

# Essays on Family Behavior in Developing Settings

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Dissertation submitted in partial fulfillment of the requirements for the degree of  
Doctor of Philosophy in the Department of Economics  
in the Graduate School of Duke University  
2012

ABSTRACT

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# Abstract

This dissertation investigates the economic behavior of families in developing settings. Utilizing uniquely rich, longitudinal survey data from Indonesia, it demonstrates the complexity of market environments facing rural households, as well as the importance of extended family networks in determining the health and well-being of young children. These essays serve as an illustration of advances in development economics that are possible when fundamental models are revisited and examined with new longitudinal data. The results of these exercises are important not only for updating economic models of behavior, but for what they reveal about the complexities of decision making and for the effective design and evaluation of development policy around the world.

To Caroline, for her unending support.

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# 1

## Introduction

In recent years, significant advances have been made in better understanding the complex environments faced by families in developing settings. The essays comprising this dissertation contribute to this discussion by empirically examining family decision making in the context of theoretical models at the foundation of development economics. Using new, longitudinal data from Indonesia, each chapter presents an innovative approach to assess the validity of commonly used frameworks for understanding family interaction. The works collectively highlight the intricacies of developing environments and the behavioral responses they induce.

The second chapter begins this discussion by providing empirical evidence on whether and how extended family members interact in the face of risk and uncertainty. In particular, I examine how resources controlled by extended family members impact child health, cognition, and education using uniquely rich longitudinal data from the Indonesia Family Life Survey (IFLS). The analysis is framed in the context of a theoretical model of family resource allocation that imposes few restrictions on the preferences of individuals within a group. I exploit a feature of the IFLS study design to gather data on non co-resident extended family members. These potentially

influential decision makers are often left out of empirical analyses, but may play a particularly important role in developing settings where families are often thought to provide an informal source of support.

Using data on resources under the control of each individual within a child's household as well as those individual family members who are not co-resident, the results provide direct empirical evidence on the role intergenerational transfers play in human capital accumulation. The findings suggest departures from the traditional unitary model of the family, but cannot rule out that co-resident and non co-resident family members make allocation decisions cooperatively.

Building from this work, the later chapters focus on the decision making process of farm households. The third chapter explores an application of the neoclassical agricultural household model, and tests the validity of its fundamental assumption that have allowed it to become a foundation for large literatures in development and agricultural economics. The model has played a central role in improving the understanding of small-scale agricultural households and non-farm enterprises, but its baseline form relies on strong assumptions regarding the features of rural markets.

Under the assumptions that all current and future markets exist and that farmers treat all prices as given, the model simplifies households' simultaneous production and consumption decisions into a recursive form. When the restrictions hold, production is independent of household characteristics and preferences, and may be analyzed separately from consumption choices. This is a tremendously useful result for both empirical and theoretical applications, as well as the design of production-side policies.

While useful, it is an empirical question if the assumptions necessary to facilitate the recursive model are valid. Important papers in the microeconomics of development have failed to reject the predictions of these assumptions, and have served to solidify the baseline model. Although requiring strong conditions, the recursive,

two-step approach to analyzing household decision making finds empirical support in past work using data from Indonesia.

The contribution of the third chapter stems from using new, longitudinal data from Central Java, Indonesia to provide new evidence on the validity of the recursive model and complete markets. I begin by testing if the demand for farm inputs is truly unrelated to the demographic composition of farm households, and reject the hypothesis. I then extend the literature by showing neither unobserved heterogeneity at the farm level, differential monitoring costs for family and hired labor, nor the potential endogeneity of household demographics can explain the relationship between household composition and labor demand on the farm. This motivates a model of resource allocation within farm households that allows for heterogeneity in the skills of household and farm laborers in on and off-farm work. I test an implication of this model and show it is consistent with the empirical evidence. The results are important not only for modeling farm-household decision making, but for the design and evaluation of development policy, and for understanding rural markets around the world.

The fourth chapter offers a novel extension of the analysis of market completeness among agricultural households. While previous literature has focused exclusively on the implications of complete markets for production decisions, this chapter defines and empirically tests an alternative prediction of complete markets for consumption allocations. The second-step of the recursive approach implies production and consumption are linked only through an income effect from the farm business. When this holds, the prices of farm inputs affect consumption solely through an income effect, and are weakly separable in the demand functions. This weak separability implies a restriction on the marginal effects of input prices on consumption allocations that is examined using new, detailed data from Indonesia that includes transaction prices for farm inputs and consumption goods collected in local shops and markets over

a four-year period. The proposed test is free from a number of concerns plaguing work examining complete markets on the production side and discussed in Chapter 3. The results support the findings in Chapter 3 and suggest that separation between production and consumption decisions is not a valid characterization of the market environment in Central Java.

The chapters of this dissertation comprise a significant portion of my research while at Duke University. As scholarship is fundamentally a collaborative enterprise, these efforts have not been conducted in isolation. The work enclosed within the following pages has benefited from discussions and collaborations with both colleagues and advisors. This is particularly true for Chapter 4, which is part of a larger research agenda analyzing agricultural household decision making with Duncan Thomas and Evan Peet. Evan, a fellow graduate student in the Department of Economics at Duke University, was particularly helpful in preparing the price and expenditure data used in the empirical applications. The analytical programs, writing, results, and any errors are solely my own.

## Extended Families and Child Well-being

### 2.1 Introduction

How intergenerational transfers impact child well-being and human capital accumulation is poorly understood. Despite its importance, few data sets provide the information on resources under the control of both co-resident and non co-resident family members necessary to examine sharing within extended families. Even fewer data sets provide information that links the level and distribution of resources in the extended family to child health and development outcomes. Using rich longitudinal data from the Indonesia Family Life Survey (IFLS), this chapter provides empirical evidence on whether, and how, resources under the control of parents, grandparents, and other non co-resident family members contribute to child development. Results are presented in the context of a general model of family behavior that provides a natural, but previously unused, framework to examine how human capital formation is influenced by intergenerational exchange and resource allocation.

There is a growing body of literature on the importance of the extended family in economic models of decision making. This is particularly true in developing set-

tings where nuclear, two adult households are far less common than in the developed world.<sup>1</sup> Living arrangements in developing countries frequently consist of multi or skip generation households, and extended families often fill gaps created by the absence of formal social safety nets.<sup>2</sup> Previous studies across the social sciences suggest that intergenerational transmission plays a particularly important role in establishing early life health and well-being. The IFLS offers a rich design and set of outcomes to study this behavior, and we focus specifically on three markers of human capital; health as captured by height-for-age, early school attendance, and cognition.<sup>3</sup>

We examine the links between extended family resources and child well-being within the context of models of family decision making. This is a unique application, as the intrahousehold literature primarily focuses on consumption allocations of nuclear households and rarely considers the extended family or health. The use of outcomes with distinct human capital interpretations give the results clear welfare implications lacking from papers studying consumption patterns. We consider both the neoclassical unitary model of the family, as well as Chiappori's (1988; 1992) collective rationality model.<sup>4</sup> The later offers the least restrictive approach in the intrahousehold literature, and relies only on the assumption that family members reach Pareto efficient outcomes when allocating resources. Although very few studies have used this model to examine the extended family, it is an appealing approach, as it permits heterogeneous preferences across family members and generations, while

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<sup>1</sup> For work and evidence on the role and importance of the extended family in the United States, see Cox (2003) and Bianchi et al. (2008) among many others.

<sup>2</sup> Evidence on extended family interaction in developing countries can be found in many settings. For example: Botswana (Lucas and Stark, 1985); India (Rosenzweig and Stark, 1989); South Africa (Duflo, 2003); and Indonesia (Thomas and Frankenberg, 2007) among many others.

<sup>3</sup> Work in nutrition (Waterlow et al., 1977) has long supported the use of height as an indicator of well-being, and a number of studies have shown it to be predictive of a multitude of later life outcomes (e.g. Alderman et al., 2006).

<sup>4</sup> A number of additional intrahousehold models exist in the literature including McElroy and Horney (1981) and Lundberg and Pollak (1993) among many others.

placing plausible, testable restrictions on the nature of interactions between relatives.

Where other studies have been limited by the lack of data on the individual level distribution of resources both within households and the extended family, this chapter benefits from the rich longitudinal design of the Indonesia Family Life Survey. The structure and tracking scheme of the survey allows one to identify extended families in the data by linking individuals who split-off from baseline households back to their original household of origin. Along with genealogical construction, the IFLS contains detailed health, education, and cognition measures that are utilized to assess how resources within a child’s family impact their development.<sup>5</sup>

The results show that children are influenced not only by the resources under control of their parents, but also those held by extended family members. We also show that the extended family not only impacts child outcomes, but they do so in a way that is consistent with a cooperative unit of heterogeneous individuals who coordinate their behavior. The empirical findings strongly reject the unitary model as the appropriate framework for the extended family, but cannot rule out that families allocate resources in a Pareto efficient manner. This result is important for the design and evaluation of development policy, as well as understanding family behavior, child health, and intergenerational exchange. The next section begins by describing a general theoretical framework to structure the analysis.

## 2.2 Theoretical Framework

Drawing on work by Chiappori and coauthors (e.g. Chiappori, 1988, 1992; Browning et al., 1994), the following is a general model of extended family behavior that encompasses both the unitary and collective forms. In this framework, the general welfare of an extended family is a function of the individual utility of each of its members. Motivated by the literature on bargaining within households, this general

<sup>5</sup> The terms “dynasty” and “extended family” will be used interchangeably throughout the chapter.

framework allows for an arbitrary bargaining process to occur between members of an extended family as they make allocation decisions.

To begin, let the welfare of an extended family,  $W$ , depend on the utility of each of its  $M$  members, where  $m = 1, \dots, M$ . Each individual's utility,  $U_m$ , is allowed to depend on their own consumption and that of all other extended family members. Each consumption vector is denoted by  $\theta_{km}$ ,  $k = 1, \dots, K$ , where  $k$  indexes goods, and  $\theta_{0m}$  denotes leisure of member  $m$ . The vectors  $\theta_{km}$  contain a variety of goods, but specifically include health and human capital outcomes. We analyze conditional demand functions related to human capital, and consider health and education directly as consumption goods. This is not an unreasonable approach, as evidence suggests extended families place great emphasis on the health and well-being of their young children. The model allows one to remain agnostic about the form of the utility functions, and only requires standard assumptions that they be quasi-concave, non-decreasing, and strictly increasing in at least one argument.

Individual utility is allowed to vary depending on individual, household, and dynasty specific characteristics. Some of these characteristics, denoted by  $\mu$ , are observed in the data, and include variables such as age, household demographic structure, anthropometrics, and socioeconomic status. Other characteristics which influence utility remain unobserved to the econometrician, and are denoted by  $\varepsilon$ . Such characteristics may include attitudes toward health investments and altruism. Each individual's utility function is defined as  $U_m(\theta, \mu, \varepsilon)$ .

The extended family welfare function,  $W$ , aggregates individual utilities with corresponding weights given by the function  $\lambda(\pi, \xi)$ . The weight an individual's utility receives within the extended family depends on observed individual, household and dynasty characteristics, denoted by  $\pi$ , which may include individual asset holdings, marriage market opportunities, age, prices, and the wealth of each dynasty member. The weights may also depend on unobserved characteristics,  $\xi$ , such as time pref-

erences.<sup>6</sup> The presence of the weighting function  $\lambda(\cdot)$  incorporates the notion of an intra-dynasty decision making process, and reflects each members' power in influencing allocation decisions. One advantage of this general model is that it is consistent with a variety of bargaining processes within the extended family, allowing one to remain agnostic on the actual process within the dynasty, including whether one occurs. As we address further when discussing the collective model, the weights do not have a direct impact on an individual's utility, but do place testable restrictions on how an individual's bargaining power may influence decisions within the family.

As stated, the dynasty's problem is to maximize extended family welfare subject to a budget constraint that requires the amount of dynasty expenditure to be less than or equal to the value of total family assets and labor income. Formally, the family solves:

$$\max_{\theta} W [U_1(\theta, \mu, \varepsilon), \dots, U_M(\theta, \mu, \varepsilon), \lambda(\pi, \xi)] \quad (2.1)$$

subject to:

$$p_{\theta}\theta \leq \sum_m [A_m + p_{0m}(T - \theta_{0m})] + A_0 \quad (2.2)$$

where  $A_m$  are assets controlled by family member  $m$ , and  $A_0$  are assets jointly controlled by the dynasty. Individual labor income is the product of an individual's wage,  $p_{0m}$ , and labor hours, where  $T$  is the time endowment. Dynasty expenditure is equal to spending on consumption goods and human capital across all members,  $p_{\theta}\theta$ .<sup>7,8</sup>

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<sup>6</sup> In this specification,  $\pi$  and  $\xi$  may include some elements that also influence preferences through  $\mu$  and  $\varepsilon$ .

<sup>7</sup> In this framework, savings may be thought of as spending on an investment good.

<sup>8</sup> Although this is a static approach, there are potentially important implications of this model in dynamic settings. Considering a dynamic model is left for future work, and will be able to speak to insurance and consumption smoothing within extended families in an important way.

The above framework is general enough to encompass both the unitary and collective models of extended family behavior. As the allocation patterns which result from the two frameworks provide the theoretical basis for the remainder of the chapter, the conditional demand functions and testable implications that stem from each of these models follow in the next sections.

### 2.2.1 Unitary Model

At the dynasty level, the unitary model is equivalent to either a model where all family members have the same preferences, or a dictator model where only one decision maker's preferences enter the welfare function  $W$  (e.g. Samuelson, 1956; Becker, 1981). When one imposes the restrictions of the unitary model on the general framework, solving the extended family's maximization problem results in a conditional demand equation for good  $k$  of the form:

$$\theta_k = \theta_k \left( \sum_m y_m, p, \mu, \varepsilon \right) \quad (2.3)$$

where resources of member  $m$ , including assets and income, are given by  $y_m$ ,  $p$  is a vector of exogenous prices, and  $\mu$  and  $\varepsilon$  are observed and unobserved characteristics. The key feature of equation (2.3) is that individual resources enter the conditional demand function only through their part in the sum total of family resources,  $\sum_m y_m$ . This is often referred to "income pooling" interpretation of the unitary model, which offers clear testable implications of the framework. In the extended family setting, the restriction implies that once we control for total dynasty resources, the share under the control of a child's own household, grandmother, father, aunt, or uncle should have no independent effect on allocation decisions. This is a strong restriction which merits empirical examination.

### *Testable Implications of the Unitary Model*

If the unitary model is valid, families act as if the resource distribution within the extended family is irrelevant. This is empirically testable by examining whether the marginal effect of each member's resources on childhood outcomes is the same regardless of whom we consider. For example, do resources under the control of fathers and grandmothers have the same impact on child health? Letting family members be indexed as  $m$  and  $n$ , in terms of equation (2.3), the theoretical predication is:

$$\frac{\partial \theta_k}{\partial y_m} = \frac{\partial \theta_k}{\partial y_n} \quad \forall k, m, n \quad (2.4)$$

As resources are effectively pooled, each addition to the pool will have the same effect. While this test has been undertaken in a variety of papers empirically assessing the validity of the unitary framework at the household level, we choose to use an alternative specification.<sup>9</sup> As only total dynasty resources matter in the conditional demand function in equation (2.3), if one conditions on total family resources,  $\sum_m y_m$ , the share controlled by any specific individual should have no impact on  $\theta$ . In terms of equation (2.3), that is:

$$\left. \frac{\partial \theta_k}{\partial y_n} \right|_{\sum_m y_m} = 0 \quad \forall k, n \quad (2.5)$$

A full description of the empirical implementation of this testable restriction, its advantages, and a discussion of results follow in later sections. We turn next to the collective framework, and discuss the testable implications that follow from a more general model of family behavior.

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<sup>9</sup> See Horney and McElroy (1988), Schultz (1990), and Thomas (1990) among others for tests of the unitary model relying on restrictions similar to (2.4).

### 2.2.2 *Collective Model*

The unitary model provides a baseline for the analysis of extended families and child well-being. However, if one rejects the unitary framework, the aforementioned tests do not immediately offer an appropriate alternative model of family behavior in its place. As a result, it is only natural to follow tests of the unitary model with those derived from a more general alternative. The collective model relaxes the common preferences or dictator assumptions of the unitary framework, and allows for sharing and bargaining within families. The key assumption maintained by the model is that allocation decisions achieve Pareto efficient outcomes.<sup>10</sup> This formulation can be interpreted in terms of how families share resources.

#### *Income Sharing Approach*

Browning and Chiappori (1998) show that the collective model is formally equivalent to a model where families make allocation decisions in a two step process. In the first stage, extended family members effectively pool their resources together and then distribute them with each member receiving a share determined by their relative power within the dynasty. In the second stage, members make maximizing allocation decisions subject to the share of resources they received in the first stage.

In this interpretation of the collective model, the fraction of total family resources a decision maker receives is determined by a sharing rule related to the weighting function,  $\lambda(\cdot)$ . The sharing function depends on individual resources, prices, other observed and unobserved factors, and is defined as  $\alpha_m(y_1, \dots, y_M, p, \pi, \xi)$  for each member  $m$ . Letting  $Y$  be total pooled dynasty resources in the first stage, each member receives a fraction of total resources,  $Y_m$ , as determined by the sharing

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<sup>10</sup> An additional additive separability assumption is also needed which we discuss later.

rule:<sup>11</sup>

$$Y_m = \alpha_m(y_1, \dots, y_M, p, \pi, \xi)Y$$

The incorporation of the sharing rule in the collective model allows more influential family members to have a greater say in the relative share each individual receives in the first stage.

In the second stage, individual family members maximize their own utility subject to a budget constraint that limits allocation decisions by  $Y_m$ . Member  $m$ 's resulting conditional demand equation for good  $\theta_k$  takes the form given below:

$$\theta_{mk} = \theta_{mk}(Y_m(y_1, \dots, y_M, \pi, \xi), p, \mu, \varepsilon) \quad (2.6)$$

Equivalently, because each  $Y_m$  depends on the sharing rule and the same arguments, equation (2.6) is the same as:

$$\theta_{mk} = \theta_{mk}(y_1, \dots, y_M, p, \mu, \varepsilon) \quad (2.7)$$

This function has several distinct properties which set it apart from the conditional demand function from the unitary model in equation (2.3). While only total family resources matter in the unitary demand function, here individual resources enter through the effect of each  $y_m$  on  $Y_m$ . This weak separability in equation (2.6) leads to a testable implication well established in the intrahousehold literature (e.g. Bourguignon et al., 1993; Browning and Chiappori, 1998).

The empirical test of the model follows from the restriction that individual resources only influence demand through the share of resources an individual receives in the first stage of the two step process. Chiappori and coauthors show that under

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<sup>11</sup>  $Y$  is equivalent to  $\sum_m y_m$  in the unitary framework. The alternative notation is used only for clarity.

the assumption of Pareto efficiency, the ratio of marginal effects of one family member's resources on good  $\theta_k$  to another member's resources will be constant across goods. This is highlighted in the specification of equation (2.6). Any factor that impacts the demand for  $\theta_k$  only through the share of resources received in the first stage must influence all demands from the second stage in the same way.

*Testable Implications of the Collective Model*

This test of Pareto efficiency can be carried out by looking at the marginal rate of substitution, the ratio of marginal effects, with respect to different family members' resources. For concreteness, consider a demand function of the form defined in equation (2.7) and  $M = 2$ , although the implication holds for an arbitrary  $M$  as shown in Bourguignon et al. (2009). The model predicts that the ratio of marginal propensities to consume from each members resources,  $y_1$  and  $y_2$ , will be constant across goods. To see this, note that the marginal impact of  $y_1$  on a good  $\theta$  is:

$$\frac{\partial \theta}{\partial y_1} = \frac{\partial \theta}{\partial Y_m} \frac{\partial Y_m}{\partial y_1} \tag{2.8}$$

Similarly, the marginal impact of  $y_2$  on the same good  $\theta$  is:

$$\frac{\partial \theta}{\partial y_2} = \frac{\partial \theta}{\partial Y_m} \frac{\partial Y_m}{\partial y_2} \tag{2.9}$$

In both derivatives, the first term is independent of the resources we are considering, while the second term is independent of the outcome. This is a direct result of each  $y$  influencing demand for  $\theta$  only through the share of resources received in the first stage.

This relationship defines the test of the collective model. If one takes the *ratio* of marginal effects, equation (2.8) divided by equation (2.9), the first term in each derivative will cancel, and the resulting expression is independent of  $\theta$ .

$$\frac{\frac{\partial \theta}{\partial y_1}}{\frac{\partial \theta}{\partial y_2}} = \frac{\frac{\partial \theta}{\partial Y_m} \frac{\partial Y_m}{\partial y_1}}{\frac{\partial \theta}{\partial Y_m} \frac{\partial Y_m}{\partial y_2}} = \frac{\frac{\partial Y_m}{\partial y_1}}{\frac{\partial Y_m}{\partial y_2}} \quad (2.10)$$

This restriction on the marginal rate of substitution follows from the two stage budgeting interpretation of family interaction. As the distribution of dynasty resources takes place before individual allocation decisions, factors which influence a members share can only affect allocations in a specific way in the second stage.

