level, of the demand system; all values are multiplied by 100. Panel B shows the rank test results for matrix M. If $rank(M) = 0$, that would indicate a failure to reject the unitary model. If $rank(M) = 2$, that would indicate a failure to reject the collective model.

note that when income information is missing for an individual for a particular job, we use average earnings for the same job at the village (or increasingly larger clusters). Additionally, the primary sampling unit of the BIHS is village. Considering these points, we check whether our results continue to hold when standard errors are clustered at the village level. The results are given in Table 5. Similar to the main results, we strongly reject the unitary model but fail to reject the collective model. Overall, these robustness checks reinforce our conclusion that Pareto efficiency is not an overly strong assumption for households in rural Bangladesh.

8 Conclusion

The collective household model, which postulates Pareto efficiency in household decisions, has recently become the workhorse model in the family economics literature. This model has been used to estimate the individual-level poverty using household-level data, as well the intra-household effects of various policies.

However, Pareto efficiency assumption has been questioned especially for developing country households. This study provides a novel, labor supply-based test of Pareto efficiency in household decisions. The test is based on price (wage) variation, and especially relevant for developing countries.

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 time series of datasets to generate sufficient price variation, we utilize individual-specific prices that exhibit substantial 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, selection into multiple job holding, and clustering standard errors at the regional level. 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: Most Common Occupations Among Men

	Percent		
Occupation	**2011/12**	**2015**	**2018/19**
Raising livestock	19.20	21.47	24.76
Working own farm (crop)	19.07	17.23	15.03
Agricultural day labor	12.29	10.10	7.86
Share cropper/tenant	9.95	10.16	9.61
Medium trader (shop or small store)	5.46	6.45	6.57
Small trader (roadside stand or stall)	4.41	4.00	4.01
Rickshaw/van pulling	3.57	2.99	2.84
Other wage labor	2.88	3.69	3.38
Other self employed	2.22	1.64	1.17
Driver of motor vehicle	1.74	2.50	2.90
Mason	1.66	1.80	2.47
Service (private sector)	1.42	2.09	2.98
Raising fish / fish pond	1.34	1.18	1.12
Other salaried worker	1.26	1.13	1.33
Large trader (large shop or whole sale)	1.22	1.17	1.22
Earth work (other)	1.20	1.52	1.40
Carpenter	1.18	1.12	1.20
Fisherman (using non owned/not leased water body)	1.08	0.82	0.68
Fish Trader	0.79	0.48	0.30
Tailor/seamstress	0.66	0.69	0.62

Note: Bangladesh Integrated Household Survey. The most common occupations, focusing on men aged 18-65, separately for each round of the BIHS.

Table A2: Most Common Occupations Among Women

	Percent		
Occupation	**2011/12**	**2015**	**2018/19**
Raising poultry	49.64	52.25	50.83
Raising livestock	36.52	33.07	34.22
Handicrafts	1.45	1.54	1.28
Agricultural day labor	1.33	1.30	1.51
Other wage labor	1.25	0.82	0.49
Tailor/seamstress	1.22	1.72	2.38
Working own farm (crop)	1.22	1.44	1.53
Small trader (roadside stand or stall)	0.89	0.71	0.78
House maid	0.76	0.63	0.60
Other self employed	0.75	0.72	0.58
Share cropper/tenant	0.56	0.93	0.96
Earth work (govt program)	0.42	0.30	0.08
Tea garden worker	0.41	0.37	0.40
Service (private sector)	0.41	0.78	0.92
Other salaried worker	0.39	0.41	0.35
Medium trader (shop or small store)	0.29	0.39	0.35
Private tutor/house tutor	0.27	0.44	0.55
Earth work (other)	0.23	0.10	0.08
Beggar	0.22	0.12	0.11
NGO worker	0.19	0.24	0.11

Note: Bangladesh Integrated Household Survey. The most common occupations, focusing on women aged 18-65, separately for each round of the BIHS.