Written more generally for arbitrary goods  $j$  and  $k$ , and resources in control of  $m$  and  $n$ , a system of demand allocations is compatible with Pareto efficiency if the ratio of marginal effects is constant across all outcomes. That is:

$$\frac{\frac{\partial \theta_j}{\partial y_m}}{\frac{\partial \theta_j}{\partial y_n}} = \frac{\frac{\partial \theta_k}{\partial y_m}}{\frac{\partial \theta_k}{\partial y_n}} \quad \forall j, k, m, n \quad (2.11)$$

This result allows us to empirically assess the predictions of the collective model.

## 2.3 Empirical Implementation

Whether the unitary or collective models is a valid characterizations of family behavior is an empirical question. This section places the theoretical predictions of the unitary and collective models into an empirical regression context.

### 2.3.1 Unitary Model Demand Functions

To analyze whether or not extended families can be appropriately characterized as unitary, we examine whether the share of total family resources controlled by a child's household is a significant predictor of human capital outcomes. This is done by estimating the following linearized version of the conditional demand function presented in equation (2.3):

$$\theta_{mhd} = \beta_1 y_h + \eta_d + X_{mh} \gamma + \varepsilon_{mhd} \quad (2.12)$$

where  $\theta_{mhd}$  is the human capital outcome of child  $m$  in household  $h$  and dynasty  $d$ ,  $y_h$  are household resources, and  $X_{mh}$  are relevant control variables at the child and household level. The dynasty fixed effect,  $\eta_d$ , captures all characteristics common, additive, and linear at the dynasty level, including total dynasty resources. This strategy controls for forms of otherwise unobserved heterogeneity that may be difficult to model. These include, but are not limited to, common genetic background, dynasty wide preferences, heredity factors, common prices, and expected future family resources. The use of a fixed effect specification exploits the genealogical construction of extended families discussed in the next section.

The coefficient of interest in equation (2.12) is  $\beta_1$ . As stated in equation (2.5), the unitary model predicts that once total dynasty resources are accounted for, the share controlled by a child's household should have no impact on  $\theta$ . Because total dynasty resources are captured through the fixed effect,  $\eta_d$ , the null hypothesis of our test is that  $\beta_1$  is equal to zero.

If the estimated  $\beta_1$  in equation (2.12) is statistically different from zero, the distribution of resources matters and one is able to reject the unitary model as an appropriate characterization of extended family behavior.

### 2.3.2 *Collective Model*

As the collective model is a more general formulation than the unitary model, it is natural to follow rejections of the unitary framework with tests of Pareto efficiency. This is done by estimating a linearized version of the conditional demand function similar to equation (2.7):

$$\theta_{mhd} = \beta_1 y_h + \beta_2 y_d + X_{mhd} \gamma + \varepsilon_{mhd} \quad (2.13)$$

where  $y_h$  are household resources, and  $y_d$  are the resources of all other households in the dynasty excluding a child's own household  $h$ . In order to estimate the impact of resources controlled by other family members outside of a child's household, we must remove the dynasty fixed effect from equation (2.12) and estimate the linear analog instead to obtain an estimate of  $\beta_2$ .<sup>12</sup> As a result of removing  $\eta_d$ , we include dynasty characteristics, along with child, household, and location controls in  $X_{mhd}$  to isolate the effect of resources in  $\beta_1$  and  $\beta_2$ .

The collective model imposes restrictions on the ratio of coefficients across outcomes. Letting  $\beta^j$  and  $\beta^k$  represent the marginal impact of resources on outcomes  $j$  and  $k$ , the null of the collective rationality test is that the ratio of marginal effects must be constant across outcomes:

$$H_0 : \frac{\beta_1^j}{\beta_2^j} = \frac{\beta_1^k}{\beta_2^k} \quad \forall j, k$$

Or alternatively:

$$H_0 : \beta_1^j \beta_2^k = \beta_1^k \beta_2^j \quad \forall j, k$$

One potential concern of this strategy at the household level is that estimates of the  $\beta$  coefficients are confounded if living arrangements within families are endogenous. If this is the case, the distribution of  $y_h$  and  $y_d$  may be endogenous as well. A key advantage of the IFLS is that it allows one to go beyond the household level and examine the impact of resources controlled by specific individuals within the extended family. This looks at the impact of individual resources regardless of living arrangements.

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<sup>12</sup> We have attempted to use the IFLS panel to avoid this issue and estimate (2.13) with a dynasty fixed effect, exploiting variation in the distribution of dynasty assets across time. However, we are limited by the nature of fertility choices, as there are not sufficient numbers of children in consecutive waves to identify a version of (2.13) with an extended family fixed effect. We discuss this further in Section 2.5.4.

When testing the collective model at the individual level, equation (2.13) is modified to include resources under the control of a child’s mother, father, grandfather, and grandmother, as well as relevant controls for each individual. Resources controlled by other coresident and non-coresident dynasty members are included to ensure all dynasty resources are accounted for in the individual level specification.<sup>13</sup> The conditional demand function we estimate is given by the following equation:

$$\theta = \beta_1 y_{father} + \beta_2 y_{mother} + \beta_3 y_{grandfather} + \beta_4 y_{grandmother} + \beta_5 y_{other\ household\ members} + \beta_6 y_{other\ dynasty\ members} + X\gamma + \varepsilon \quad (2.14)$$

where  $X$  now includes controls for child, household, location, maternal, paternal, and grandparent characteristics. In equation (2.14)  $y_{other\ household\ members}$  are the assets controlled by those family members who co-reside with the child of interest, but are not the child’s parent or grandparent. Similarly,  $y_{other\ dynasty\ members}$  are the assets owned by non co-resident family members that are not a child’s grandparent or parent. These typically include resources of a child’s older siblings, cousins, aunts, and uncles. A similar ratio test used at the household level applies to the individual model for each of the possible coefficient pairs. The null is simply a more general version of the previous form, which must hold across all outcomes for all combinations of the six  $\beta$  coefficients rather than only two.<sup>14</sup>

### 2.3.3 Estimation

As the collective model imposes cross equation restrictions, the three equations are estimated jointly to obtain the variance covariance matrix necessary to construct

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<sup>13</sup> To be clear, individual assets are constructed so that  $y_h + y_d = y_{father} + y_{mother} + y_{grandfather} + y_{grandmother} + y_{other\ hh\ members} + y_{other\ dynasty\ members}$ . The two “other” categories typically include siblings, aunts, and uncles.

<sup>14</sup> For example, the ratio of mothers to grandmothers marginal effects must be the same for all outcomes, as well as mothers and grandfathers resources, and every other combination of the coefficients from equation (2.14).

the nonlinear Wald statistics for the Pareto efficiency tests. All standard errors reported in the results are calculated allowing for intra-family correlation by clustering at the family level. This is potentially important as the results rely on comparing health outcomes across children in the same family who clearly share genetic components. Results using block-bootstrapping with blocks defined at the family level are consistent with those reported here.

## 2.4 Data

Extensive data is required to analyze the relationship between extended family resources and child well-being. Few data sets provide information on the level and distribution of resources controlled by both co-resident and non co-resident family members as well as detailed information on child outcomes. Our empirical results rely on one source which does contain such data, the most recent wave of the Indonesia Family Life Survey (IFLS). The IFLS is a large-scale, ongoing longitudinal survey that collects detailed information on individuals, households, and the communities in which they live. The IFLS began in 1993 with a sample of 7,224 households and 22,000 individuals, and was representative of 83 percent of the Indonesian population. The second wave was collected in 1997, and a third in 2000. The most recent wave in late 2007 and early 2008 included approximately 13,500 households and 43,500 individual interviews.<sup>15</sup> One of the exceptional features of the survey is the high re-contact rate of respondents, including among those who relocate.<sup>16</sup> The IFLS4 team successfully re-contacted 90.6% of the living IFLS1, 2 and 3 households, and 87% of original living IFLS1 respondents. These rates are as high, or higher, than the majority of large scale longitudinal surveys in the United States and Eu-

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<sup>15</sup> For a full description of IFLS1, IFLS2, IFLS3 and IFLS4, respectively see Frankenberg and Karoly (1995), Frankenberg and Thomas (2000), Strauss et al. (2004), and Strauss et al. (2009).

<sup>16</sup> IFLS tracks all movers if they relocate to one of the 13 IFLS provinces.

rope. For the purpose of this study, high recontact is essential to maintain detailed information on extended family members.<sup>17</sup>

#### *2.4.1 Constructing the Extended Family*

The structure and tracking scheme in the IFLS allow one to identify families within the survey by linking individuals who move away from the families back to their household of origin. This is only possible due to the great efforts of the IFLS team to track individuals across the country. The study protocol states that when a member leaves an original IFLS household, their new household is located and becomes part of the IFLS target sample in all subsequent waves. As families have grown between 1993 and 2007, the continued tracking and inclusion of split-off households makes it possible to retain data on the extended family. IFLS dynasties are created by linking these split-off households back to their original roots.<sup>18</sup>

Figure 2.1 provides an illustration of how this process works for a sample dynasty. Consider a base household in the first wave of IFLS that contains two parents and their two children. Four years later when recontacted in IFLS2, the two children have left and split-off to form their own households. These households are located and interviewed by IFLS enumerators, and the original base household is now considered a dynasty consisting of three households. In the following wave, IFLS3, the original children have married, and their spouses have become part of the IFLS sample. These spouses are administered the same full individual interview as the original panel members. The light gray individuals signify that there are members of the joiners' families which are not directly interviewed in the survey. The IFLS does collect extensive information about the joiners' parents and siblings, including their education level, vital status, and data on transfers, but they are not administered

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<sup>17</sup> See Thomas et al. (2012) for a more detailed account of attrition in the IFLS.

<sup>18</sup> This is similar to a method used by Altonji et al. (1992) with the Panel Study of Income Dynamics and Witoelar (2012) with earlier waves of the IFLS.

interviews themselves. Finally, fourteen years after the IFLS began, each of the original split-off households now has two children. These children define the analytical sample. In the case of the example family in Figure 2.1, the original root household is now a dynasty made up of three households, with individual data for the children's parents and grandparents in IFLS4. This rich structure allows us to empirically test the theoretical models presented in Section 2.3.

Although we do not observe the full genealogical family tree, this is a detailed characterization of the extended family, and allows the use of dynasty fixed effects to control for unobserved, extended family heterogeneity in the tests of the unitary model. We discuss the issue of the incomplete family further in Section 2.5.4. Table 2.1 provides an overview of the number of children, households, dynasties, parents and grandparents in our sample.

#### *2.4.2 Health and Development Outcomes*

The IFLS not only contains genealogical families, but detailed health and development outcomes as well. This analysis focuses on three markers of child health and development; height-for-age, early school attendance, and cognition.<sup>19</sup> Height is measured as a z-score standardized for gender and age in months using the 2000 Center for Diseases Control growth tables, which are normed to a representative, well-nourished child in the United States. Height is an accepted long-run marker of human capital, and a stock variable embodying nutritional investments made during early childhood.<sup>20</sup> While a variety of nutrition and medical studies have found the heredity of height to be approximately 75 to 80 percent (Silventoinen et al., 2000), the

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<sup>19</sup> Trained health workers collect anthropometric data in IFLS, and the survey contains a wide range of potential outcomes. Along with those presented here, body mass index, hemoglobin levels, weight-for-age, an interviewer's health assessment, school enrollment, and others outcomes have also been considered. Results using alternative outcomes besides those presented here are consistent with those shown and available upon request.

<sup>20</sup> See, for example, Alderman et al. (2006), Mwabu (2008), Strauss and Thomas (1998), and Waterlow et al. (1977).

remaining 20 to 25 percent is a reflection of environmental factors during pregnancy and early life such as maternal smoking, nutritional intake, the disease environment, and health insults. The effect of resources on height have been shown to be most influential in the early years of life (Alderman et al., 2006), and we focus on children up to six years of age when examining height-for-age.

We also consider early school attendance as a dependent variable and marker of human capital accumulation. Although in a different context, work examining the causal effect of early start programs in the United States show a significant positive effect of early school attendance on markers such as high school completion, college attendance, and later life outcomes (e.g. Garces et al., 2002). We simply follow the reasoning that attending school at an early age will offer students an advantage in later life. The marker of early attendance is whether or not a child ever attended kindergarten in a sample of children age six to fourteen.<sup>21</sup>

The third outcome takes advantage of a non-verbal cognitive assessment included in the IFLS. Individuals age seven to twenty four were given a test comprised of Raven’s Colored Progressive Matrices (CPM) pattern recognition questions and SAT style math problems to assess their cognitive function.<sup>22,23</sup> A sample CPM question is included in Figure 2.2. Individuals age seven to sixteen are used when examining the impact of family resources on cognitive scores, although both qualitative and quantitative results are not sensitive to this restriction. The CPM assessment is frequently used in medicine and psychology as a measure of general intelligence, and is accepted as the single best measure of Spearman’s general intelligence factor  $g$  (e.g. Raven, 2000; Kaplan and Saccuzzo, 1997). For ease of interpretability, scores

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<sup>21</sup> The question on kindergarten attendance was new in IFLS4 and not asked to those above the age of 15.

<sup>22</sup> Individuals over the age of 24 who had taken the cognitive function test in a previous wave of IFLS were also administered the exams in IFLS4.

<sup>23</sup> The CPM is designed particularly for children. For a background on the Raven’s Standard Progressive Matrices (SPM) test, see Raven (1958), or Raven (2000) for a more recent treatment.

are reported as the percent correct, and age is flexibly controlled for in the empirical analysis to account for the fact that older children naturally perform better.

### *2.4.3 Family Resources*

The theoretical predictions outlined in Section 2.2 rely on the distribution of resources within the family. Child outcomes will be invariant to this distribution in the unitary model, but will be influenced through its impact on family bargaining in the collective model. Previous studies in the intrahousehold literature have estimated Engel curves relying primarily on expenditure to test the unitary and collective models. However, this strategy presents several concerns, and bargaining power is instead associated with the value of assets under the control of each household, or individual, within a dynasty. The IFLS includes a detailed roster of assets, and this analysis focuses on the eleven liquid assets in the estimation.<sup>24,25</sup>

One of the benefits of focusing on assets rather than household expenditure is the ability to conduct the analysis at both the household and individual level. The IFLS questionnaire asks each adult member of a household age 15 and above about the total value of household assets in each of the categories, as well as the share which they and others within and outside the household control. The measures of individual resources are obtained by multiplying the reported value of an asset by

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<sup>24</sup> In the order asked, the liquid asset categories are: poultry, livestock, hard stem plant, vehicles (cars, boats, bicycles and motorbikes), household appliances, savings/certificate of deposit/stocks, receivables, jewelry, household furniture and utensils, and other.

<sup>25</sup> Results including illiquid assets, house occupied by the household, other house, non-agricultural land, are qualitatively similar and available upon request.

an individual's share, and summing over the liquid asset categories.<sup>26</sup>

While we begin with household level analysis as a first step and to be consistent with the previous literature, utilizing individual level data has many advantages. Chief among these is the ability to avoid concerns associated with endogenous living arrangements and the distribution of household assets mentioned in Section 2.3.2. Using individual level data allows us to compare resources of different family members both within and across households. This lets us examine any sharing that happens between extended family members, even within a household unit. For instance, if the primary means of sharing amongst families happens through co-residence patterns, i.e. young children living with their grandmothers, this will be clear at the individual level, but undetectable using household level data.

Focusing on assets is certainly not without risk, and our results come with the caveat that the distribution of asset may be the outcomes of an extended family allocation process and pose endogeneity concerns. However, they do serve a distinct improvement over utilizing expenditure. To be consistent with the literature, we have done tests of the unitary and collective models with household per capita expenditure instead of assets and include a discussion of the results in Supplemental Section 2.7. We maintain a preference for assets, as they reflect a closer representation of long-run resources and power in the family. Without additional restrictive assumptions, expenditure should be seen as the outcome of the bargaining process, not a distribution factor which influences the first stage of the budgeting process.

Summary statistics reporting means and standard errors are shown in Table 2.2.

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<sup>26</sup> There are often different and inconsistent answers for individuals' assets within the same household, which leaves many plausible models for constructing individual assets. One possibility would be to trust the household head's response as the correct depiction of the asset distribution, and create individual assets from their response on others' ownership. However, the data shows spouses systematically underreport the value of assets held by their partner. This pattern is particularly true for husbands' reports on their wives' assets. Instead, each individual's own response is used if available. If an individual's own response is not available due to refusal or other reason, we use the response from a spouse. This occurs for approximately 6% of cases.

Because we consider different samples due to the relevance of our outcomes for different age groups, Table 2.2 includes summary statistics for all children from birth to sixteen in column 1, and for each of the three groups in columns 2 through 4. Mean height for age in young children is -1.14, implying that an average child in the Indonesian sample is more than one standard deviation shorter than a well-nourished child of the same age and gender in the United States. Approximately half of the children between the ages of 6 and 14 attended kindergarten, and the mean score on the cognitive assessment is seventy percent correct. Additional control variables used in the regressions appear below the outcomes.<sup>27</sup> With a theoretical model at hand, and a knowledge of the data and empirical specification, we move next to discuss our results.

## 2.5 Findings

This section presents and discusses the empirical results in the context of the unitary and collective models. Throughout, we refer to tables 2.3 through 2.6, which report  $\beta$  estimates and model tests.<sup>28</sup> At the household level, we use a logarithmic transformation of assets as our key resource measure. However, for analysis at the individual level we instead use a quartic root transformation. This approximates the common logarithmic function, but is defined at zero and allows us to include children whose family members report zero assets. We maintain logs at the household level for ease of interpretation, and because there are not a significant amount of

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<sup>27</sup> Controls include gender and age of the child, using indicator variables for each age, and whether the child lives with their mother and father. At the household, and dynasty level when appropriate, we include demographic controls including household size and composition, and age and education of the household and dynasty head. Factors common at the province level are controlled for with province fixed effects, and we include an indicator for whether the household is located in an urban or rural region. In regressions examining child height, both mother's and father's height is included to capture the genetic component of height as well as additional factors not controlled for by parental education and age.

<sup>28</sup> Due to space considerations, only the  $\beta$  coefficients are reported here. Results including all additional controls are available upon request.

zero-valued observations to warrant concern.<sup>29</sup> Supplemental Section 2.7 discusses tables 2.7 and 2.8 containing comparable results using per capita expenditure rather than assets.

### *2.5.1 Tests of the Unitary Model*

To begin, Table 2.3 shows results for tests of the unitary model from equation (2.12) using dynasty fixed effects to sweep out factors that are common, additive, and linear at the extended family level. Assets are reported in the log of Rp0,000, implying  $\hat{\beta}$  may be interpreted as the change in the outcome variable due to a percentage change in assets. However, the main interpretation and inference relies only on the sign and significance regardless of the transformation; the unitary model predicts that child outcomes should not be sensitive to the distribution of resources within the extended family, and each  $\beta$  should be zero. The results in Table 2.3 clearly reject this prediction. Instead, when the value of resources controlled by a child's own household increases, there is a significant increase in all three of their health and human capital outcomes.

These results strongly reject the restrictions of the unitary model. We reject the notion that the share of family resources controlled by a child's own household does not have an impact on outcomes. It follows that the unitary model is not an appropriate representation of the extended family, and alternative frameworks need to be considered. The more general collective model of Pareto efficiency provides a natural next step.

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<sup>29</sup> 99.2% of all households report non-zero values for liquid asset holdings. The remaining 0.8% are not dropped, but instead we replace the 0 value with the imputed mean value and include an indicator in the regression noting replacement.

### *2.5.2 Tests of the Collective Model at the Household Level*

In order to test Pareto efficiency between a child's own household and the remainder of the extended family, we estimate the impact of dynasty resources independent of household assets as in equation (2.13). Doing so allows one to estimate the marginal effect of resources controlled by non-co-resident family members to compare the marginal rate of substitution across outcomes. These results are reported in Panel A of Table 2.4, which shows estimates of the impact of household and dynasty resources on child well-being.

The results provide clear evidence that extended family resources matter on top of household assets. Household resources have a strong positive relationship with each of the outcomes, but the table also shows that assets controlled by non-co-resident family members have an independent impact on human capital accumulation of young children. In all cases, increasing the value of assets held by non-co-resident family members is associated with a statistically significant increase in the outcomes of interest.

Panel B of Table 2.4 includes the analog to the unitary test in Table 2.3 as well as the ratios of coefficients needed for the tests of the collective model. In the estimation equation used in Table ??, the unitary model predicts the marginal impact of household and dynasty assets,  $\beta_1$  and  $\beta_2$ , be equal. The  $p$ -values for this test are shown in Panel B, and are all below any reasonable level of rejection, further supporting our rejections of the unitary model from Table 2.3.