Table A3: Most Common Occupations in Each Division

Occupation	Percent							
	All	**Barisal**	**Chittagong**	**Dhaka**	**Khulna**	**Rajshahi**	**Rangpur**	**Sylhet**
Raising livestock	27.00	20.55	19.24	26.39	29.58	32.63	36.02	23.25
Raising poultry	25.22	30.80	33.54	25.39	21.37	22.55	22.69	22.25
Working own farm (crop)	9.71	8.28	5.13	10.81	13.63	10.02	8.73	7.05
Agricultural day labor	5.91	5.24	3.60	5.14	6.61	7.37	8.73	5.52
Share cropper/tenant	5.77	5.24	7.42	5.92	4.26	5.35	5.95	6.79
Medium trader (shop or small store)	3.56	3.43	4.14	3.23	3.63	3.57	2.35	5.16
Small trader (roadside stand or stall)	2.43	3.15	2.20	3.02	1.85	1.20	2.49	2.63
Other wage labor	2.33	2.70	3.78	2.38	1.13	1.83	1.77	3.37
Rickshaw/van pulling	1.57	1.30	1.44	1.73	1.58	1.64	1.82	1.16
Service (private sector)	1.46	0.96	1.84	1.93	1.61	1.11	0.43	1.42
Driver of motor vehicle	1.31	1.63	2.20	1.02	1.19	1.11	0.58	2.05
Other self employed	1.20	1.41	1.35	1.16	1.01	1.83	1.01	0.84
Tailor/seamstress	1.18	0.79	1.44	1.24	1.34	0.72	0.86	1.63
Mason	0.95	1.24	1.44	0.49	0.65	0.63	0.53	2.74
Handicrafts	0.95	1.01	1.80	0.65	0.45	1.83	0.62	1.00
Earth work (other)	0.85	1.46	1.17	0.71	1.19	0.14	0.38	0.95
Other salaried worker	0.79	0.45	0.72	0.67	0.80	0.53	0.77	1.79
Large trader (large shop or whole sale)	0.64	0.51	0.81	0.65	0.48	0.77	0.38	0.95
Raising fish / fish pond	0.63	0.06	0.31	0.53	2.02	0.48	0.19	0.00
Carpenter	0.59	1.01	0.81	0.65	0.42	0.39	0.14	0.74

Note: Bangladesh Integrated Household Survey, round 2015. The most common occupations in each seven divisions of Bangladesh, and the whole country.

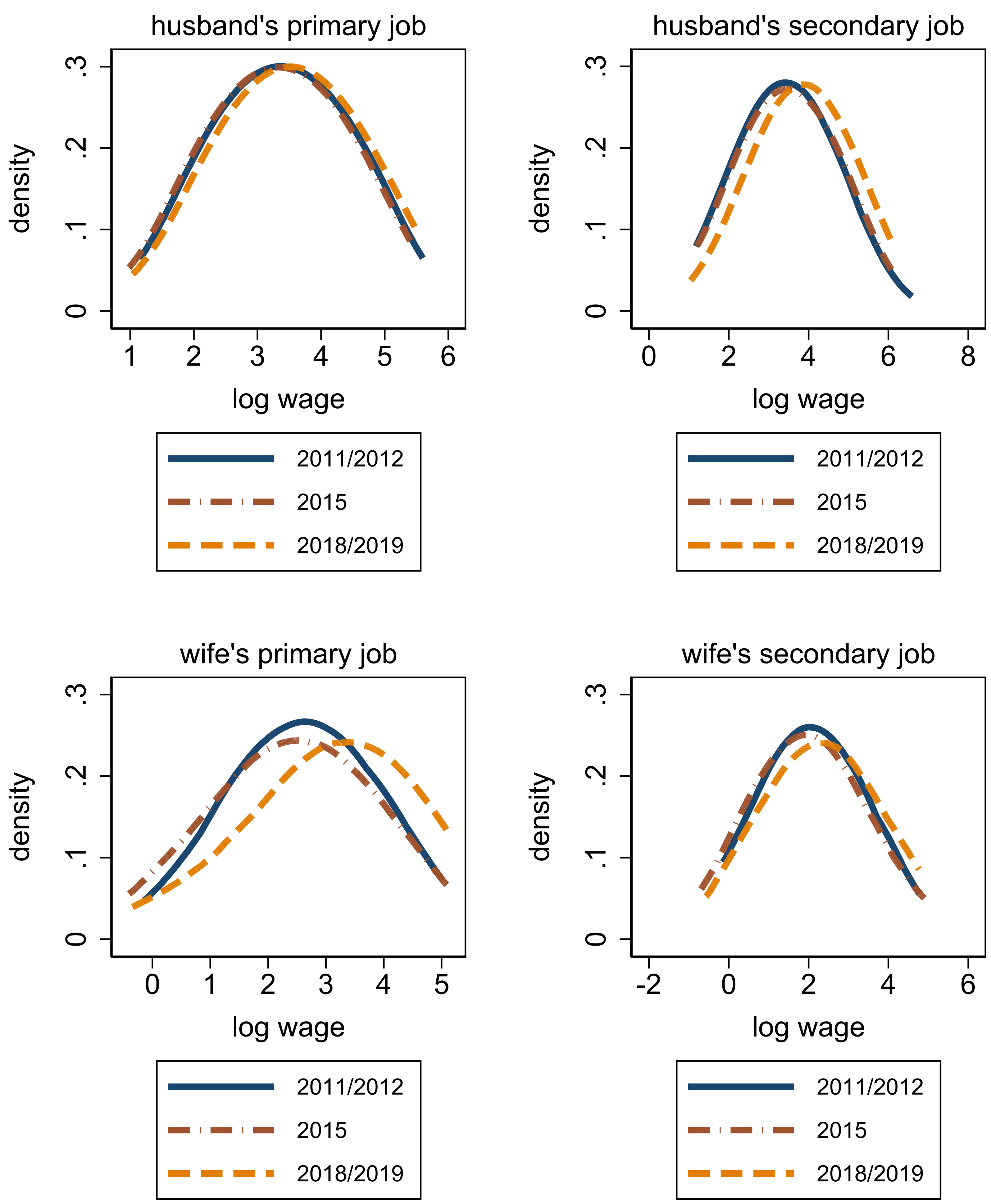
Table A4: Difference in Means: Estimation vs. Control Sample

	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).