Tests of the collective model rely on assessing whether the ratio of coefficients from Panel B are equal across outcomes. These ratios are calculated using the delta method, with standard errors calculated allowing for clustering at the family level. They are remarkably close and precisely estimated, and imply the marginal impact of resources controlled by a child's own household is approximately two and half times

larger than resources controlled by non-coresident family members. Panel C reports results from the formal tests of equality across these three ratios.

The first three rows of Panel C show  $p$ -values from the pairwise tests of the equality between the outcomes in the first and second column. For example, the first value in Panel C of 0.97 suggests that we cannot reject that the ratio of household to dynasty resources is the same for height-for-age (2.65) and early school attendance (2.60). This is true for each of the pairwise tests. The final row shows the test for equality across all three ratios (2.65, 2.60, and 2.60) is not rejected. All of the  $p$ -values are well above any reasonable range of rejection, implying that we are not able to rule out Pareto efficiency in any of the tests. While the unitary model of the extended family is clearly rejected, it is not possible to reject that extended families allocate resources Pareto efficiently and may be appropriately modeled as a cooperative unit of heterogeneous individuals.

This is an important insight on two fronts. First, it provides empirical evidence on the appropriate theoretical model to analyze extended family interaction and generational exchange. Second, it provides support for theories which justify observed patterns of family behavior as the outcome of cooperative, efficient decision making.

### *2.5.3 Individual Level Analysis*

Having rejected the unitary model at the household level but not tests of collective rationality, we next take a deeper look within the extended family and analyze efficiency at the individual level. These results provide empirical evidence on the importance of intergenerational transfers in child development, and go beyond previous literature which has focused primarily on the household. Although the estimates require a slightly more nuanced interpretation due to the quartic root specification of assets, the main implications and interpretation based on the sign and significance of the resource effects is still valid.

Table 2.5 contains estimates of equation (2.14) exploring the effect of individual level assets on child outcomes. The results highlight the importance of resources under the control of mothers for child outcomes. This is true across all of the outcomes, as the impact of mothers resources are strongly significant and larger in magnitude than those controlled by any other source. This finding suggests persistent benefits for those children in families where mothers control a substantial amount of resources.

Along with mothers' assets, there are also positive and significant effects for father's and grandmother's assets on child outcomes. The relationship between grandmothers and grandchildren highlights the importance of intergenerational interaction, as the effect of grandmothers' assets is on the order of fathers' resources.

Assets held by the remainder of a child's household and other non co-resident family members are strongly significant and large in magnitude across all outcomes. This suggests that a broader view of the family beyond paternal and grandparent resources should be considered when analyzing interactions and sharing within families. Siblings and non co-resident relatives including aunts and uncles may play as much, if not more, of a role than a child's own father and grandparents. Examining the role of sibling networks in child development is an exciting area for future work.

#### *Individual Pareto Efficiency Tests*

The results in Table 2.5 not only reveal patterns of sharing within families, but make it possible to test the collective model. Table 2.6 shows the individual level analog to the household Pareto efficiency tests in Panel C of Table 2.4. Similar to the previous results, the table shows  $p$ -values from the nonlinear Wald tests of the restrictions imposed by the collective model. As six different resource coefficients are included in equation (2.14) (resources controlled by mothers, fathers, grandmothers, grandfathers, and other household and dynasty members), there are fifteen pairwise restrictions to test. In order for the collective model to be valid, each of these pairs

must be equal for each outcome. Table 2.6 reports results from both pairwise tests as well as joint tests over groups of ratios.

In each case, the individual listed in the column of Table 2.6 is the denominator and the individual in the row is the numerator. For example, 0.72 is the  $p$ -value of the test comparing the marginal impact of father's resources to mother's resources between height-for-age and early school attendance.<sup>30</sup> The value suggests that we cannot reject the null that the ratios are the same. The same holds true for each of the pairwise tests, the tests examining equality between parents and grandparents, and the overarching tests across outcome pairs and across all three outcomes. While the unitary model is clearly rejected, these results in combination with those in Table 2.3 suggest that we cannot reject Pareto efficiency and the collective model amongst the extended family.

This is a remarkable result, and extends the household level analysis in a new dimension. The empirical findings again suggest that we cannot rule out that extended families behave in a cooperative manner consistent with Pareto efficiency. Extended family networks in Indonesia appear to be able to overcome market imperfections and barriers to exchange to allocate resources efficiently. Moreover, this appears to be the case in the particular domain of child well-being and human capital accumulation. The relationship between individual wealth and child outcomes with clear welfare implications appears to be consistent with a model of collective rationality within families.

#### *2.5.4 Sensitivity Analysis and Robustness*

In order to ensure the validity of the results, numerous robustness checks were conducted in a number of subsamples and alternative specifications to address various hypothesis concerning the sharing habits of extended families. The rejections of the

<sup>30</sup> The ratios are 0.40 and 0.74 as calculated from Table 2.5.

unitary model and failure to reject efficiency remained robust throughout these variations. Allowing for nonlinearities in the impact of resources, considering additional child outcomes, and examining specific subsamples does not change the conclusions: interactions within extended families appears consistent with the collective model.

While this analysis focuses on three outcomes with clear welfare implications, the findings are robust to using BMI, weight-for-age, a health worker’s observational health assessment, and school enrollment as outcomes of interest. Similarly, variations to the functional form used for assets do not change the conclusions. While results presented earlier are linear in the log or quartic root of assets, allowing assets to enter in non-linear forms including quadratics, cubic polynomials, and splines does not change the rejections of unitary or failures to reject Pareto efficiency.<sup>31</sup>

It is possible that efficiency may be rejected for certain fractions of the population such as families with low socioeconomic status, or findings may differ by the gender of the child. To test whether Pareto efficiency could be rejected for sub-groups of the population, we stratified our sample on a variety of demographic factors as well as running fully interacted models with a number of characteristics. We examined if Pareto efficiency could be rejected for families with different age and gender composition, education levels, greater physical distance between households, or more resources, and found no differences. We stratified the sample based on household and dynasty size, parents’ co-residence status, the number of children within a family, and the number of other children within the household or dynasty close in age to the child. These sample cuts suggest competing over resources with more family members has no impact on efficiency, nor are the results driven by wealthy families providing resources for their children.

We also examined whether stratifying the sample based on urban and rural families, geographic distance to other family members, the age of a child’s mother and

<sup>31</sup> Furthermore, we were not able to rule out linearity through the use of specification tests.

father, and the median, mean, and maximum levels of education of adults in the household and family had any impact on our results. Across all stratifications, we found no rejections of Pareto efficiency.

The panel structure of the IFLS also offers a number of additional explorations beyond the 2007 wave used in the body of the results. However, using previous waves presents challenges due to the reliance on split-offs for identifying extended families. As families expand over the course of the survey, the number of dynasties with split-off households is significantly smaller in earlier waves of the survey. However, prior waves have slightly lower levels of attrition, which makes analyzing them attractive.<sup>32</sup> Despite the smaller sample of households, reestimating the models using data from the 2000 wave of the IFLS produce results that are consistent with those shown here: we again reject the unitary model, and fail to reject Pareto efficiency. Moreover, many of the coefficient estimates are also similar across the different waves.

We also considered combining data across waves to form a panel to estimate models which control for dynasty fixed effects in all regressions, not only those testing the unitary model. Combining the 2000 and 2007 waves would provide data where dynasty assets vary across time.<sup>33</sup> This strategy is used in Witoelar (2012) in estimating Engel curves. However, because the outcomes of interest are at the child level, the sample of families for which these models is identified is small and selected. Consider the model which estimates the impact of household and dynasty resources on height-for-age for children up to six years of age. In order to identify the effect of dynasty resources independent of a dynasty fixed effect, there must be multiple children in the extended family between birth and age six in both the 2000 and 2007 waves of the survey. Furthermore, the children would have to be in differ-

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<sup>32</sup> IFLS3 re-contacted 95 percent of living IFLS1 households, while IFLS4 re-contacted 91 percent.

<sup>33</sup> The proposed estimation equation would then be  $\theta_{mhd} = \beta_1 y_{ht} + \beta_2 y_{dt} + \eta_d + X_{mhd} \gamma + \varepsilon_{mhd}$  where  $\eta_d$  captures time-invariant observed and unobserved heterogeneity at the dynasty level.

ent households within the extended family. Despite these challenges, undertaking this estimation strategy produces qualitatively consistent findings, and the magnitude of the coefficients are similar albeit imprecisely estimated.

One limitation of the approach used in this chapter is that the data does not have “complete” extended families, as seen in Figure 2.1. The IFLS tracking scheme offers a number of opportunities to explore the extended family, but the sample does not include any children who are in the extended family, but outside of the IFLS sample. The data does have variation in the branch of the family tree the dynasty is built from; some families form from the maternal branch (split-off women) while others from the paternal (male split-offs). To assess whether it matters if the root household is on the maternal or paternal side of the dynasty, we separately estimated models for families where the mother in a new household is an IFLS panel member compared with those where the father is an IFLS panel member. Again, we found no significant differences.

A related concern is if selected family members are lost due to attrition when they split off. If those extended family members least likely to engage in sharing and efficient behavior are unable to be recontacted in subsequent waves, the results may be potentially biased. To address this issue, we examined whether results differed based on the fraction of known IFLS family members present in the IFLS4 dynasties. The results are not sensitive to dividing the sample into families where a majority of the family is included in the IFLS and a majority is missing. This suggests that selection into the IFLS dynasty is not driving our results.

The robustness of the results to a number of concerns and variations suggests the findings are not unreasonable. A wealth of literature supports the importance of the extended family in human capital accumulation, and previous work has shown allocations to be Pareto efficient at the household level. This analysis has extended these important results to the extended family.

## 2.6 Conclusion

Transfers between extended family members are understood to be an important part of the lives of many individuals, yet there is little known empirically on the subject. This chapter offers an improved way to understand the role that interactions within families play in child development. Through the use of general models of family behavior and rich data on extended families, we show that the unitary model is not a valid characterization of the relationship between co-resident and non co-resident family members. However, we are not able to rule out that extended families behave cooperatively, and that their allocation decisions achieve Pareto efficiency. This result holds not only at the household level, but the rich nature of the IFLS allows us to go beyond previous literature and show that it holds at the individual level as well. These results highlight the role and importance of the extended family in early life human capital accumulation, and provide an empirically supported framework to understand observed patterns of sharing and exchange within families.

The results presented here are important for understanding intra-family relationships and inter-generational transfers. We show that even in a developing setting where market imperfections and shocks are often thought to disrupt exchange, extended families are able to efficiently allocate resources to aid in the health and development of their youngest generation.

## 2.7 Supplement: Testing the Models with Per Capita Expenditure

A number of studies in the intrahousehold literature test the unitary and collective models by estimating Engel curves; consumption shares are regressed against the expenditure or income of different household members to estimate the marginal effect of different family members' resources. In this chapter, we prefer to look at the effect of different family members' *assets* on human capital *outcomes*. We believe this gives the analysis a clearer interpretation, as we examine efficiency in an important realm of family decision making with outcomes that have clear welfare implications. However, to be consistent with the previous literature, we include results for tests of the unitary and collective models using monthly per capita expenditure (PCE) as the right-hand side variable of interest while maintaining child outcomes as the dependent variables.<sup>34</sup> As noted in the the body of this chapter, we do not see this as the most appropriate resource measure for our application.

Results using PCE comparable to those tests of the unitary and collective models at the household level are included as tables 2.7 and 2.8. As expenditure is only recorded at the household level, we are not able to perform comparable tests at the individual level.

Table 2.7 shows results for tests of the unitary model that are consistent with those in Table 2.3. As with assets, the share of total family resources controlled by a child's own household matters. The estimated  $\beta$  coefficients are positive and statistically significant, implying that we clearly reject the unitary model.

As with assets, we are also unable to reject that families allocate resources efficiently. Table 2.8 reports results for regressions examining how child outcomes relate to household and dynasty per capita expenditure. These results are slightly different than the results using assets in Table 2.4. The coefficients on extended family PCE

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<sup>34</sup> PCE is recorded as Rp000 per month.

are statistically indistinguishable from zero apart from height-for-age. This is an interesting result, and adds support to our use of assets as a marker of resources rather than expenditure. If sharing is done in the first stage of the two-stage budgeting process, and expenditure decisions are made in the second, it is intuitive that dynasty expenditure would have little or no impact on child human capital outcomes in our model. Instead of impacting the preliminary sharing stage, decisions on the allocation of expenditure take place in the second stage.

We include results from nonlinear Wald tests of Pareto efficiency in Panel C, but do not place much weight on these tests. Although the  $p$ -values are lower than those in Table 2.4, this may be due to the imprecisely estimated coefficients on dynasty PCE. Panel B shows that the standard errors on the ratios are large and the ratio estimates for early school attendance and cognitive scores are indistinguishable from zero. We remain confident in our use of assets rather than per capita expenditure on the right-hand side of our regressions, and believe that the results presented in the body of the chapter are more reliable and reasonable than those using expenditure data. Expenditure should be seen as the outcome of the bargaining process, not a distribution factor which influences first stage budgeting.

## 2.8 Primary Tables and Figures

Table 2.1: Sample Description

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<i>Number of Unique [...]</i>	
Children ( <i>birth - 16 yrs</i> )	14881
Households	8480
Dynasties	5283
Fathers	7809
Mothers	8438
Grandfathers	4386
Grandmothers	5448

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Table 2.2: Descriptive Statistics

	<i>Sample</i>			Cognitive Score (7 - 16 yrs)
	All Children (Birth - 16 yrs)	Height-for-Age (Birth - 6 yrs)	Attended Kindergarten (6 - 14 yrs)	
<i>Outcomes</i>				
Height-for-Age (z-score)		-1.14 (0.02)		
Attended Kindergarten (%)			50.8 (0.58)	
Cognitive Score (%)				69.6 (0.21)
<i>Liquid Assets of [...]*</i>				
Household	1928.8 (38.9)	1949.1 (60.3)	1854.7 (49.7)	1902.7 (51.5)
Dynasty	2579.5 (47.3)	3027.9 (74.6)	2355.9 (64.7)	2148.9 (59.5)
Father	872.2 (22.9)	821.5 (37.1)	907.9 (29.9)	904.2 (28.2)
Mother	762.8 (17.7)	680.6 (22.1)	822.4 (26.8)	831.3 (27.1)
Grandfather	799.8 (35.3)	885.6 (51.5)	658.3 (37.7)	657.9 (42.2)
Grandmother	616.7 (19.9)	697.4 (29.4)	510.8 (22.7)	480.5 (23.7)
<i>Additional Controls</i>				
Age	7.37 (0.04)	2.88 (0.02)	9.79 (0.03)	11.26 (0.03)
Female	0.48 (0.00)	0.48 (0.01)	0.48 (0.01)	0.49 (0.01)
Co-reside with Father	0.81 (0.00)	0.87 (0.00)	0.78 (0.00)	0.76 (0.00)
Co-reside with Mother	0.90 (0.00)	0.96 (0.00)	0.87 (0.00)	0.85 (0.00)
Household Size	4.98 (0.02)	4.86 (0.02)	5.06 (0.02)	5.08 (0.02)
Dynasty Size	11.16 (0.05)	11.94 (0.08)	10.86 (0.07)	10.45 (0.07)
<i>Age of [...]</i>				
Father	38.7 (0.08)	34.4 (0.09)	41.0 (0.10)	42.5 (0.10)
Mother	34.1 (0.07)	29.8 (0.08)	36.4 (0.08)	37.9 (0.08)
Grandfather	62.0 (0.13)	59.9 (0.16)	64.7 (0.19)	65.5 (0.21)
Grandmother	58.5 (0.11)	55.9 (0.14)	61.2 (0.16)	62.1 (0.17)
<i>Years of Education of [...]</i>				
Father	8.52 (0.04)	9.15 (0.05)	8.22 (0.05)	7.96 (0.05)
Mother	8.03 (0.03)	8.96 (0.05)	7.56 (0.05)	7.26 (0.05)
Grandfather	4.89 (0.03)	5.47 (0.05)	4.54 (0.04)	4.33 (0.04)
Grandmother	3.71 (0.03)	4.30 (0.04)	3.38 (0.04)	3.16 (0.04)
Paternal Height (cm)	162.0 (0.05)	162.6 (0.07)	162.0 (0.06)	161.6 (0.06)
Maternal Height (cm)	151.1 (0.04)	151.5 (0.06)	151.0 (0.06)	150.9 (0.06)
Urban Household	0.51 (0.00)	0.53 (0.01)	0.50 (0.01)	0.49 (0.01)
N. Observations	14881	6567	7493	7727

\* In Rp0,000 (~ 1 USD)

Table 2.3: Household Unitary Tests

		<i>Child Outcomes</i>	
		<b>Attended</b>	<b>Cognitive</b>
	<b>Height-for-Age</b>	<b>Kindergarten (%)</b>	<b>Score (%)</b>
Household Assets	0.06** (0.03)	4.25*** (0.97)	0.80** (0.41)
Dynasty Fixed Effects	Yes	Yes	Yes
N. Observations	6567	7493	7727

*Notes:* All regressions include dynasty fixed effects and assets in log form, as well as controls for gender, age, household size and composition, parental education, age and gender of the household head and location as described in the text. Standard errors in parentheses account for clustering at the family level.

\*\*\* Significant at the 1% level, \*\* Significant at the 5% level.

Table 2.4: Household Pareto Efficiency Tests

<b>Panel A: Estimates for Tests of the Collective Model</b>			
		<i>Child Outcomes</i>	
	<b>Height-for-Age</b>	<b>Attended Kindergarten (%)</b>	<b>Cognitive Score (%)</b>
Household Assets	0.09*** (0.02)	5.02*** (0.45)	1.17*** (0.18)
Dynasty Assets	0.03** (0.02)	1.93*** (0.52)	0.45** (0.22)
N. Observations	6567	7493	7727
<b>Panel B</b>			
<i>Unitary Tests</i>			
<i>p</i> -value	0.02	0.00003	0.02
<i>Ratios of Coefficients</i>			
Household to Dynasty Assets	2.65* (1.41)	2.60*** (0.78)	2.60* (1.40)
<b>Panel C: Collective Model Nonlinear Wald Tests (<i>p</i>-values)</b>			
	<i>Test of equality of ratios between [...] and [...]</i>		<i>p</i> -value
	Height-for-Age	Attend Kindergarten	0.97
	Height-for-Age	Cognitive Score	0.98
	Attend Kindergarten	Cognitive Score	0.99
	All Ratios		0.99

*Notes:* Panel A: All regressions include assets in log form, as well as controls for gender, age, household and dynasty size and composition, parental education, age and gender of the household and dynasty head and location as described in the text. Standard errors in parenthesis account for clustering at the family level. Panel B: The *p*-values correspond to a test of the unitary mode based on the equivalence of the household and dynasty asset effects, where the null is that the two coefficients in each outcome in Panel A are equal. The collective model test relies on the equivalence of the ratio of coefficients from Panel A. The ratios and their standard errors are calculated using the delta method, allowing for clustering at the family level. Panel C: The *p*-values correspond to results from nonlinear Wald tests where the null is Pareto efficiency. These tests compare the equivalence of the ratios shown in Panel B for the outcome pairs in each row. The final *p*-value is for the test of equivalence across all three ratios.

\*\*\* Significant at the 1% level, \*\* Significant at the 5% level, \* Significant at the 10% level.

Table 2.5: Individual Level Regressions for Tests of the Collective Model

	<i>Child Outcomes</i>		
	<b>Height-for-Age</b>	<b>Attended Kindergarten (%)</b>	<b>Cognitive Score (%)</b>
Father's Assets	0.02 (0.02)	1.72*** (0.51)	0.25 (0.19)
Mother's Assets	0.05*** (0.02)	2.32*** (0.53)	0.66*** (0.19)
Grandfather's Assets	0.01 (0.02)	-0.46 (0.78)	0.13 (0.31)
Grandmother's Assets	0.01 (0.02)	1.48** (0.72)	0.12 (0.31)
Rest of Household Assets	0.04** (0.02)	1.21*** (0.45)	0.35** (0.16)
Rest of Dynasty Assets	0.03*** (0.01)	1.46*** (0.36)	0.24 (0.15)
N. observations	6567	7493	7727

*Notes:* Each regression includes assets at the individual level in quartic root form, and controls for the age and gender of the child, household and dynasty size and composition, age and education of parents and grandparents, and location as described in the text. Ratios and their standard errors similar to those shown in Panel B of Table 2.4 are not reported for space concerns, but are available from the authors upon request. Standard errors in parentheses account for clustering at the family level.

\*\*\* Significant at the 1% level, \*\* Significant at the 5% level.

Table 2.6: Individual Level Tests of the Collective Model (*p-values*)

<b>Height-for-Age and Attended Kindergarten</b>					
	Mother	Grandfather	Grandmother	Rest of HH	Rest of Dyn
Father	0.72	0.45	0.58	0.39	0.69
Mother		0.44	0.39	0.55	0.97
Grandfather			0.50	0.44	0.43
Grandmother				0.28	0.41
Rest of HH					0.54
Equality among parents and grandparents (6 ratios)			0.97		
Equality among all ratios (15 ratios)					0.99

<b>Height-for-Age and Cognitive Score</b>					
	Mother	Grandfather	Grandmother	Rest of HH	Rest of Dyn
Father	0.83	0.97	0.89	0.91	0.86
Mother		0.96	0.95	0.60	0.54
Grandfather			0.95	0.93	0.91
Grandmother				0.87	0.86
Rest of HH					0.93
Equality among parents and grandparents (6 ratios)			0.99		
Equality among all ratios (15 ratios)					0.99

<b>Attended Kindergarten and Cognitive Score</b>					
	Mother	Grandfather	Grandmother	Rest of HH	Rest of Dyn
Father	0.48	0.55	0.78	0.49	0.91
Mother		0.48	0.43	0.99	0.46
Grandfather			0.56	0.49	0.53
Grandmother				0.45	0.73
Rest of HH					0.54
Equality among parents and grandparents (6 ratios)			0.96		
Equality among all ratios (15 ratios)					0.99

<i>Overarching Test</i>					
Equality across all ratios, all outcomes (45 ratios)	0.97				

*Notes:* Table reports *p-values* from nonlinear Wald tests of Pareto efficiency. Each cell is the *p-value* comparing the ratio of marginal effects for assets owned by the individual listed in the row with the individual in the column. For example, 0.72 is the *p-value* for the test of equivalence between the ratio of effects for a child's father's to their mother's assets for height-for-age and attending kindergarten. Also included in each panel are tests of equivalence of ratios for parents and grandparents, and the test of equality of all fifteen ratios in the panel. Rest of HH and Rest of Dyn stand for Rest of Household and Dynasty. The overarching test at the bottom of the table is for equality of all ratios across all outcomes (45 total ratios). Tests are conducted allowing for clustering at the family level.

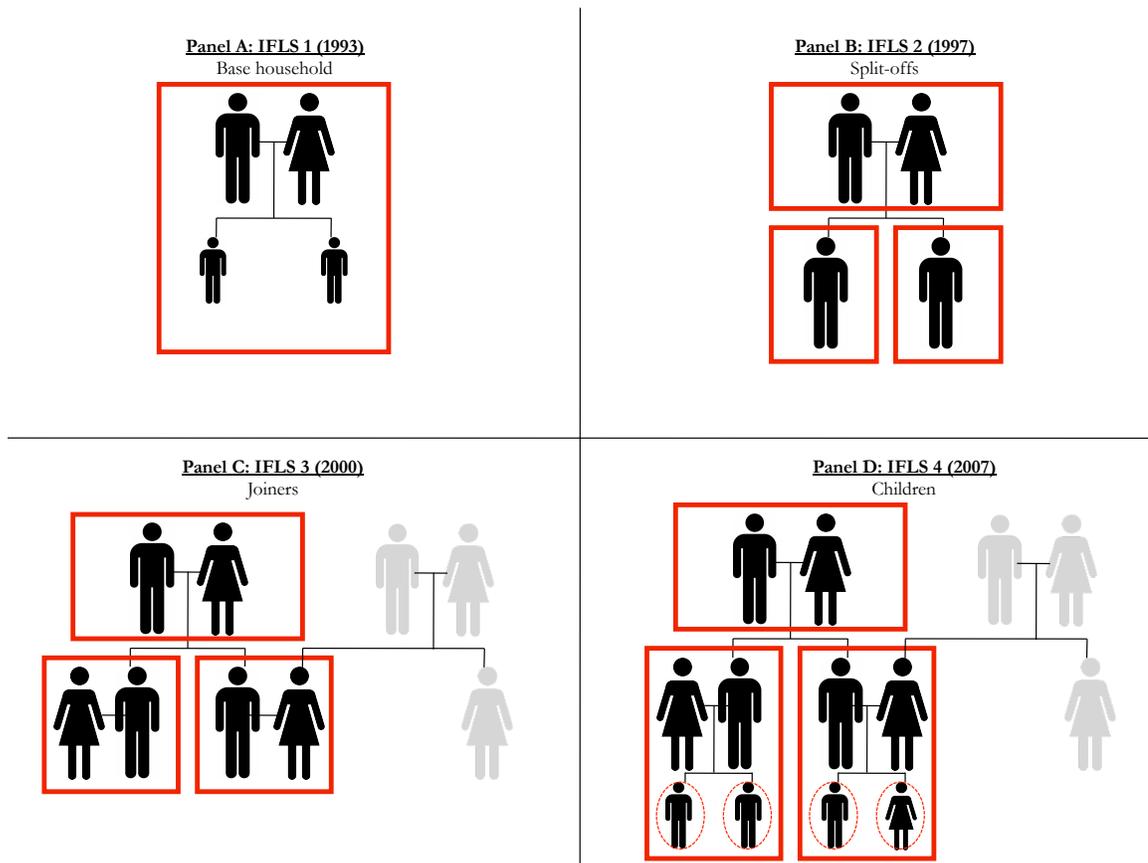


FIGURE 2.1: This figure depicts how extended families are identified in the IFLS. Each box represents an IFLS household. Starting from a baseline household in the first wave of IFLS in 1993, when children split-off and form their own households they are followed and become part of the IFLS sample, as shown in Panel B. When spouses join the newly formed households, as in Panel C, we obtain information on the spouses and their new non-IFLS relatives, but only the new joiner is part of the IFLS sample. Our analytical sample consists of the young children shown in Panel D and their families.

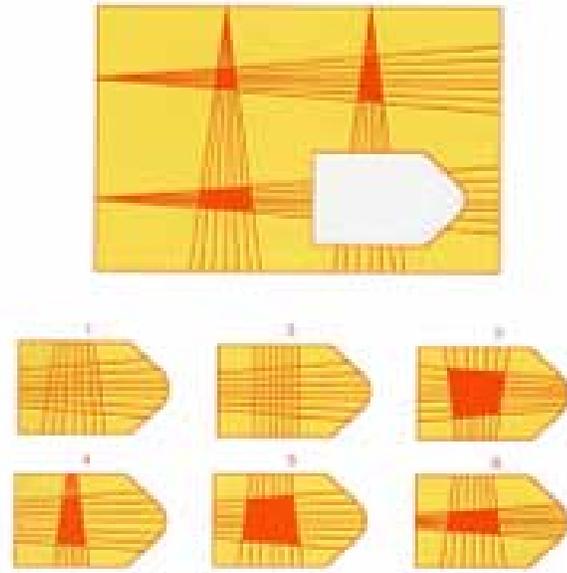


FIGURE 2.2: Sample Question from a Raven's Colored Progressive Matrices (CPM) assessment. The directions instruct respondents to choose the option that completes the figure.

## 2.9 Supplemental Tables

Table 2.7: Household Unitary Tests - Monthly Per Capita Expenditure

	<i>Child Outcomes</i>		
	<b>Height-for-Age</b>	<b>Attended Kindergarten (%)</b>	<b>Cognitive Score (%)</b>
Household Per Capita Expenditure	0.12** (0.06)	5.47*** (1.92)	1.86** (0.88)
Dynasty Fixed Effects	Yes	Yes	Yes
Observations	6567	7493	7727

*Notes:* All regressions include dynasty fixed effects and household per capita expenditure in log form, as well as controls for gender, age, household size and composition, parental education, age and gender of the household head and location as described in the text. Standard errors in parentheses account for clustering at the family level.

\*\*\* Significant at the 1% level, \*\* Significant at the 5% level.

Table 2.8: Household Pareto Efficiency Tests - Monthly Per Capita Expenditure

<b>Panel A: Estimates for Tests of the Collective Model</b>			
		<i>Child Outcomes</i>	
	<b>Height-for-Age</b>	<b>Attended Kindergarten (%)</b>	<b>Cognitive Score (%)</b>
Household Per Capita Expenditure	0.17*** (0.03)	9.28*** (1.07)	2.46*** (0.36)
Dynasty Per Capita Expenditure	0.08** (0.03)	1.60 (1.05)	0.48 (0.41)
N. Observations	6567	7493	7727
<b>Panel B</b>			
<i>Unitary Tests</i>			
<i>p</i> -value	0.08	0.00002	0.0008
<i>Ratios of Coefficients</i>			
Household to Dynasty PCE	2.05** (0.95)	5.80 (3.93)	5.16 (4.60)
<b>Panel C: Collective Model Nonlinear Wald Tests (p-values)</b>			
	<i>Test of equality of ratios between [...] and [...]</i>		<i>p</i> -value
	Height-for-Age	Attend Kindergarten	0.18
	Height-for-Age	Cognitive Score	0.28
	Attend Kindergarten	Cognitive Score	0.92
	All Ratios		0.60

*Notes:* Panel A: All regressions include monthly per-capita expenditure in log form, as well as controls for gender, age, household and dynasty size and composition, parental education, age and gender of the household and dynasty head and location as described in the text. Standard errors in parenthesis account for clustering at the family level. Panel B: The *p*-values correspond to a test of the unitary mode based on the equivalence of the household and dynasty effects, where the null is that the two coefficients in Panel A are equal. The collective model test relies on the equivalence of the ratio of coefficients from Panel A. The ratios and their standard errors are calculated using the delta method allowing for clustering at the family level. Panel C: The *p*-values correspond to results from nonlinear Wald tests where the null is Pareto efficiency. These tests compare the equivalence of the ratios shown in Panel B for the outcome pairs in each row. The final *p*-value is for the test of equivalence across all three ratios.

\*\*\* Significant at the 1% level, \*\* Significant at the 5% level.

## Farms, Families, and Markets: New Evidence on Agricultural Household Behavior

### 3.1 Introduction

Small, family-run enterprises are the backbone of many developing countries, and millions of households around the world produce goods and services both for their own consumption as well as for sale. These micro-enterprises and family farms operate in complex, interlinked markets for consumption, labor, credit, and output, and face considerable risk and uncertainty. Despite their importance, there is no consensus on the appropriate framework to analyze the interactions between buyers and sellers in rural areas. Using new, longitudinal data from Central Java, Indonesia, this chapter studies the behavior of family farms who grow food both for sale and their own consumption. Understanding these households' constraints and choices is a key challenge for global development.

To investigate the interactions between consumption and production choices in farm households, a large body of literature has utilized the neoclassical agricultural household model. The model incorporates a family operated firm into the household

utility maximization problem, and links profit maximization with time allocation and consumption choices. It has played an integral role in both theoretical and empirical studies, and serves as the foundation for seminal work in development and agricultural economics. The model is easily adopted to analyze nutrition decisions, agricultural technology adoption, labor supply choices, and responses to policy interventions (e.g. Yotopolous and Lau, 1974; Barnum and Squire, 1979; Strauss, 1982, 1984; Singh et al., 1986).<sup>1</sup> More recently, the model has been used in assessing the impact of agricultural productivity shocks (Jayachandran, 2006), studying the provision of property rights (Field, 2007), and investigating child labor and household production (Akresh and Edmonds, 2011). The model plays a vital role in development and agricultural economics, and provides a framework for understanding household production in sectors beyond agriculture.<sup>2</sup>

Under specific assumptions, the model greatly simplifies the two sided production consumption problem into a recursive form. If households function as price-taking utility maximizers in a world of complete markets, production and consumption decisions may be treated as separate, albeit related, problems. When all current and future markets exist, optimal choices regarding farm production are made as if households operate profit maximizing firms. In such a setting, input choices depend only on the prices of inputs and characteristics of the farm. Production choices effectively occur independently from household preferences in a first stage, and the family business only influences consumption allocations through the income from farm profits.

The model under complete markets is advantageous for both theoretical and empirical applications, as it allows production decisions to be analyzed independently

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<sup>1</sup> Taylor and Adelman (2003) offers an overview of the agricultural household literature. See also Strauss and Thomas (1995), Behrman (1999), or Schultz (2001).

<sup>2</sup> See Grogger (1998) for an application of the model to crime.

of consumption and household characteristics, and simplifies the relationship between production and consumption allocations. While strong assumptions, a subset of seminal papers uphold the predictions of complete markets, including influential work using data from rural Indonesia (Pitt and Rosenzweig, 1986; Benjamin, 1992).<sup>3</sup> These papers test whether production choices are invariant to household characteristics that impact consumption allocations, and are unable to reject predictions of recursion. Their failure to reject separation has provided a bedrock foundation for papers that continue to exploit the features and ease of complete markets.

However, despite its widespread use, there is inconclusive evidence on the validity of separation and the recursive form. Others, notably Lopez (1984, 1986), Jacoby (1993), and Grimard (2000), reject separation in data from Canada, Peru, and Côte d’Ivoire. More recent work finds mixed results in rural China (Bowlus and Sicular, 2003). However, previous studies are not only inconclusive on separation, but subject to a number of empirical concerns as well. With the exception of Bowlus and Sicular, all of the aforementioned papers rely on a static framework and test market completeness with cross sectional data. While the researchers are careful to control for factors which may bias their empirical strategies, it is difficult to fully address the concern that unobserved heterogeneity at the farm and household level may be driving the results. Unobserved factors such as soil quality or farm-specific knowledge may result in rejections of separation due to a spurious correlation between household characteristics and farm inputs. Similarly, measurement error may play a role in attenuating results toward the null.

This chapter’s first contribution to the literature is to empirically assess whether separation between production and consumption holds among rural farmers in Central Java, Indonesia using new, longitudinal data from the Work and Iron Status Evaluation (WISE) (Thomas et al., 2011). The data come from a region of the

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<sup>3</sup> Pattanayak and Kramer (2001) also finds support for complete markets in Indonesia.

world where past results have led some to conclude that complete markets may exist (Bardhan and Udry, 1999). I begin by empirically assessing the implication of market completeness that the demand for farm labor is unrelated to the demographic composition of the household. If markets are complete, who lives in a household will have no impact on farm labor, as farmers can hire whatever labor they need through the market.

The empirical results establish a clear link between who is residing in a household and the demand for farm labor that rejects separation and the recursive model. I then extend the literature and consider specific reasons for rejecting complete markets. I show that neither time invariant unobserved heterogeneity at the farm level, differential monitoring costs for family and hired labor, nor addressing the potential endogeneity of household composition changes the conclusion: household composition affects labor demand on the farm.

This result is inconsistent with a world of complete markets, and suggests a wedge exists between the productivities of family and hired labor that links who is in the household to farm labor demand. Motivated by this finding, I develop an extended model of resource allocation within agricultural households allowing for heterogeneity in the skills of household and farm laborers. I test an implication of this model and show it is consistent with empirical evidence on the sorting of household members to farm versus market work. While much of the literature testing separation stops at a dichotomous test of complete versus incomplete markets, this extension and empirical evidence is a step towards a deeper understanding of the effects of market imperfections in rural areas.

The overall results of this chapter are important not only for modeling farm-household decision making, but for the design and evaluation of development policy, and for understanding complex behaviors of agricultural households in rural markets around the world. Policy analyses conducted with the recursive model may in fact be

missing important outcomes by oversimplifying the relationship between production, preferences, and consumption. The next section begins with an outline of a dynamic version of the neoclassical agricultural household model to guide the work in the body of the chapter. This precedes the empirical model and a description of the longitudinal data. I then present the results from the baseline tests of separation, as well as those examining potential reasons for rejecting complete markets. These findings motivate a model of heterogeneous skills and empirical evidence on household labor allocation before concluding and discussing future work.

## 3.2 Theoretical Framework: A Dynamic Agricultural Household Model

The following section describes a dynamic generalization of the neoclassical agricultural household model in Singh et al. (1986) to formalize intuition and establish the empirically testable implications of the model. The model incorporates production into the intertemporal consumer demand problem with exogenous prices and complete markets.

If implications of the model with complete markets are rejected, formalizing deviations from this framework is a natural next step. However, as discussed in the introduction, the literature is still inconclusive on the validity of the commonly used model. Before considering extensions, I first provide evidence regarding the suitability of separation in the baseline neoclassical agricultural household framework.

### *3.2.1 The Farm Household's Problem*

Semi-commercial households simultaneously act as both producers and consumers: they make decisions regarding inputs on their farms in one realm, and maximize utility at the household level in the other.

For an infinitely lived household, the objective is to maximize the expected sum of discounted future utility choosing consumption, leisure, savings, farm labor, and

other variable farm inputs in each time period and state.<sup>4</sup> The household is constrained by the farm production process, its time endowment, and an intertemporal budget constraint. Formally, the objective is:

$$\max E \left[ \sum_{t=0}^{\infty} \beta^t u(x_{mt}, x_{at}, \ell_t; \mu_t, \varepsilon_t) \right] \quad (3.1)$$

where  $x_{mt}$  is a vector of market consumption goods,  $x_{at}$  is consumption of agricultural goods (i.e. food, some of which may be grown by the household), and  $\ell_t$  is a vector of household members' leisure. Preferences are captured by  $\mu_t$ , which includes observed characteristics that parameterize the utility function such as household size and composition, and unobserved characteristics,  $\varepsilon_t$ . Although I remain agnostic about the particular form of the utility function, I maintain the standard assumptions that it be intertemporally separable, quasi-concave, non-decreasing, and strictly increasing in at least one argument.

The agricultural production function relates labor, variable inputs such as seed and fertilizer, and farm land to output.<sup>5,6</sup> Output in a given period,  $Q_t$ , is defined as:

$$Q_t = Q_t(L_t, V_t, A_t) \quad (3.2)$$

where  $L_t$  is labor used on the farm,  $V_t$  is a vector of other variable inputs, and  $A_t$

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<sup>4</sup> The problem may be formulated to a finite time  $T$  rather than infinity without loss of generality.

<sup>5</sup> Land remains a choice variable in the model, but in the actual rural Indonesian setting studied in this chapter there is little new land to acquire, and very few purchases or sales of land in the data. Family farms remain generally stable over time. Ethnographic evidence suggests land is typically inherited by the eldest son rather than divided amongst all siblings. Often the eldest may temporarily share the land with their younger siblings while retaining ownership, but when the younger siblings become deceased, the entire plot falls to the primary heir and their children (White and Schweizer, 1998).

<sup>6</sup> Farms in the region have small capital stocks, and what capital does exist, such as sickles to harvest rice, can effectively be thought of as variable inputs.

is land.<sup>7</sup> Equation (3.2) models output in period  $t$  as a function only of variable inputs in the current period. This is appropriate for the empirical application in this chapter where one time period of data corresponds to both a planting and harvesting cycle.<sup>8</sup>

Total farm labor consists of the sum of family labor supplied to the farm,  $L_t^F$ , and outside labor hired onto the farm from the marketplace,  $L_t^H$ .

$$L_t = L_t^F + L_t^H \quad (3.3)$$

Both family and hired labor are assumed in the baseline model to share a common wage as in Benjamin (1992). A household's endowment of labor,  $E^L$ , is divided between leisure, time spent working on the family farm, and time in off-farm labor,  $L_t^O$ .

$$E^L = \ell_t + L_t^F + L_t^O \quad (3.4)$$

The household is also constrained by an intertemporal budget constraint that describes the evolution of wealth between periods. With complete credit markets, any income not consumed in period  $t$  is saved and earns interest at a rate of  $r_{t+1}$  between periods. Letting  $W_t$  be assets or wealth at the beginning of time period  $t$ , the budget constraint is as follows:

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<sup>7</sup> Due to the dominance of rice farming in Central Java, and to follow the basic model, equation (3.2) is for a single output crop. This assumption is not necessary for the validity of the empirical tests. If households are price takers in the relevant output markets, the introduction of multiple outputs from production does not alone affect the primary testable property of the model (see Singh et al., 1986).

<sup>8</sup> The empirical application of the model is robust to a number of alternative forms of the production function, including those allowing for intertemporal links in production where output in period  $t$  is a function of inputs in the current period as well as those from a previous period (e.g. Kochar, 1999). The empirical tests and results are also robust to production frameworks that explicitly include capital as an input and specify a transition process for capital over time. The form in equation (3.2) is maintained for ease of exposition.

$$W_{t+1} = (1+r_{t+1}) [W_t + w_t(E^L - \ell_t) + p_{at}Q_t(t) - w_tL_t - p_{vt}V_t - p_{At}A_t - p_{mt}x_{mt} - p_{at}x_{at}] \quad (3.5)$$

Wealth in the next period is equal to the interest earned on period  $t$  wealth and income, less period  $t$  expenditure. The household earns wage income equal to the wage rate multiplied by the sum of on and off-farm labor,  $w_t(E^L - \ell_t)$ , the gross from the sale of its output  $p_{at}Q_t(t)$ , and purchases farm labor, variable farm inputs, land, and consumption goods.

Under the assumption of complete markets for credit, insurance, labor, consumption, and agricultural goods, maximizing the household's objective function subject to restrictions (3.2)-(3.5) yields the standard first order conditions. Current consumption demands depend on current prices, wages, the interest rate, and net income, as well as expected future prices, wages, and interest rates. An Euler equation guides intertemporal decisions, and the demands for farm inputs are determined solely by the relationship between their marginal products and prices.