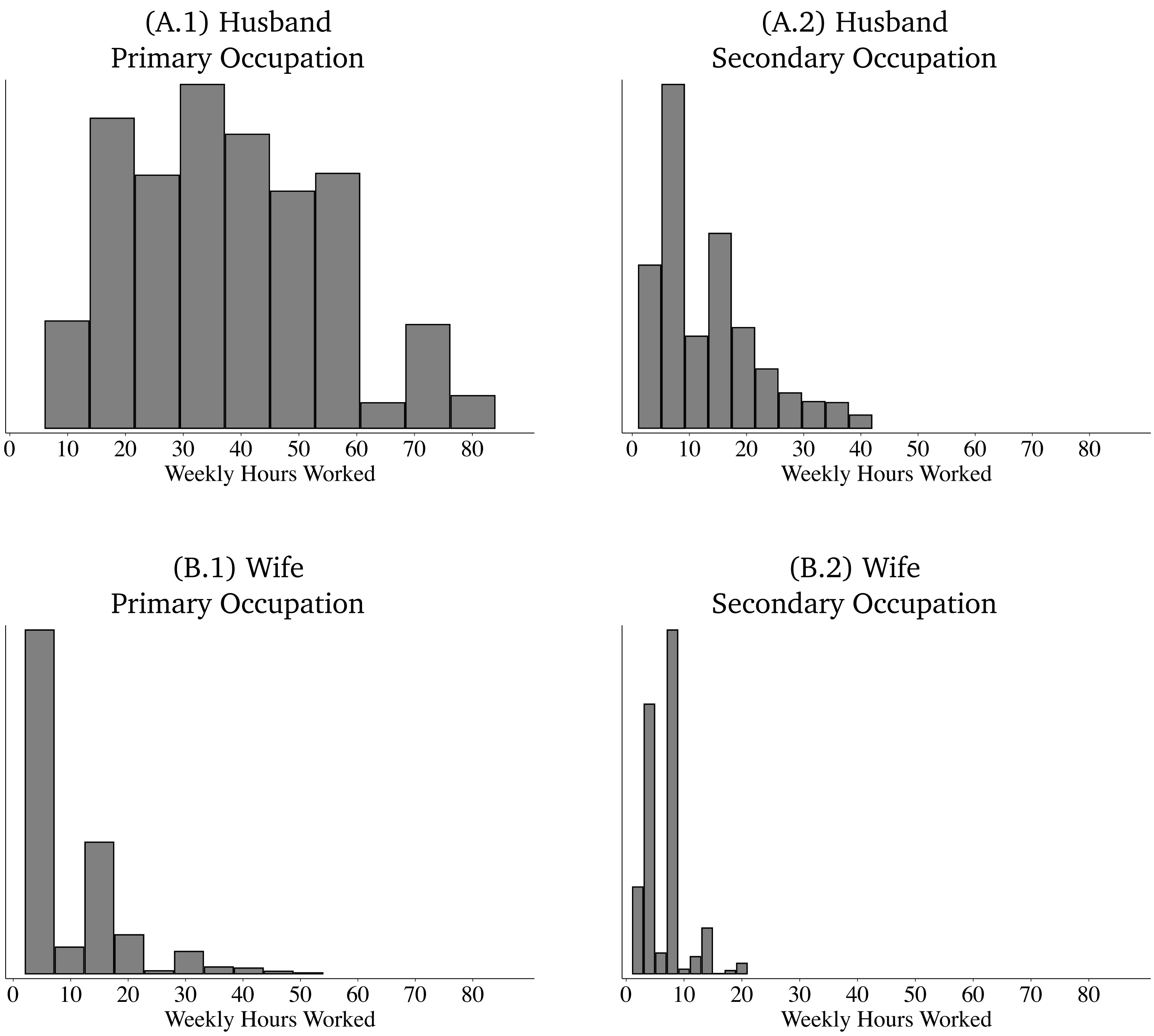
B Additional Figures

Figure A1: Wage Distribution by Year



Notes: Bangladesh Integrated Household Survey (2011/12, 2015, 2018/19). Kernel density of primary and secondary wages of husbands and wives.

Figure A2: Hours Worked by Occupation



Notes: Bangladesh Integrated Household Survey (2011/12, 2015, 2018/19). Weekly hours worked in primary and secondary occupations.