The solution to the joint production-consumption problem reveals that the optimal choice of farm inputs is determined as if households operate their farms as risk neutral profit maximizing firms. There is a clear separation between production and household preferences that implies the joint problem above may be formulated recursively in a two-step process. In the first stage, households maximize profits on their farms independent of preferences or any consumption side influences by choosing farm labor, variable inputs, and land.<sup>9</sup> Utility is then maximized in the second stage, and consumption allocations are affected by production decisions only through

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<sup>9</sup> Letting  $\pi_t$  represent farm profits, households solve the following problem in the first stage:

$$\max \pi_t = p_{at}Q_t(L_t, V_t, A_t) - w_tL_t - p_{vt}V_t - p_{At}A_t$$

This is a straightforward maximization which captures that households treat their farms strictly as risk neutral profit maximizing firms when separation holds.

the amount of income provided by farm profits.<sup>10</sup> The result of the second stage is a set of conditional demand functions similar to those obtained in standard intertemporal models, but augmented by farm profits in a particular way. The demand for consumption good  $c$  in period  $t$  is the following:

$$x_{ct} = x_{ct}(p_{mt}, p_{at}, w_t, r_{t+1}, \pi_t(p_{vt}, p_{at}, w_t, p_{At}), y_t, \lambda_t; \mu_t, \varepsilon_t) \quad (3.6)$$

where consumption depends on market and agricultural prices,  $p_{mt}$  and  $p_{at}$ , wages, interest rates, farm profits,  $\pi_t$ , income,  $y_t$ , and expected future prices through the marginal utility of wealth,  $\lambda_t$ . The key feature of the recursive framework is visible in equation (3.6). When separation holds, the family farm only affects consumption demand through the profits determined in the first stage. Variables which affect production, including farm characteristics and the prices of variable inputs, impact consumption only through their influence on farm profits.

### 3.2.2 Separation, Farm Production, and Labor Demand

The recursive result greatly simplifies the model, as it implies production decisions may be analyzed independently of preferences and consumption side variables, and that households' businesses influence their consumption only in a specific way. While a convenient feature, the validity of separation is an empirical question. This chapter follows the previous work in the literature that assesses the validity of the recursive model by testing whether production decisions can truly be characterized as independent of household characteristics. Complete markets also define an additional set of restrictions on consumption allocations that are examined in the next chapter.

As previously stated, when separation holds, the demand for variable inputs depends only on the marginal productivity of the inputs, prices, and wages. Following Benjamin (1992), I focus on examining separation of labor demand decisions, although the same principles apply to other variable inputs as well. Consider the first order condition determining the profit maximizing amount of farm labor below:

<sup>10</sup> Strauss (1986) illustrates the recursive form of the model and derives the bordered Hessian matrix for the static version of the farm household's problem under complete markets. The block diagonal form of the bordered Hessian illustrates how production decisions may be modeled as independent of consumption side variables.

$$p_{at} \frac{\partial Q_t}{\partial L_t} = w_t \quad \forall t \quad (3.7)$$

This is a straightforward relationship between the marginal revenue product of labor and its price. The total amount of labor demanded by the farm, the sum of both hired and family supplied labor, can be determined by solving equation (3.7) for  $L_t$  as a function of exogenous variables in the model. The result is a labor demand function of the form:

$$L_t^D = L_t^D(p_{at}, p_{vt}, w_t, p_{At}) \quad \forall t \quad (3.8)$$

where  $L_t^D$  is total farm labor demand in period  $t$ . As a result of separation, household characteristics represented by  $\mu_t$  and  $\varepsilon_t$  in the utility function do not affect labor demand. Equation (3.8) implies that when labor is flexibly hired and households can freely allocate labor between on or off-farm employment in a complete market, two households with the exact same farm will have the same labor demand regardless of their preferences, demographic composition, or other characteristics.

While a useful result, there are a number of potential market imperfections or violations of assumptions within the model that may result in the standard neoclassical model being an inadequate characterization of agricultural household behavior. For example, an intrahousehold bargaining process between household members that occurs over both consumption and production decisions may exist.<sup>11</sup> Additional constraints on the number of hours individuals can work off-farm, the amount of labor available to hire onto one's own farm, or lack of access to credit markets may also pose barriers for agricultural households. Transaction costs, monitoring costs, or preferences for own farm versus market work may stand in contrast to the perfect substitutability and homogeneity of hired and family labor. These and other mod-

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<sup>11</sup> Separation between production decisions and consumption side variables is robust to intrahousehold bargaining on the consumption side where household utility is a convex combination of each household members individual utility function (see Chiappori, 1988, 1992; Bardhan and Udry, 1999). The same is not true if bargaining occurs over production decisions. There is ample evidence regarding the failure of the unitary model in developing countries, including Thomas (1990), Udry (1996), and the second chapter of this dissertation among many others.

ifications represent potentially important alternatives to the traditional framework, and a number will be examined in later sections of this chapter.

However, if separation does hold and the simple framework is a valid model, it greatly simplifies the study of producer-consumer households. Before considering extensions, this chapter empirically assesses separation under the commonly used model presented above.

### 3.3 An Empirical Model of Farm Labor Demand

Testing the validity of separation is an empirical question, and one which has significant implications for our understanding of agricultural household behavior and rural markets. This section specifies a version of the labor demand function in equation (3.8) applicable to panel data from Central Java, Indonesia. The empirical model follows directly from the theoretical result that household characteristics are excludable from farm labor demand under the null of complete markets. By including household characteristics in the estimation of equation (3.8) and testing their significance, one may empirically assess the validity of separation in the neoclassical agricultural household model.

Given a Cobb-Douglas production function as in Benjamin (1992), let the farm labor demand of household  $h$  in community  $j$  and time  $t$  be the following:

$$\ln L_{hjt} = \alpha + \beta N_{hjt} + \delta X_{hjt} + \mu_{jt} + \mu_h + \varepsilon_{hjt} \quad (3.9)$$

where  $L_{hjt}$  is the total number of person-days of farm labor,  $N_{hjt}$  represents excludable household characteristics under the null,  $X_{hjt}$  are time-varying household and farm level variables,  $\mu_{jt}$  community-time fixed effects, and  $\mu_h$  household-farm fixed effects.<sup>12</sup> With labor measured as log person-days,  $\beta$  represents the approximate percentage change in labor demand due to a change in  $N$ . Testing separation amounts to testing whether  $\beta$  is significantly different from zero in this regression model.

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<sup>12</sup> As households and their farms are stable over time in the study setting, I refer to  $\mu_h$  as a household-farm fixed effect rather than simply a household fixed effect.

By considering the model in a dynamic framework, equation (3.9) exploits the panel dimensions of the data in two ways to control for variables which could potentially bias the results. Community-time indicators,  $\mu_{jt}$ , flexibly control for time-varying factors at the local level including the wages and prices households face, as well as common factors that may impact production such as weather patterns. Similarly, the household-farm fixed effect,  $\mu_h$ , captures all additive, time-invariant unobserved and observed heterogeneity of a given household and their farm. The inclusion of  $\mu_h$  is potentially important, as it addresses concerns raised in past work that unobserved factors may contaminate estimates of labor demand from a single wave of data. As noted in Benjamin (1992), variables such as soil quality, farm specific knowledge, and managerial experience are both difficult to measure, and may bias cross sectional test results due to omitted variables. This chapter examines labor demand within households over time while controlling for time-invariant farm and household heterogeneity as a strategy to overcome these concerns.

With the inclusion of  $\mu_h$ , identification of  $\beta$  in equation (3.9) comes from changes in  $N_{hjt}$  for a given household across waves. Rather than examining variation across households, this test is more inline with the theory in Section 3.2, which predicts changes in household characteristics should not impact changes in labor demand when farms operate as if they are profit maximizing firms under complete markets. As households appear multiple times in the data, reported standard errors are clustered allowing for arbitrary correlation within households across time.<sup>13</sup>

Although  $N_{hjt}$  may be any number of household characteristics, in the spirit of Benjamin (1992), I use household demographic composition as the excludable variables to test separation. I choose to specify household composition slightly differently than Benjamin and past work, although the results are not sensitive to this choice. For each household, let there be  $K$  gender-age specific demographic groups, e.g. the number of children, adolescent, prime age, and senior household members of each

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<sup>13</sup> Standard errors calculated using block-bootstrapping with blocks defined at the household level are nearly identical to the results that will be presented with clustered standard errors, and do not change the quantitative nor qualitative results.

gender.  $N_{hjt}$  is then the sum of the number of household members in each of the  $K$  groups:

$$N_{hjt} = \sum_{k=1}^K n_{hjt}^k \quad (3.10)$$

where  $n_{hjt}^k$  represents the number of household members in a specific demographic group, e.g. boys from birth to age 14. This specification has the advantage that the coefficient for each group may be clearly interpreted as the impact on labor demand of having one additional household member in the given gender-age group.<sup>14</sup> Identification of each  $n_{hjt}^k$  comes from variation due to births, deaths, individuals exiting and joining the household, or aging and transitioning to another demographic category. The results presented below use six different age groups for both males and females: children and adolescents from birth to 14 years old, young adults ages 15 to 19, prime age adults ages 20 to 34 and 35 to 49, adults 50 to 64 and seniors 65 and above. These divisions are intended to capture variation by age and gender in a flexible way, and the results are robust to different age groupings as well as using only household size as the excludable characteristic.

The data required to examine farm labor use and household demographic composition over time is not trivial to collect. The next section presents the new, longitudinal data which makes this study possible.

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<sup>14</sup> Past work in the literature testing separation, including Benjamin (1992) and Bowlus and Sicilar (2003), use the following functional form for  $N$ :

$$N = \log(n) + \sum_{k=1}^{K-1} \frac{n^k}{n}$$

where  $n$  is total household size. In this specification, the first term captures scale effects and the later measure shares of different demographic groups. While this allows one to directly estimate the coefficient on household size while controlling for composition, the specification produces estimates of household composition effects that are difficult to interpret. When group  $K$  is omitted, an increase in the share of young children, for example, must be interpreted conditional on household size and shares of other groups being held constant. For example, when omitting senior women as group  $K$ , the share of children may increase due to an additional young child or one less senior female. While I maintain (3.10) for clarity, results using this alternative specification are consistent with the findings in the rest of the chapter and available upon request.

## 3.4 Research Setting and Data

### *3.4.1 The Work and Iron Status Evaluation*

The empirical analysis relies on new data from the Work and Iron Status Evaluation (WISE) project in Central Java, Indonesia (Thomas et al., 2011). The data comes from a large-scale longitudinal survey conducted as part of a randomized controlled trial, and contains detailed information on individuals, households, and the communities in which they live. Following a screening survey at the end of 2001 and selection of a population-representative sample, participant households were interviewed every four months beginning in 2002 and continuing through 2005. A longer-term follow-up was also conducted five years from the start of the survey in 2007. Supplemental Table 3.8 shows a timeline of the first 11 waves of the survey used in this chapter. At baseline in 2002, the WISE sample consisted of approximately 146 communities, 4,500 households, and 20,000 individuals in the Purworejo regency. Purworejo is a primarily rural region located along the southern coast of Java, southwest of Yogyakarta, and home to approximately one million people.

As the empirical model relies on observing changes in household composition and labor demand within the same household across time, maintaining minimal attrition is essential to the validity of the results. A great effort was made by the research team to track respondents over all waves of the survey. Farm households, which are relatively stable, were especially well tracked. Ninety-seven percent of the original farm households from the 2002 baseline were interviewed five years later in the 2007 wave.<sup>15</sup>

### *3.4.2 Agricultural Household Data*

As agriculture is the dominant economic activity in the region, the WISE data contains extensive information on the details of households' farm businesses. Those households who participate in agriculture report on their land ownership and its use, the farm activities performed by each household member, asset holdings of the farm

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<sup>15</sup> Thomas et al. (2011) reports further on attrition and the tracking scheme used in the WISE study.

business, expenditure, profits, and extremely detailed information concerning labor use. For each farm, the data contains the number of hired laborers, the wages they are paid, and the activities and amount of work they perform. This rich set of information allows one to examine detailed interactions between buyers and sellers of labor well beyond previous work testing separation.

Table 3.1 reports means and standard errors of the data pooled over the eleven waves of WISE used in this chapter. Supplemental Table 3.9 reports statistics for each of the eleven cross sections individually. The sample consists of approximately 4,500 unique farm households and 38,000 household-wave observations. In order for the study to maintain a representative sample over time, the number of households in the survey grows across waves. When individuals move out of original WISE households, their new split-off households becomes part of the sample thereafter. This strategy tracks all respondents who were in baseline WISE households as well as adds new family members who join split-off households.

Panel A describes characteristics of the farms in the WISE sample. Small, semi-commercial agriculture is the primary source of income for residents in Purworejo, with wetland rice being grown by 85% of farm households. Rice is typically harvested three times per year and farmers often grow a small amount of oranges, groundnuts, and coconuts as well. Farm households own approximately half an acre of land, and have small capital stocks.

Household composition is quite variable in the sample. Column 2 in Panel B shows the average farm household has approximately four members, with the number in each of the twelve demographic groups varying considerably. As identification in the household-farm fixed effects model requires that composition changes over time, column 3 shows the fraction of households that experience a change in each of the groups. Approximately 80% of households experience a change in composition over the course of the panel. An average of 2 household members work on the farm in each household, with both men and women participating in almost all tasks.<sup>16</sup> Household

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<sup>16</sup> The exceptions are preparing land and working with livestock, which are nearly exclusively male tasks.

members also sell their labor off farm, with 78% of households ever having a member who works away from the farm as a private employee.<sup>17</sup> Approximately one-third of all off-farm jobs are in the service sector in small shops and restaurants

The key independent variable in the analysis, labor demand, is constructed as the total time hired labor and household members spend working on the farm. It is measured throughout the regressions and in Panel C of Table 3.1 as person-days over the previous four months. Household members supply approximately three-quarters of labor used on their own farms, 54 out of 72 person-days, with 75% of household labor supplied by males. The remaining 18 person-days of non-family labor are hired through the market. Nearly all farm households, approximately 90%, report hiring labor at some point in the survey. The most commonly hired tasks are for planting (an average of 6.4 person-days in the last 4 months), harvesting (4.9 person-days), and weeding (4.1 person-days). Ninety-five percent of hired labor is paid a daily wage, with harvesting labor earning nearly three times the wage paid for planting and weeding.

Assessing the validity of separation in the neoclassical agricultural household model is an empirical question. The baseline results follow in the next section.

### 3.5 Baseline Tests of Separation

The results presented below show a statistically significant relationship between household demographic composition and labor demand that rejects separation.

#### *3.5.1 Static Framework*

Although there are numerous issues with estimating labor demand in a single cross section without properly controlling for unobserved household and farm level heterogeneity, I begin by presenting a cross-sectional analog before moving to the estimation of the dynamic model. This serves to establish a connection with previous literature

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<sup>17</sup> Household members working away from the family farm is a common feature regardless of whether the household hires in labor onto their own farm or not. Seventy nine percent of households that hire in labor have members working off, while 73% of those who do not hire in labor have members who work off-farm.

and provides a baseline to discuss the value added of panel data.

In a static framework, let the labor demand of household  $h$  in community  $j$  be the following:

$$\ln L_{hj} = \alpha + \sum_{k=1}^{12} \beta_k n_{hj}^k + \delta X_{hj} + \mu_j + \varepsilon_{hj} \quad (3.11)$$

where  $L_{hj}$  is total farm labor demand,  $n_{hj}^k$  the number of household members in one of the 12 age-gender groups, and  $X_{hj}$  farm and household characteristics. Household-farm fixed effects do not appear in the model, and variation comes from across households rather than within. Community fixed effects,  $\mu_j$ , are included to control for prices and conditions at the local level, and standard errors are clustered allowing for arbitrary correlation across households within a community.

Column 1 of Table 3.2 reports estimates of the  $\beta_k$  coefficients from the first cross section collected in January 2002. Similar results for all eleven cross sections appear in Supplemental Table 3.10 and are consistent with those from the first wave.<sup>18</sup> The results show a strong relationship between household demographic structure and labor demand that is a direct contradiction of separation. Having additional young, prime age, and senior males in a household is significantly related to utilizing more farm labor. A similar pattern exists for the number of females in the household between the ages of 35 and 64.<sup>19</sup> For example, having an additional 15 to 19 year old male in a household is associated with approximately a 9% increases in farm labor demand. The natural interpretation of this result is that these individuals supply labor on the farm that is otherwise not hired. This result is inconsistent with profit maximizing behavior under complete markets, where farm labor would be determined not by who is available within the household, but the relationship

<sup>18</sup> Estimates of additional  $\delta$  coefficients are omitted for space reasons but available upon request.

<sup>19</sup> While the estimates of the  $\beta_k$  coefficients clearly violate the null under separation that each should be zero, Table 3.2 also includes joint tests of household demographic groups below the individual point estimates. These test combinations of groups which may play particular importance in providing family farm labor. The overarching test of the joint significance of all 12 groups clearly rejects separation in the cross-sectional model, as do the joint tests of the male, female, and prime-age (ages 15 to 49) groups.

between the market wage and the productivity of farm labor.

Column 2 of Table 3.2 pools the eleven cross sections together and estimates an equation similar to equation (3.9) including community-time effects,  $\mu_{jt}$ . Household-farm fixed effects,  $\mu_h$ , are again omitted. While subject to the same concerns regarding unobserved heterogeneity as the single cross section, this allows for identifying variation across households, and is a type of summary of all the cross section results. As households appear in the full sample multiple times, standard errors in this specification and the remainder of the results are estimated allowing for arbitrary correlation at the household level, including within household serial correlation. The results in column 2 again reject separation, and the  $\beta_k$  estimates are statistically indistinguishable from those in column 1 when testing across the two columns. All of the male demographic groups and two of the six female groups are significantly associated with higher labor demand. The presence of young girls and older women relates negatively to labor demand, and may be due to members of the household working less on the farm to care for these individuals. The joint tests of the composition coefficients reinforce the rejections.

### *3.5.2 A Dynamic Model Accounting for Unobserved Heterogeneity*

While the static and pooled analyses suggest a relationship between household composition and labor demand, their identification strategies may be fundamentally flawed. Among the previously mentioned concerns is the potential for omitted variables that may be correlated with household demographics. For instance, if soil quality or better land is related to greater farm income and household size, separation may be rejected not due to a failure of complete markets, but due to a correlation between having fertile soil and being able to support a large household. As a strategy to control for such factors, the preferred panel model developed in Section 3.3 includes household-farm fixed effects to sweep away observed and unobserved time invariant heterogeneity common and additive at the farm level. The interpretation of this model is quite different than the cross section, as it looks within households rather than across. As the household-farm fixed effect,  $\mu_h$ , captures a household's

average composition and labor demand, the  $\beta_k$  coefficients now measure the impact of having additional household members in each demographic group relative to their within household mean.

The baseline results from estimating equation (3.9) appear in Column 3 of Table 3.2. After controlling for time invariant farm and household characteristics as well as community-time influences, there is still a statistically significant relationship between household composition and farm labor demand. This is a clear rejection of separation. An increase in the number of male household members over the age of 15 results in an increase in labor demand on the farm, as does increasing the number of women between 20 and 64. The joint tests of all composition coefficients, and the male, female, and prime age coefficients show that the result holds jointly along with individual demographic groups. These patterns are intuitive if one thinks of household members being the primary providers of on-farm labor, but are a clear rejection of separation. The similarity between the results in columns 1 through 3 show that while accounting for threats to identification posed by unobserved heterogeneity with household-farm fixed effects is theoretically important, their inclusion does not change the implication of the results: household composition affects farm labor demand.<sup>20</sup>

Along with being inconsistent with separation, the results are in direct contradiction to those supporting complete markets in Benjamin (1992). Unlike the results in Table 3.2, Benjamin finds no statistically significant relationship between household composition and farm labor demand in a cross sectional sample from the 1980 Agricultural Supplement to the Indonesia Socioeconomic Survey (SUSENAS). Supplemental Section 3.9 investigates a number of potential reasons for the difference in findings including model specification and survey design. The findings suggest discrepancies in the two data sets may play a key role.

The single largest difference between WISE data used in this chapter and the 1980 SUSENAS data is the amount families report working on their own farms. Recall

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<sup>20</sup> All coefficients in columns 1 and 3 are statistically indistinguishable besides those for women age 20-34 and 65 and older.

from Table 3.1 that household members in WISE supply an average of 54.4 person-days of farm labor over the course of 4 months, or an average of 163.2 person-days a year. In contrast, families in the SUSENAS sample report only 26 person-days of farm labor per year.<sup>21</sup> This amounts to a single day’s work, by a single household member, once every other week, and is inconsistent with any available estimate of own farm labor supply in Indonesia or elsewhere. To make the two samples comparable, I modify the WISE data by down-weighting family labor supply by a factor of 6.27 (163.2/26) so the two sample means are consistent. Results with this alternative measure of scaled labor supply come close to matching Benjamin’s failure to reject complete markets once additional restrictions on the data and specification of household composition are made.<sup>22</sup> See Supplemental Table 3.11 for estimates and the supplemental section at the end of this chapter for a more detailed discussion.

The results in Table 3.2 show a clear rejection of complete markets in the WISE sample. The labor demand test executed in this section establishes a link between household demographics and labor use on the farm that suggests a wedge exists between the marginal productivities of family and hired labor. Household members may have certain traits or skills that make them particularly well-suited to family labor. However, understanding why the implications of complete markets are rejected is not immediately clear. The next section further refines the results presented in Table 3.2, and extends the literature by explicitly considering a number of potential reasons for rejecting separation. Understanding the causes of market imperfections is necessary to evaluate their implications, as well as to guide alternative models of producer-consumer household behavior that are consistent with the empirical evidence.

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<sup>21</sup> The data from the Agricultural Supplement to the 1980 SUSENAS is no longer available from Badan Pusat Statistik (Statistics Indonesia), although the questionnaire is available from the online RAND Indonesia Data Core (<http://www.rand.org/labor/bps.html>). The value of 26 person-days per year is the value of “Average Family person-days of Total Labor” in Table II of Benjamin (1992).

<sup>22</sup> The modified dependent variable is  $\log(L^{Hired} + \frac{L^{Supplied}}{6.27})$  as oppose to  $\log(L^{Hired} + L^{Supplied})$ .

## 3.6 Extensions: Investigating Why Complete Markets are Rejected

This section explores the robustness of the previous results to a variety of potentially confounding issues, and aims to understand why complete markets are rejected. I first analyze whether monitoring costs for hired labor drive the results by disaggregating labor demand into different tasks. I then address the potential endogeneity of household composition by exploiting temporal variation in the panel and considering larger extended families rather than households as the appropriate decision making unit. I also explore heterogeneity in the baseline results by stratifying households according to their socioeconomic status.

### *3.6.1 Differential Monitoring Costs and Farm Tasks*

One potential explanation for finding rejections of separation and a connection between household composition and labor demand is the presence of labor market frictions resulting in a discrepancy between the marginal products and wages of hired and family labor. The most frequently discussed potential friction is a monitoring cost for hired labor, as farmers and day laborers are often thought to be engaged in a principal-agent problem. The extra cost results in a wedge between the market wage and the effective shadow wage of family labor. In the case of rice production, monitoring costs and the threat of shirking are particularly relevant for certain tasks but not others. Weeding, planting, and fertilizing are all tasks that are easily masked by the flooded paddy field and difficult to monitor. In contrast, harvesting is a visible activity often paid a piece-rate rather than daily wage, and subject to fewer concerns regarding shirking. By disaggregating labor demand into specific tasks, it is possible to investigate the importance that monitoring costs play in the connection between family demographics and farm labor, and examine if markets are in fact complete for certain tasks with low monitoring costs.

The agricultural module in WISE contains the number of person-days hired for each of seven tasks performed on the farm, as well as who in the household worked

in each task.<sup>23</sup> Task specific labor demand is the sum of person-days hired for a task and labor supplied by family members to a task. Family supplied labor is calculated by matching the farm tasks reported for each household member to their individual employment data.<sup>24</sup>

Labor demand regressions for specific types of labor appear in Table 3.3. The tasks are grouped into three categories based on potential monitoring costs, wages, and the amount of hired labor used to complete the tasks. Harvesting has low monitoring costs, requires substantial amounts of labor, and pays a daily wage nearly three times that of other types of labor (an average of approximately Rp18,000 per day). Weeding, planting, and fertilizing are the second group, and tasks that face high monitoring costs, yet rely on large amounts of hired labor. The remaining three tasks; preparing land, working with livestock, and drying, selling and milling the harvest, are done almost exclusively by household members. Young and prime age males do the majority of preparing land and working with livestock, while female household members contribute to drying, selling and milling.<sup>25</sup>

Columns 1 through 4 of Table 3.3 report estimates from the panel labor demand model with household and community-time fixed effects in equation (3.9). Column 1 is the baseline panel regression for total labor demand from Table 3.2, and is included for comparison to the task specific regressions. As not every household performs each of the tasks in every period, the samples in columns 2 through 4 are smaller than

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<sup>23</sup> The seven tasks are: working with livestock, preparing land, planting, weeding, fertilizing, harvesting, and drying, selling and milling the harvest.

<sup>24</sup> Individuals report on the primary activities of all on and off farm labor in every wave. To construct the amount of family supplied hours of harvesting labor, for example, I count the hours on the family farm denoted as “harvesting,” by household members reported by the household head to work on the harvest. The same is true for each of the seven activities. There are a small fraction of cases where a household member is listed as performing a farm task by the household head, but does not mention the task as a primary activity of any of their jobs over the previous four months. Results in this section use only family labor from those that could be matched while Supplemental Table 3.12 includes results where these potentially missing hours were imputed based on the hours the individual worked doing the same task in surrounding waves. The results are consistent between the two methods of calculating family labor.

<sup>25</sup> Results using other combinations of tasks, and each of the tasks individually are available upon request.

the full sample in column 1.<sup>26</sup> Coefficients on individual demographic groups remain highly significant across all types of labor demand, and the joint F-statistics are well above their critical values. The results show no sign of complete markets holding for tasks where monitoring costs are not a dominant concern.

Table 3.3 also shows that not only are complete markets rejected for each group of tasks, but the point estimates are largely indistinguishable from each other. Columns 5 through 8 report the differences across columns with harvesting taken as the comparison group. Each cell contains the difference of the point estimates for the demographic group in the row with the standard error of the difference below.<sup>27</sup> Only one out of the 36 differences is significant at the five percent level. Combined with the results in columns 1 through 4, the statistical similarity between each of the regressions suggests that the overall rejection of complete markets is not driven by aggregating labor across activities, nor are the baseline results masking that separation holds for certain tasks. This is a somewhat surprising result, as much of the literature posits monitoring costs and contracting constraints to be the driving frictions in agricultural labor markets. With monitoring shown to not explain the results, I next turn to examine the potential endogeneity of household composition.

### *3.6.2 Endogenous Household Composition and Family Labor*

Identification in the panel model comes from how changes in household composition relate to changes in farm labor demand. By exploiting the panel, the household-farm fixed effects remove concerns of time invariant unobserved heterogeneity at the farm and household level, and the community-time indicators control for local time-varying shocks and fluctuations. The endogeneity concerns that remain are household specific productivity shocks that may bias the results toward rejecting complete markets.

There are a number of ways to address this potential threat. A significant source

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<sup>26</sup> Restricting the sample to those households who perform a task within each of the groups does not change the results.

<sup>27</sup> As with the standard errors on the point estimates, the standard errors on the differences also account for clustering within households. These are calculated using the delta method.

of variation in household composition comes from individuals moving away from their households of origin due to marriage, or pursuing education or employment in a different location. Family living arrangements are often quite complex in developing settings, and who resides in a particular household at a particular time may be endogenously chosen. To address this concern, I make use of a unique feature in the WISE tracking scheme. As described in Section 3.4, when members of the survey leave their original households for marriage, education or other reasons, they are followed and their new households become part of the WISE panel thereafter. By linking these split-off households back together, it is possible to construct detailed information on the non co-resident family members of each household.<sup>28</sup> With this strategy, the relevant unit of observation is the larger family rather than a household, and variation in family demographics no longer comes from split-offs. The variation that remains is due to aging, births, deaths, and new entrants into the family.

Table 3.4 reports results from regressions that include non co-resident family composition as well as household composition to test whether separation holds when considering the family as the unit of observation. Each family stemming from an original farm household appears once in each wave, and the household-farm fixed effect is now a family-farm fixed effect.<sup>29</sup> For comparison, column 1 contains results from a specification similar to the household model but restricted to the baseline farm households. The results again reject separation, and the point estimates are nearly identical to those in the household panel in Table 3.2.

Column 2 expands the model to the larger extended family level. Family composition is specified as the number of members in a given demographic group in the baseline farm household and all split-off households. The estimates once again reject separation, with individual coefficients remaining statistically significant. This sug-

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<sup>28</sup> See the second chapter of this dissertation and Witoelar (2012) for work exploiting a similar design in the Indonesia Family Life Survey to construct data on extended families.

<sup>29</sup> Labor demand is also now “family” labor demand - the sum of labor demand used on all of the farms within an extended family. In 95% of cases this is just the labor used on the base household farm. The small number of families that report two farm households are typically new split-offs where a son has moved out from his parents home but works the existing farm land with his family. In these cases, I group the farm split-off with the base farm household as they remain essentially one family farm. Results are invariant to this choice.

gests that variation from strategically sending away family members is not driving the results in the baseline rejections of complete markets.

In column 3, members of the baseline farm household and members of non co-resident households are separated.<sup>30</sup> Separation is still rejected in the specification, although significance is concentrated in base household composition rather than non co-resident family members. Estimates of non co-resident composition are jointly insignificant, although having additional non co-resident women over the age of 65 in the family relates negatively to farm labor demand. Including non co-resident composition has little impact on the estimates of household composition, as shown in column 4 which reports the differences between columns 1 and 3 and shows that the estimates are nearly all statistically indistinguishable.<sup>31</sup>

The results in Table 3.4 show that the rejection of complete markets is robust to considering the larger family rather than only the household, and that the relationship between family demographics and labor demand is concentrated within the actual farm household itself. Although variation due to split-offs does not seem to drive the results, it is possible that the remaining within household variation may be endogenously related to unobserved farm specific productivity shocks. Table 3.5 presents results addressing this concern by exploiting a number of temporal features of the WISE panel.

Columns 1 and 2 of Table 3.5 relate contemporaneous labor demand to one period lagged and lead composition. If transitory household level shocks create a relationship between household composition in period  $t$  and labor demand in period  $t$ , moving one period away and examining lags and leads removes some concerns of the contemporaneous endogeneity. If markets are complete, labor demand in period  $t$  should be unrelated to past and future household composition. This is not the case, as the results remain consistent with those shown previously. In both the lagged and

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<sup>30</sup> Identification of non co-resident composition independently of farm composition requires there be a sufficient number of split-offs. Over forty percent of families experience a split-off at some point of the survey.

<sup>31</sup> Where they are statistically different, girls birth to 19 and women over the age of 65, the point estimate of the differences are only 0.01.

lead specifications, additional male and female household members are related to an increase in labor used on the farm.

The variation in demographics that is the least concerning is from household members aging and transitioning between demographic groups. Unlike a strategically timed birth or marriage, aging from 14 to 15, for example, cannot be due to household specific shocks. One strategy to bypass the concerns with endogenous composition changes is to look at those households where the only variation is through aging. While this may be a selected group, column 3 uses the subsample of households with no new entrants, births, exits, or deaths, and shows the results remain consistent. Individual and joint tests reject separation and show that household members aging is related to changes in farm labor use. Column 4 uses a similar strategy to look at variation only through aging for those households in the baseline sample. Household composition in each subsequent wave is constructed as if the individuals in the baseline remain within the household and age throughout the panel. If markets are complete, household composition constructed in this way should not affect labor demand. Again, this is clearly rejected with both individual and joint tests establishing a significant relationship between changes in household structure due to aging and labor demand.

As a final approach, column 5 exploits potential instrumental variables to correct for the endogeneity of changes in household composition. Household demographics in previous periods provide a set of potential instruments for current composition in the spirit of Arellano and Bond (1991). Conditional on the household and community-time fixed effects, as well as additional explanatory variables, lagged household composition should impact labor demand only through its relationship with current household composition.<sup>32</sup>

Column 5 reports second stage estimates from an overidentified model using 1

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<sup>32</sup> Bowlus and Sicular (2003) use a similar strategy when testing separation using a four-period panel of rural Chinese farmers. While they do not report the point estimates or results using lagged values as instruments, they use lagged differences of household composition to instrument for contemporaneous composition. They find that separation can still be rejected at the 10% level in their IV estimates.

and 2 wave lags as instruments.<sup>33</sup> Full first stage results are included in Supplemental Table 3.11. Although the sample shrinks by removing early waves where lags are not available, the instruments are highly predictive, with first stage F-statistics well above the critical value associated with weak instruments. The second stage results again show a clear relationship between household composition and labor demand. Even after instrumenting for current household composition with lagged values, individual composition characteristics remain statistically significant both individually and jointly. Furthermore, the C-test of overidentification restrictions cannot reject the validity of the 1 period lagged instruments conditional on the exogeneity of the 2 period lags.<sup>34</sup> The results show the rejection of separation is robust to correcting for the potential endogeneity of changes in household composition when lagged values are used as instruments.

While no single strategy may be ideal, the combined evidence from tables 3.4 and 3.5 suggest that the endogeneity of changes in household composition is not driving the results. Instead, there appears to be a significant connection between household demographics and labor demand that violates the predictions of complete markets.

### *3.6.3 Are Markets Complete for a Select Few?*

While the rejection of complete markets appears robust to disaggregating labor demand and accounting for the endogeneity of household composition, it is still possible that complete markets are a valid characterization for a subset of the population. Households that are wealthier and more advantaged may be better able to cope with shocks, smooth consumption, and function according to market completeness.<sup>35</sup> Results in this section present suggestive evidence that separation may in fact hold for

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<sup>33</sup> One and 2 wave lags measure household composition 4 and 8 months prior to the current wave.

<sup>34</sup> The C-test is also known as the difference-in-Sargan statistics test. The test statistics is the difference of the Sargan-Hansen statistics from the equation with the smaller set of instruments that are valid under both the null and alternative, and the equation with the full set of instruments (Hayashi, 2000, pp. 218-222).

<sup>35</sup> This is a common finding in the empirical risk pooling literature. See Townsend (1994) among many others.

a small fraction of farm households at the top of the distribution.

Table 3.6 reports results from stratifying the sample according to two different dimensions. The first, in columns 1 through 3, divides households based on the cognitive test scores of the household head. Those individuals with higher levels of cognition may be better able to take advantage of market environments and operate according to complete markets. WISE contains several cognitive assessments throughout the survey including a number of non-verbal reasoning tests. Scores on these exams are transformed to gender-age specific z-scores, and households are divided into three groups based on whether the household head's average z-score was below -1 or above 1 to classify the bottom and top of the distribution.<sup>36</sup> The results show that households with heads who score the highest on cognitive assessments appear close to behaving as if markets are complete, while those in the middle and bottom of the distribution exhibit the link between household demographics and labor demand seen in previous tables. While the joint test of composition is able to reject separation for households headed by individuals at the bottom of the cognitive distribution at the 10% level ( $p$ -value 0.07) and middle at 1% ( $p$ -value 0.00), the same is not true for the highest achieving households. The estimates for males 20 to 34 and females 35 to 64 remain significant on their own, but the joint test fails to reject the null ( $p$ -value 0.23).

Another marker of a household's socioeconomic status is their average (real) per-capita expenditure over the course of the study. Columns 4 through 6 of Table 3.6 report results dividing the sample into the bottom 15% of the distribution, the middle 70% of the distribution, and the remaining top 15%. The results reveal a sharp distinction between the top of the distribution and the remainder below. Columns 4 and 5 mirror earlier results as separation is clearly rejected for households in the bottom 85% of the distribution. In contrast, no individual demographic groups are significantly related to labor demand amongst those households at the top of the distribution, and the joint test of all 12 groups is also not able to reject separation in

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<sup>36</sup> Other transformations of the cognitive scores and divisions of the z-scores produce qualitatively similar results.

the subsample ( $p$ -value 0.14). This is unlikely to be a result of insufficient statistical power, as the 15-70-15 division ensures there are similar numbers of households in the bottom as well as the top of the distribution.<sup>37</sup>

The stratified results provide suggestive evidence that separation between production and consumption may be valid for a small subset of farmers with potentially better access to information and markets. However, for the majority of farms, who resides in the household matters. This suggests the marginal products and wages of family and hired labor differ in ways that connect household composition to farm labor use. This section has shown that this link is not simply due to the endogeneity of changes in household composition or monitoring costs for hired labor. The next section considers whether the empirical link between composition and labor demand is consistent with a difference in the skills and productivities of family versus hired labor.

### 3.7 Household Labor Allocation with Heterogeneous Skills

Recall from Section 3.2 that the baseline model in the literature specifies a homogeneous type of labor with a common wage for both hired and family workers. The previous results suggest that labor markets and household behavior are significantly more complex. This section describes a model of household labor allocation that allows for heterogeneity in individuals' on and off-farm skills that is consistent with the empirical link between household composition and labor demand.<sup>38</sup> Households in the WISE sample are active in both sending family members to work away from the farm, and hiring workers from the labor market, with 70% of households reporting both hiring labor and having family members work away from the farm. This pattern, along with the relationship between household composition and the skill

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<sup>37</sup> The result is qualitatively similar for other divisions of PCE, however the joint test is able to reject separation for the top of the distribution when it is expanded beyond 18% of households. The  $p$ -value for the joint test where the top of the distribution is defined as 18% of household is 0.015.

<sup>38</sup> Conceptually the model is similar to Jacoby (1993), which structurally estimates a farm production function to estimate marginal productivities for different types of family labor (i.e. male versus female) on small farms in the Peruvian sierra.

levels of family members, suggests differential productivities of household members and hired labor may be an important feature of labor markets in the region.<sup>39</sup>

### *3.7.1 A Simple Model of Household Labor Allocation*

By aggregating labor as the sum of family and hired person-days, the baseline model assumes that there is a common type of labor that is perfectly substitutable between family and hired workers.<sup>40</sup> As an alternative, consider a model with two different types of labor; type  $f$  labor with skills best suited toward farm work, and type  $n$  with non-farm skills. Both types of labor may exist among family members within a household and for hire in the market. Households face a decision as to where to sort their own family members as well as who, if anyone, to hire as farm labor. Optimizing farmers will compare the marginal product of each household member in on and off-farm employment, and allocate each type to the sector with its comparative advantage. As a result, subject to the availability of employment, type  $n$  family members will be sent to work off the farm, while type  $f$  labor is kept at home.

Farmers are able to hire both types of labor for use in their fields, however, under plausible conditions they will choose to only hire type  $f$  labor. If the marginal product of farm production from type  $f$  hired labor exceeds that of type  $n$  family labor, households will choose to use a combination of hired and family type  $f$  labor on the farm while sending type  $n$  labor to the market. As a result, those household members who remain in family farm employment will look substantially different than those sent to work off-farm.

### *3.7.2 Empirical Framework*

The high frequency of households hiring in farm labor while family members work off-farm is suggestive evidence of sorting. However, whether or not heterogeneous

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<sup>39</sup> Household size and the number of prime age males and females in the household relates positively to both years of education and cognitive scores of household heads and their spouses.

<sup>40</sup> Examining labor demand for specific tasks in Section 3.6 was a way to relax the single-labor input assumption. However, even in the case that planting labor may be different than harvesting, for example, complete markets implicitly assumes family and hired workers were perfect substitutes in each task.

skills are present and households sort labor according to its comparative advantage is an empirical question. If sorting occurs based on the relative productivity of each family member in on and off-farm production, individuals' human capital will affect the probability of working on the family farm. This is in contrast to the predictions of a model with a single type of labor. If labor is homogenous, as in the model in Section 3.2, an individual's marginal product will be the same in on and off farm labor and their individual traits will not predict in which sector they work. If there are differing returns to type  $n$  and  $f$  labor in off-farm and farm labor, efficient households will send members to the tasks where they have a comparative advantage.

Examining the likelihood a farm household member works off the family farm as a function of their characteristics provides empirical evidence on the validity of the model with heterogeneous skills. Characteristics that may be relevant for determining comparative advantage in on versus off farm labor include gender, age, education, cognition, and long-run measures of human capital.

For household member  $i$  in farm household  $h$ , let the likelihood they ever work away from the family farm as a function of their individual characteristics be given by the following:

$$1(Off\ farm_{ih}) = \alpha + \beta_1 A_{ih} + \beta_2 E_{ih} + \beta_3 C_{ih} + \beta_4 H_{ih} + \mu_h + \varepsilon_{ih} \quad (3.12)$$

where the dependent variable is an indicator equal to one if the individual ever works in off-farm employment.<sup>41</sup> The individual's age,  $A_{ih}$ , years of education,  $E_{ih}$ , and cognitive score,  $C_{ih}$ , are included, as is height,  $H_{ih}$ , as a measure of long-term human capital.<sup>42</sup> As in the empirical tests of separation, equation (3.12) includes a household-farm fixed effect,  $\mu_h$ , to capture all common observed and unobserved heterogeneity at the household and farm level. With the inclusion of the fixed effects,

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<sup>41</sup> This includes working off farm as a primary occupation and providing family farm labor on the side.

<sup>42</sup> Cognition is measured as the average cognitive score across several non-verbal assessments within WISE. Height is standardized using gender-age norms from the 2000 CDC growth tables, and the mean value is -2.14 (s.d. 0.87). Height-for-age is a well accepted measure of early life investments and long-term human capital (Strauss and Thomas, 2008).

the model examines variation within households, and the  $\beta$  coefficients on individual characteristics measure individual  $i$ 's characteristics relative to household  $h$ 's average.

An additional testable implication of the heterogeneous skill model is that households optimize by sending the individual with the highest comparative advantage for market labor to off farm employment. Instead of each individual's characteristics entering equation (3.12), this can be tested by including indicators for when individual  $i$  is the most experienced, most highly educated, has the highest cognitive score, and the tallest among household members. In this formulation, the  $\beta$  coefficients measure the impact of absolute rather than relative characteristics within a household.

All farm household members 15 and older who ever report working on or away from the family farm during WISE are included in the estimation sample.<sup>43</sup> The model examines the decision of where a household member works conditional on being employed.

### 3.7.3 Results

Table 3.7 contains estimation results for the linear probability model in equation (3.12) predicting off-farm labor as a function of an individual's human capital. Columns 1 through 3 tests an individual's characteristics relative to the household average, while columns 4 through 6 include indicators for the absolute characteristics within a household.

The results are consistent with the model of heterogeneous skills and household optimizing behavior sketched above. The results in column 1 including male and female household members suggest that high human capital, prime-age males are sent to market work. As predicted, the probability an individual works off farm is increasing in their years of education, cognition, and height. Columns 2 and 3 show

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<sup>43</sup> Only a small fraction, approximately 10%, of household members age 15 and above never work on or off farm.

this is consistent for males and females as well.<sup>44</sup> The model is also supported by the alternative specification in columns 4 through 6 examining absolute characteristics of members within the family. The estimates show that the individual with the highest human capital in the household is more likely to work off farm. This is true for years of education, cognition, and long run human capital captured by height.

These results suggest that households optimize in the face of differing returns to heterogeneous labor by sorting family members between farm production and market work. This empirical evidence is a preliminary step toward understanding household behavior in more complex labor markets than those in the traditional agricultural household model. It also suggests a way to examine the effects of market incompleteness on rural households. If certain households are constrained by the market in their ability to send away family members or hire on farm laborers, this will result in a loss from inefficient labor allocation. Ongoing work motivated by the findings in Table 3.7 looks to assess the impacts of incomplete markets, and further examine the differential marginal productivities of hired and family laborers.

### 3.8 Conclusion

Small, family-run farms and microenterprises play an important role in developing settings, and are potential drivers of global growth. In order to understand these households' behaviors and to formulate and evaluate policies, appropriate models of the constraints and choices these household face are essential. This chapter shows that the commonly used agricultural household model with complete markets and separation between production and consumption decisions is inconsistent with new empirical evidence from rural Indonesia. Using new, longitudinal data from Central Java, I show a link exists between household characteristics and farm labor demand that is inconsistent with complete markets. This is in direct contrast to seminal findings in the literature which have upheld the predictions of complete markets

<sup>44</sup> The coefficients and standard errors for males and females in columns 2 and 3, as well as 5 and 6, are obtained through interactions rather than stratifying the sample. This preserves the interpretation of the individual relative to the entire household rather than only household members of the same gender. Columns 2 and 5 are from a fully interacted model with female indicators, and columns 3 and 6 from a fully interacted model with male indicators.

in rural Indonesia. I also extend the literature by showing neither time invariant unobserved heterogeneity at the farm level, separately examining labor demand for tasks with differential monitoring costs, nor addressing the potential endogeneity of household composition changes the conclusion: household composition affects labor demand on the farm.

Understanding the margins where deviations from complete markets appear is a natural next step. The results suggest a wedge exists between the productivity of family and hired labor that links who is in the household to farm labor demand. Motivated by this finding, I develop an extended model of resource allocation within agricultural households allowing for heterogeneity in the skills of household and farm laborers. The model predicts that households sort their members to on and off-farm work according to their comparative advantage, and hire in labor with farm specific skills to replace those household members in the market. I provide empirical evidence that an individual's human capital predicts their sector of employment that is consistent with the model's predictions.

This chapter has highlighted a number of findings that call for further work. A particular focus for future projects is assessing the welfare loss due to market incompleteness, its underlying causes, and further analyzing family decision making in the face of risk, uncertainty, and market imperfections. The overall results of this chapter are important not only for modeling farm-household decision making, but emphasize the importance of recognizing market complexities in designing and evaluating development policy around the world.

### 3.9 Supplement: Reconciling Discrepancies with the Previous Literature

This supplement investigates the discrepancy between the baseline rejections of separation shown in Table 3.2 and the failure to reject separation in Benjamin (1992), a seminal paper in the literature on separation and complete markets in agricultural settings. By matching features of the dataset and empirical specification used by Benjamin, I am able to reconcile the otherwise inconsistent results.

Benjamin’s analysis uses a one-time agricultural supplement given to farm households across Java as part of the 1980 Indonesia Socioeconomic Survey (SUSENAS). Despite their many similarities, this data is fundamentally different than WISE in two ways: i) it is cross-sectional while WISE is a panel, and ii) families report working significantly less on their own farms than in WISE. These two discrepancies are addressed in Supplemental Table 3.11 by modifying WISE to resemble the 1980 data.<sup>45</sup>

The first modification is to account for seasonality. As SUSENAS is collected in the beginning of each year, I restrict the WISE sample to the 3 waves that began in January and had the majority of fieldwork completed by March.<sup>46</sup> This restricts the sample within these waves by approximately 40%. Benjamin also chose to only use rice farmers in his sample, while results presented in the body of this chapter include those who were farming other crops as well. Restricting WISE to households that grow rice further reduces the sample by approximately 10%.

Columns 1 through 4 of Supplemental Table 3.11 repeat the first cross section and panel estimates using this sample. The cross sectional estimates are presented for comparison with SUSENAS’s single wave of data although the panel models are included and preferred for reasons of unobserved farm and household heterogeneity

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<sup>45</sup> The Agricultural Supplement (Section IV) to the 1980 SUSENAS is no longer available from Badan Pusat Statistik (Statistics Indonesia), although the questionnaire is available from the online RAND Indonesia Data Core (<http://www.rand.org/labor/bps.html>). Any efforts to make the two data sets comparable rely on summary statistics presented within Benjamin (1992).

<sup>46</sup> These are waves 1, 4, and 7 which began in January of 2002, 2003, and 2004. This is potentially important if there is seasonal variation in the availability of hired labor due to the observance of Ramadan which occurred in the later half of the year throughout WISE.

discussed in previous sections. Columns 1 and 2 use the preferred model in Table 3.2, while columns 3 and 4 use Benjamin’s alternative specification for household composition. Regardless of the specification, the rejections of separation are upheld across columns 1 through 4 in both cross section and panel estimates. Individual coefficients and the joint test over all demographic variables remain statistically significant, rejecting complete markets as in Table 3.2.

These results suggest that neither the seasonality of the data nor the cross section versus the panel components can account for the discrepancy between the two sets of results. However, one large discrepancy remains. As mentioned in Section 3.5, according to summary statistics in Benjamin (1992), WISE families spend significantly more hours working on their farms than those in the SUSENAS sample. Recall from Table 3.1 that household members work an average of 54.4 person-days on their farms over the course of 4 months, or an average of 163.2 person-days over the course of a year. In contrast, families in the SUSENAS sample report only 26 person-days of farm labor per year (Benjamin, 1992, Table II p. 300). This is equivalent to a single day’s work by a single household member once every two weeks. To address this inconsistency, I down-weight WISE labor supply by a factor of 6.27 (163.2/26) so the WISE mean matches the SUSENAS mean.<sup>47</sup> This transforms the dependent variable from labor demand to a value closer to the amount of hired farm labor.

Columns 5 through 8 of Supplemental Table 3.11 use the same restricted sample used in columns 1 through 4, but with the down-weighted measure of household labor supply. Even with this transformation, results using the preferred specification for household composition in columns 5 and 6 still reject separation both jointly and with individual gender-age groups being statistically significant. This is true in both the cross section and panel.

Estimates using the alternative measure of household composition in columns 7 and 8 reveal a different story. Once family labor supply is modified and the alternative specification for household composition is utilized, none of the individual

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<sup>47</sup> The modified dependent variable is  $\log(L^{Hired} + \frac{L^{Supplied}}{6.27})$  as oppose to  $\log(L^{Hired} + L^{Supplied})$ .

coefficients are significant.<sup>48</sup> This closely matches the failures to reject separation in previous literature, and suggests the driving factor may be the discrepancy between the amount of labor families report working on their own farms in the different data sets.

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<sup>48</sup> Although separation is rejected jointly in columns 7 and 8 ( $p$ -value = 0.03 for the cross section and 0.07 for the panel), if a random sample of 1443 observations is taken from this modified WISE data to match the sample size in the SUSENAS, neither of the joint tests can be rejected.

### 3.10 Primary Tables

Table 3.1: Summary Statistics

Panel A Farm Characteristics		Panel B Household Composition			Panel C Farm Labor	
	(1)		(2)	(3)		(4)
	Mean		Mean	Percent with a Change		Mean
Rice Farm (%)	84.89 (0.18)	Household Size	3.83 (0.008)	60.34 (0.77)	<i>Person-Days of [...]</i>	
		<i>Males age [...]</i>			Total Labor Demand	72.45 (0.30)
Own Land (%)	73.20 (0.23)	Birth to 14 years	0.51 (0.004)	28.87 (0.72)	Hired Labor	18.07 (0.19)
Size of Land Owned ( $m^2$ )	2076.45 (70.72)	15 to 19	0.19 (0.002)	27.64 (0.71)	Family Supplied Labor	54.38 (0.22)
Value of Farm Assets (Rp0,000)	236.29 (4.50)	20 to 34	0.30 (0.003)	27.02 (0.70)	<i>Person-Days Hired for [...]</i>	
Value of Non-Farm Assets (Rp0,000)	461.01 (5.49)	35 to 49	0.36 (0.003)	22.36 (0.66)	Planting	6.39 (0.07)
<i>Age of [...]</i>		50 to 64	0.31 (0.002)	24.44 (0.68)	Harvesting	4.86 (0.07)
Primary Male	54.50 (0.07)	65 and older	0.30 (0.002)	16.07 (0.58)	Weeding	4.10 (0.08)
Primary Female	49.23 (0.06)	<i>Females age [...]</i>			Other Farm Tasks	2.72 (0.08)
<i>Years of Education of [...]</i>		Birth to 14 years	0.47 (0.004)	26.36 (0.70)	<i>Family labor supplied by [...]</i>	
Primary Male	6.14 (0.02)	15 to 19	0.14 (0.002)	24.51 (0.68)	Male Household	40.33 (0.18)
Primary Female	4.98 (0.02)	20 to 34	0.27 (0.002)	26.19 (0.70)	Members	14.05 (0.10)
		35 to 49	0.41 (0.003)	23.76 (0.67)	Female Household	
		50 to 64	0.34 (0.002)	25.91 (0.69)	Members	
N. Households	4452	65 and older	0.25 (0.002)	17.70 (0.60)		
N. Household-wave Obs.	38189					
		Any Change in Household Composition		81.42 (0.62)		

*Notes:* Table reports means and standard errors for variables of interest over the first 11 full waves of WISE. The sample consists of households with farm businesses, approximately 75% of households in the survey. All labor is measured as unconditional means of person-days over the past 4 months, and assets as January 2002 Rp0,000.

Table 3.2: Cross Section and Panel Labor Demand Regressions

	(1)	<i>Model</i> (2)	(3)
	Wave 1 Cross Section	Pooled Cross Sections	Household Fixed Effects
<i>Number of males [...]</i>			
Birth to 14 years	0.02 (0.02)	0.02** (0.01)	0.00 (0.02)
15 to 19	0.09*** (0.03)	0.11*** (0.01)	0.09*** (0.02)
20 to 34	0.16*** (0.03)	0.17*** (0.01)	0.14*** (0.02)
35 to 49	0.18*** (0.04)	0.19*** (0.02)	0.16*** (0.03)
50 to 64	0.31*** (0.04)	0.27*** (0.02)	0.21*** (0.03)
65 and older	0.26*** (0.05)	0.21*** (0.03)	0.18*** (0.03)
<i>Number of females [...]</i>			
Birth to 14 years	-0.00 (0.02)	-0.02* (0.01)	-0.03** (0.02)
15 to 19	-0.01 (0.03)	0.01 (0.02)	-0.00 (0.02)
20 to 34	0.01 (0.04)	0.01 (0.02)	0.05*** (0.02)
35 to 49	0.12** (0.05)	0.07*** (0.02)	0.14*** (0.02)
50 to 64	0.12** (0.05)	0.10*** (0.02)	0.10*** (0.03)
65 and older	-0.02 (0.04)	-0.04** (0.02)	0.02 (0.03)
<i>Joint tests of demographics (F-stats)</i>			
All Groups	11.64	39.33	13.98
<i>p</i> -value	0.00	0.00	0.00
Males	17.22	55.63	19.62
<i>p</i> -value	0.00	0.00	0.00
Females	2.81	10.58	6.86
<i>p</i> -value	0.01	0.00	0.00
Prime age adults 15 to 49	11.02	50.02	24.09
<i>p</i> -value	0.00	0.00	0.00
Observations	3421	38189	38189
N. of Households	3421	4452	4452
F-test of All Regressors	20.61	109.5	25.55
$R^2$	0.39	0.25	0.05

*Notes:* Table reports coefficients of interest from estimates of labor demand equations with log of total person-days as the dependent variable. Column 1 includes a single cross section from the first wave of WISE and column 2 pools all cross sections and includes a locality-time effect. Column 3, equation (3.9), adds a household-farm fixed effect to the model in column 2. Under separation, each coefficient should be zero. The reported F-statistics and *p*-values are for joint tests of the specified coefficients. Regressions also control for the following: land ownership and the size of land owned, whether land is irrigated and size of irrigated land, quintiles of farm and household (real) assets, age and education of the household head and spouse, and month of interview indicators. Indicators for the primary crop grown are also included in the cross section, but are controlled for with the household fixed effect in panel estimates. Standard errors in parentheses are calculated accounting for clustering at the locality level in column 1 and the household level in columns 2 and 3. The  $R^2$  in column 3 is for within variation. \*\*\* Significant at the 1% level, \*\* Significant at the 5% level, \* Significant at the 10% level

Table 3.3: Labor Demand by Farm Tasks

	Demand for [...] Labor				Differences across coefficients (harvesting as base)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total	Harvesting	Weeding Planting Fertilizing	Land Prep Livestock Dry/Sell/Mill	Total	Harvesting	Weeding Planting Fertilizing	Land Prep Livestock Dry/Sell/Mill
<i>Number of males [...]</i>								
Birth to 14 years	0.00 (0.02)	-0.03 (0.02)	-0.01 (0.02)	0.01 (0.03)	-0.04 (0.02)	-	-0.03 (0.03)	-0.04 (0.03)
15 to 19	0.09*** (0.02)	0.06** (0.02)	0.07*** (0.02)	0.17*** (0.03)	-0.03 (0.02)	-	-0.01 (0.03)	-0.11*** (0.04)
20 to 34	0.14*** (0.02)	0.13*** (0.03)	0.09*** (0.02)	0.15*** (0.03)	-0.01 (0.03)	-	0.04 (0.03)	-0.02 (0.04)
35 to 49	0.16*** (0.03)	0.18*** (0.04)	0.12*** (0.03)	0.18*** (0.05)	0.02 (0.04)	-	0.05 (0.04)	-0.01 (0.06)
50 to 64	0.21*** (0.03)	0.22*** (0.04)	0.15*** (0.03)	0.24*** (0.05)	0.01 (0.05)	-	0.07 (0.05)	-0.02 (0.07)
65 and older	0.18*** (0.03)	0.18*** (0.05)	0.12*** (0.04)	0.20*** (0.06)	-0.01 (0.05)	-	0.05 (0.06)	-0.03 (0.07)
<i>Number of females [...]</i>								
Birth to 14 years	-0.03** (0.02)	-0.03 (0.02)	-0.04** (0.02)	-0.03 (0.03)	0.00 (0.02)	-	0.02 (0.03)	0.00 (0.03)
15 to 19	-0.00 (0.02)	-0.02 (0.02)	-0.02 (0.02)	0.00 (0.03)	-0.02 (0.02)	-	0.00 (0.03)	-0.03 (0.04)
20 to 34	0.05*** (0.02)	0.06** (0.03)	0.05** (0.02)	0.04 (0.03)	0.01 (0.03)	-	0.02 (0.04)	0.02 (0.06)
35 to 49	0.14*** (0.02)	0.10*** (0.04)	0.12*** (0.03)	0.06 (0.05)	-0.04 (0.04)	-	-0.02 (0.04)	0.04 (0.06)
50 to 64	0.10*** (0.03)	0.10** (0.04)	0.11*** (0.03)	0.04 (0.05)	0.00 (0.04)	-	-0.01 (0.05)	0.06 (0.06)
65 and older	0.02 (0.03)	0.07 (0.04)	0.04 (0.03)	-0.05 (0.05)	0.04 (0.04)	-	0.03 (0.05)	0.12* (0.06)
<i>Joint tests of demographics (F-stats)</i>								
All Groups	13.98	5.46	5.64	7.75				
p-value	0.00	0.00	0.00	0.00				
Males	19.62	7.65	7.23	12.32				
p-value	0.00	0.00	0.00	0.00				
Females	7.00	1.81	3.83	1.32				
p-value	0.00	0.09	0.00	0.24				
Prime age adults 15 to 49	24.09	8.61	9.91	12.99				
p-value	0.00	0.00	0.00	0.00				
<i>Mean person-days of [...]</i>								
Family Supplied Labor	54.38	9.64	25.12	22.91				
Hired Labor	18.07	7.63	12.49	2.84				
Observations	38189	24353	33166	27387				
N. of Households	4452	4022	4166	4176				
F-test of All Regressors	25.55	11.02	16.16	7.55				
Within R <sup>2</sup>	0.05	0.03	0.03	0.02				

*Notes:* Columns 1 through 4 report estimates of labor demand for all types of labor and specific farm tasks. Column 1 matches results in the previous table, while 2 through 4 divide total person-days of labor into the tasks listed in each column. Labor demand for each task is calculated as the sum of person days hired to perform the task and labor supplied by household members who are both listed as performing the task and name it as an employment activity. Joint tests of demographic groups and p-values appear below. Along with locality-wave and household fixed effects, additional controls include land ownership status and the size of land owned, whether land is irrigated and size of irrigated land, quintiles of farm and household (real) assets, age and education of the household head and spouse, and month of interview indicators. Columns 5 through 8 report the differences across coefficient for each task with harvesting as the comparison task. Standard errors appear below. All standard errors in columns 1 through 8 are calculated allowing for clustering at the household level.

\*\*\* Significant at the 1% level, \*\* Significant at the 5% level, \* Significant at the 10% level

Table 3.4: Labor Demand Accounting for Non Co-Resident Family Composition

	<i>Family Composition Defined as [...]</i>			
	(1) Baseline Farm Household	(2) Sum of Farm and Non-Farm Family	(3) Farm Composition, Non-Farm Family	(4) Difference Between Columns (1) and (3)
<i>Number of males [...]</i>				
Birth to 14 years	0.01 (0.01)	0.00 (0.01)	0.01 (0.02)	0.001 (0.003)
15 to 19	0.09*** (0.02)	0.05*** (0.02)	0.09*** (0.02)	0.004 (0.004)
20 to 34	0.15*** (0.02)	0.04*** (0.01)	0.15*** (0.02)	0.001 (0.004)
35 to 49	0.20*** (0.02)	0.07*** (0.02)	0.20*** (0.02)	-0.001 (0.003)
50 to 64	0.25*** (0.03)	0.14*** (0.02)	0.25*** (0.03)	-0.003 (0.003)
65 and older	0.23*** (0.03)	0.14*** (0.03)	0.24*** (0.03)	-0.003 (0.004)
<i>Number of females [...]</i>				
Birth to 14 years	-0.01 (0.02)	-0.00 (0.01)	0.00 (0.02)	-0.010** (0.004)
15 to 19	0.01 (0.02)	0.00 (0.02)	0.02 (0.02)	-0.010* (0.005)
20 to 34	0.08*** (0.02)	0.00 (0.01)	0.08*** (0.02)	-0.006 (0.004)
35 to 49	0.16*** (0.02)	0.05*** (0.02)	0.16*** (0.02)	0.000 (0.003)
50 to 64	0.15*** (0.02)	0.05** (0.02)	0.15*** (0.02)	0.005 (0.004)
65 and older	0.07*** (0.02)	-0.01 (0.02)	0.06*** (0.02)	0.010* (0.006)
<b>Composition of Non Co-Resident Family Members</b>				
<i>Number of males [...]</i>				
Birth to 14 years			0.01 (0.02)	
15 to 19			-0.03 (0.02)	
20 to 34			-0.01 (0.02)	
35 to 49			0.01 (0.03)	
50 to 64			0.03 (0.07)	
65 and older			0.09 (0.07)	
<i>Number of females [...]</i>				
Birth to 14 years			0.03 (0.02)	
15 to 19			0.02 (0.02)	
20 to 34			0.01 (0.02)	
35 to 49			-0.02 (0.04)	
50 to 64			-0.02 (0.05)	
65 and older			-0.10** (0.05)	
<i>Joint test of demographics (F-stats)</i>				
All Family Demographics	24.85	7.15	13.08	
p-value	0.00	0.00	0.00	
All Farm Groups			23.68	
p-value			0.00	
All Non-Farm Groups			0.96	
p-value			0.48	
Observations	35270	35270	35270	
N. of Households	3833	3833	3833	
F-test of All Regressors	24.85	18.98	20.14	
Within $R^2$	0.05	0.04	0.05	

*Notes:* Table reports coefficients of interest and their standard errors for farm labor demand regressions including household and non co-resident family composition. Non co-resident family composition is determined by linking split-off households back to their household of origin. The level of observation is the extended family rather than the household. Column 1 is restricted to baseline farm households, while column 2 combines composition in the baseline farm household with that of the non co-resident split-offs. Column 3 includes farm household and non co-resident composition separately, and column 4 reports the differences between columns 1 and 3. Regressions also control for the following: land ownership status and the size of land owned, whether land is irrigated and size of irrigated land, quintiles of farm and household (real) assets, age and education of the household head and spouse, and month of interview indicators. Standard errors and test statistics are calculated allowing for clustering at the family level.

\*\*\* Significant at the 1% level, \*\* Significant at the 5% level, \* Significant at the 10% level

Table 3.5: Labor Demand Accounting for Endogenous Household Structure

	(1)	(2)	(3)	(4)	(5)
	1 Period Lagged Composition	1 Period Lead Composition	Only Aging Variation	Baseline Household Composition	Instrumenting with 1 and 2 Period Lags
<i>Number of males [...]</i>					
Birth to 14 years	-0.02 (0.02)	0.03** (0.02)	0.00 (0.06)	0.13** (0.06)	-0.00 (0.03)
15 to 19	0.06*** (0.02)	0.08*** (0.02)	0.09 (0.06)	0.20*** (0.06)	0.10*** (0.03)
20 to 34	0.09*** (0.02)	0.08*** (0.02)	0.18** (0.07)	0.17*** (0.06)	0.17*** (0.04)
35 to 49	0.09*** (0.03)	0.05** (0.02)	0.21** (0.08)	0.18*** (0.06)	0.17*** (0.06)
50 to 64	0.09*** (0.03)	0.12*** (0.03)	0.27*** (0.09)	0.21*** (0.07)	0.16** (0.08)
65 and older	0.05 (0.03)	0.12*** (0.03)	0.23** (0.09)	0.19*** (0.07)	0.12 (0.08)
<i>Number of females [...]</i>					
Birth to 14 years	-0.01 (0.02)	-0.00 (0.02)	-0.08 (0.06)	-0.05 (0.05)	-0.02 (0.03)
15 to 19	0.01 (0.02)	0.00 (0.02)	-0.12* (0.06)	-0.02 (0.05)	-0.03 (0.04)
20 to 34	0.06*** (0.02)	0.00 (0.02)	-0.02 (0.07)	0.00 (0.06)	0.08* (0.04)
35 to 49	0.13*** (0.03)	0.05* (0.03)	0.05 (0.07)	0.05 (0.06)	0.23*** (0.06)
50 to 64	0.07** (0.03)	0.07*** (0.03)	0.02 (0.08)	0.02 (0.06)	0.14** (0.06)
65 and older	0.01 (0.03)	-0.01 (0.03)	-0.08 (0.08)	-0.08 (0.07)	0.02 (0.06)
<i>Joint tests of demographics</i>					
All Groups	6.29	6.36	2.60	4.15	52.89
p-value	0.00	0.00	0.00	0.00	0.00
Males	6.77	9.39	2.40	4.21	26.18
p-value	0.00	0.00	0.03	0.00	0.00
Females	4.56	2.64	2.22	3.53	18.28
p-value	0.00	0.01	0.04	0.00	0.01
Prime age adults 15 to 49	10.96	7.20	2.25	2.94	45.72
p-value	0.00	0.00	0.04	0.00	0.00
C-test - 1 Period Lags ( $\chi^2$ )					9.07
p-value					0.70
Observations	33781	33185	11596	33827	30150
N. Households	3950	3810	1585	3421	3888
F-test of All Regressors	20.44	16.9	9.16	20.2	17.83
Within $R^2$	0.04	0.03	0.05	0.04	0.04

*Notes:* Table reports coefficients of interest from a number of different regression models that address the potential endogeneity of changes in household composition. Columns 1 and 2 use 1 period lagged and lead household composition rather than contemporaneous values. Column 3 is limited to those households where the only variation in household composition is through aging. These are households with no split-offs, births, deaths, or new entrants throughout WISE. Column 4 is a similar strategy, but starts with baseline households in wave 1 and creates household composition in later waves as if aging is the only variation. Finally, column 5 reports estimates from the second stage of fixed effect-IV labor demand regressions with 1 and 2 period lagged household composition as IVs for contemporaneous demographics. Full first stage results appear in Supplemental Table 3.11. The table also reports joint tests of the demographic groups. These are F-statistics for columns 1-4, and chi-squared in column 5. The C-test in column 5 is an overidentification test examining the exogeneity of 1 period lags conditional on the validity of the 2 period lags. Along with locality-wave and household fixed effects, additional controls include land ownership status and the size of land owned, whether land is irrigated and size of irrigated land, quintiles of farm and household (real) assets, age and education of the household head and spouse, and month of interview indicators. All standard errors and test statistics allow for clustering at the household level.

\*\*\* Significant at the 1% level, \*\* Significant at the 5% level, \* Significant at the 10% level

Table 3.6: Labor Demand for Stratified Samples

	Cognitive Test Score of Household Head (z-score)			Position in Per Capita Expenditure Distribution		
	(1)	(2)	(3)	(4)	(5)	(6)
	< -1	Between -1 and 1	> 1	Bottom 15%	Middle 70%	Top 15%
<i>Number of males [...]</i>						
Birth to 14 years	-0.04 (0.06)	-0.01 (0.02)	0.02 (0.05)	-0.03 (0.03)	0.01 (0.02)	-0.07 (0.05)
15 to 19	0.15** (0.07)	0.09*** (0.02)	0.08 (0.05)	0.11*** (0.04)	0.09*** (0.02)	0.05 (0.05)
20 to 34	0.11* (0.06)	0.15*** (0.02)	0.09* (0.05)	0.17*** (0.04)	0.15*** (0.02)	0.07 (0.05)
35 to 49	0.17* (0.09)	0.18*** (0.03)	0.02 (0.08)	0.34*** (0.06)	0.15*** (0.03)	0.12 (0.08)
50 to 64	0.20* (0.12)	0.21*** (0.03)	0.08 (0.10)	0.28*** (0.07)	0.20*** (0.04)	0.13 (0.08)
65 and older	0.27* (0.14)	0.17*** (0.03)	0.06 (0.12)	0.24*** (0.08)	0.19*** (0.04)	0.04 (0.09)
<i>Number of females [...]</i>						
Birth to 14 years	-0.07 (0.07)	-0.03* (0.02)	0.03 (0.04)	-0.03 (0.04)	-0.02 (0.02)	-0.07 (0.05)
15 to 19	-0.05 (0.07)	0.00 (0.02)	0.03 (0.05)	-0.04 (0.04)	-0.00 (0.02)	-0.02 (0.05)
20 to 34	0.11* (0.06)	0.06*** (0.02)	0.02 (0.05)	0.07 (0.05)	0.06*** (0.02)	0.07 (0.06)
35 to 49	0.18** (0.08)	0.14*** (0.03)	0.13** (0.06)	0.14*** (0.05)	0.15*** (0.03)	0.11 (0.07)
50 to 64	0.07 (0.11)	0.12*** (0.03)	0.13* (0.08)	0.03 (0.06)	0.13*** (0.03)	0.09 (0.07)
65 and older	0.06 (0.11)	0.03 (0.03)	0.04 (0.09)	0.01 (0.06)	0.04 (0.03)	0.03 (0.07)
<i>Joint test of demographics</i>						
All Groups	1.67	12.68	1.28	4.74	11.62	1.44
p-value	0.07	0.00	0.23	0.00	0.00	0.14
<i>Mean person-days of [...]</i>						
Hired Labor	11.81	17.32	27.25	7.42	16.95	33.96
Family Supplied Labor	50.89	55.42	52.20	62.73	55.73	40.38
Observations	2745	30822	4200	5684	26724	5638
N. of Households	327	3396	464	660	2966	729
F-test of all regressors	3.93	23.91	5.27	5.96	11.62	6.91
Within $R^2$	0.07	0.05	0.07	0.06	0.05	0.07

*Notes:* Table reports estimates of interest for labor demand regressions stratified by household per capita expenditure and cognitive test scores. Columns 1 through 3 divide the sample by the cognitive score of the household head. The division is determined by the average age-gender specific z-score obtained on non-verbal cognitive tests throughout WISE. Columns 1 and 3 include those households whose head scores below and above 1 s.d. on average, and column 2 includes the middle of the distribution. Columns 4 through 6 divide the sample by the average (real) per capita expenditure over the course of the survey. Column 4 includes households at the bottom 15% of the distribution, column 5 the middle 70%, and column 6 the top 15%. Joint tests over all demographic groups appear below the coefficient estimates. Along with locality-wave and household fixed effects, additional controls include land ownership status and the size of land owned, whether land is irrigated and size of irrigated land, quintiles of farm and household (real) assets, age and education of the household head and spouse, and the month of interview. All standard errors are calculated allowing for clustering at the household level.

\*\*\* Significant at the 1% level, \*\* Significant at the 5% level, \* Significant at the 10% level

Table 3.7: Household Labor Allocation - Probability of Working Away from the Family Farm

	Relative Characteristics within Households			Absolute Characteristics within Households		
	(1) All Household Members	(2) Male Household Members	(3) Female Household Members	(4) All Household Members	(5) Male Household Members	(6) Female Household Members
Male	0.04*** (0.01)			Male	0.09*** (0.01)	
<i>Age Brackets (15-19 Excluded)</i>						
20 to 34	0.05*** (0.02)	0.08*** (0.02)	0.01 (0.03)	1(Eldest)	-0.18*** (0.01)	-0.23*** (0.01)
35 to 49	-0.00 (0.02)	0.05** (0.02)	-0.06** (0.03)			
50 to 64	-0.14*** (0.02)	-0.15*** (0.02)	-0.14*** (0.03)			
65 and above	-0.38*** (0.02)	-0.37*** (0.03)	-0.31*** (0.04)			
<i>Years of Education Brackets (5 and under excluded)</i>						
6 to 8	-0.06*** (0.02)	0.01 (0.02)	-0.05** (0.02)	1(Highest Education)	0.07*** (0.01)	0.08*** (0.02)
9 to 11	-0.02 (0.02)	0.07** (0.03)	-0.06** (0.03)			
12 and above	0.09*** (0.02)	0.17*** (0.03)	0.06* (0.03)			
Cognitive z-score	0.02** (0.01)	0.02*** (0.01)	0.02* (0.01)	1(High Cognitive Score)	0.04*** (0.01)	0.03** (0.02)
Height-for-age (z-score)	0.02*** (0.01)	0.02* (0.01)	0.02 (0.01)	1(High Height-for-Age)	0.03*** (0.01)	0.03** (0.02)
Household Fixed Effects	Yes	Yes	Yes	Household Fixed Effects	Yes	Yes
Constant	0.77*** (0.02)	0.71*** (0.03)	0.79*** (0.04)	Constant	0.63*** (0.01)	0.74*** (0.02)
Observations	10679	10679	10679	Observations	10679	10679
N. of Households	4450	4450	4450	N. of Households	4450	4450
F-test of All Regressors	113.28	66.78	66.78	F-test of All Regressors	119.29	83.63
Within $R^2$	0.17	0.18	0.18	Within $R^2$	0.09	0.11

*Notes:* Table reports regression results for whether an individual ever works off farm in the private or government sector as a function of their individual characteristics. Sample consists of all individuals over the age of 15 from farm households who ever work on or off farm. The inclusion of a household fixed effects means coefficients can be interpreted relative to the within household average. Columns 4 through 6 also includes a household fixed effect, but characteristics are specified in absolute terms within a household with indicators for the eldest, highest education, highest cognitive score and highest height-for-age. Cognition is measured as the average gender-age z-score across non-verbal cognitive assessments in WISE. Coefficients in columns 2 and 3 and 5 and 6 are from models fully interacted by gender rather than stratifying the sample. This preserves the same interpretation for male and female estimates relative to all household members rather than only those of the same gender. Standard errors are calculated allowing for clustering amongst individuals within a household.

\*\*\* Significant at the 1% level, \*\* Significant at the 5% level, \* Significant at the 10% level

### 3.11 Supplemental Tables

Table 3.8: Work and Iron Status Evaluation (WISE) Timeline

Year	Starting Month	Wave Number	Survey Month		
2002	January	1	-4		
	February				
	March				
	April				
	May	2	0		
	June				
	July				
	August	3	4		
	September				
	October				
	November				
	December	4	8		
2003	January				
February					
March					
April					
May	5			12	
June					
July					
August	6			16	
September					
October					
November					
December	7	20			
2004			January		
February					
March					
April					
May			8	24	
June					
July					
August			9	28	
September					
October					
November					
December	10	32			
2005			January		
2007			January	11	56

*Notes:* Table includes the 11 waves of WISE used in this chapter. The initial screening survey was conducted in September of 2001 (survey month -8). The survey month is relative to the baseline for the health intervention (0 in May 2002) and follows the classification of waves in Thomas et al. (2011).

Table 3.9: Summary Statistics by Wave

Date	Wave										
	1 Jan 2002	2 May 2002	3 Sep 2002	4 Jan 2003	5 May 2003	6 Sep 2003	7 Jan 2004	8 May 2004	9 Sep 2004	10 Jan 2005	11 Jan 2007
<i>Person-Days of [...]</i>											
Total Labor Demand	84.49 (1.19)	81.88 (1.17)	60.67 (0.88)	71.67 (0.95)	81.83 (1.06)	71.49 (0.95)	66.84 (0.89)	75.03 (0.92)	66.12 (0.81)	71.35 (0.91)	64.47 (0.88)
Hired Labor	24.15 (0.83)	23.37 (0.85)	11.95 (0.51)	18.40 (0.63)	21.36 (0.71)	15.98 (0.56)	16.13 (0.53)	19.07 (0.61)	15.43 (0.44)	17.77 (0.60)	14.74 (0.45)
Family Supplied Labor	60.36 (0.82)	58.51 (0.79)	48.71 (0.73)	53.27 (0.73)	60.48 (0.78)	55.51 (0.74)	50.71 (0.69)	55.96 (0.70)	50.70 (0.69)	53.58 (0.70)	49.73 (0.76)
Household Size	3.99 (0.03)	3.94 (0.03)	3.94 (0.03)	3.90 (0.03)	3.87 (0.03)	3.86 (0.03)	3.80 (0.03)	3.79 (0.03)	3.77 (0.03)	3.72 (0.03)	3.58 (0.03)
<i>Number of Males age [...]</i>											
Birth to 14 years	0.54 (0.01)	0.53 (0.01)	0.54 (0.01)	0.52 (0.01)	0.51 (0.01)	0.51 (0.01)	0.50 (0.01)	0.50 (0.01)	0.49 (0.01)	0.48 (0.01)	0.45 (0.01)
15 to 19	0.21 (0.01)	0.20 (0.01)	0.20 (0.01)	0.19 (0.01)	0.20 (0.01)	0.19 (0.01)	0.18 (0.01)	0.19 (0.01)	0.18 (0.01)	0.18 (0.01)	0.16 (0.01)
20 to 34	0.32 (0.01)	0.32 (0.01)	0.32 (0.01)	0.32 (0.01)	0.31 (0.01)	0.31 (0.01)	0.30 (0.01)	0.29 (0.01)	0.28 (0.01)	0.28 (0.01)	0.26 (0.01)
35 to 49	0.37 (0.01)	0.37 (0.01)	0.37 (0.01)	0.36 (0.01)	0.36 (0.01)	0.36 (0.01)	0.36 (0.01)	0.35 (0.01)	0.36 (0.01)	0.35 (0.01)	0.34 (0.01)
50 to 64	0.32 (0.01)	0.31 (0.01)	0.32 (0.01)	0.32 (0.01)	0.31 (0.01)	0.32 (0.01)	0.32 (0.01)	0.31 (0.01)	0.31 (0.01)	0.31 (0.01)	0.32 (0.01)
65 and older	0.30 (0.01)	0.30 (0.01)	0.29 (0.01)	0.30 (0.01)	0.29 (0.01)	0.29 (0.01)	0.30 (0.01)	0.31 (0.01)	0.31 (0.01)	0.31 (0.01)	0.30 (0.01)
<i>Number of Females age [...]</i>											
Birth to 14 years	0.50 (0.01)	0.48 (0.01)	0.47 (0.01)	0.49 (0.01)	0.48 (0.01)	0.47 (0.01)	0.47 (0.01)	0.47 (0.01)	0.47 (0.01)	0.45 (0.01)	0.41 (0.01)
15 to 19	0.15 (0.01)	0.15 (0.01)	0.15 (0.01)	0.15 (0.01)	0.14 (0.01)	0.14 (0.01)	0.13 (0.01)	0.14 (0.01)	0.13 (0.01)	0.14 (0.01)	0.13 (0.01)
20 to 34	0.28 (0.01)	0.28 (0.01)	0.28 (0.01)	0.28 (0.01)	0.27 (0.01)	0.27 (0.01)	0.26 (0.01)	0.26 (0.01)	0.26 (0.01)	0.25 (0.01)	0.24 (0.01)
35 to 49	0.42 (0.01)	0.41 (0.01)	0.42 (0.01)	0.40 (0.01)	0.40 (0.01)	0.41 (0.01)	0.40 (0.01)	0.40 (0.01)	0.40 (0.01)	0.40 (0.01)	0.39 (0.01)
50 to 64	0.35 (0.01)	0.34 (0.01)	0.34 (0.01)	0.35 (0.01)	0.34 (0.01)	0.34 (0.01)	0.34 (0.01)	0.34 (0.01)	0.34 (0.01)	0.34 (0.01)	0.34 (0.01)
65 and older	0.24 (0.01)	0.25 (0.01)	0.24 (0.01)	0.24 (0.01)	0.25 (0.01)	0.25 (0.01)	0.24 (0.01)	0.25 (0.01)	0.25 (0.01)	0.25 (0.01)	0.25 (0.01)
Rice Farm (%)	88.04 (0.55)	85.37 (0.60)	76.35 (0.74)	87.55 (0.55)	86.09 (0.58)	78.09 (0.70)	88.32 (0.54)	87.79 (0.55)	83.76 (0.62)	86.99 (0.58)	84.97 (0.62)
Own Land (%)	73.75 (0.75)	73.86 (0.75)	73.84 (0.76)	73.99 (0.74)	73.35 (0.74)	73.41 (0.74)	73.44 (0.74)	72.28 (0.75)	72.46 (0.76)	72.03 (0.77)	72.79 (0.78)
Size of Land Owned (m <sup>2</sup> )	2318.30 (243.40)	1900.16 (66.11)	2015.72 (246.60)	1862.10 (59.57)	2001.38 (112.73)	2001.99 (112.27)	2391.31 (404.52)	2391.31 (46.39)	2026.73 (174.38)	2336.42 (369.67)	2240.94 (370.67)
Value of Farm Assets	244.51 (12.98)	297.73 (22.01)	255.08 (11.77)	249.24 (18.60)	242.67 (8.96)	246.07 (22.48)	213.75 (12.01)	204.85 (6.84)	217.59 (14.24)	193.18 (6.20)	235.37 (17.02)
Value of Non-farm Assets	454.34 (20.16)	444.14 (16.97)	453.29 (20.08)	441.43 (18.14)	458.42 (16.64)	448.57 (18.42)	461.57 (17.44)	451.43 (15.56)	454.52 (20.32)	441.80 (16.92)	568.04 (19.50)
<i>Age of [...]</i>											
Primary Male	54.67 (0.22)	54.42 (0.22)	54.48 (0.23)	54.43 (0.23)	54.21 (0.22)	54.29 (0.22)	54.41 (0.22)	54.52 (0.22)	54.56 (0.22)	54.64 (0.23)	54.88 (0.23)
Primary Female	49.19 (0.21)	49.02 (0.21)	48.88 (0.21)	49.16 (0.21)	49.04 (0.21)	49.04 (0.21)	49.12 (0.21)	49.35 (0.21)	49.32 (0.21)	49.56 (0.22)	49.92 (0.22)
<i>Years of education of [...]</i>											
Primary Male	5.95 (0.06)	6.00 (0.06)	6.01 (0.06)	6.02 (0.06)	6.10 (0.06)	6.12 (0.06)	6.17 (0.06)	6.19 (0.06)	6.21 (0.06)	6.30 (0.06)	6.52 (0.06)
Primary Female	4.58 (0.06)	4.79 (0.06)	4.85 (0.06)	4.83 (0.06)	4.97 (0.06)	4.95 (0.06)	5.04 (0.06)	5.03 (0.06)	5.14 (0.06)	5.18 (0.06)	5.42 (0.06)
N. Observations	3421	3478	3306	3557	3610	3528	3536	3572	3486	3421	3274

Notes: Table reports means and standard errors for variables of interest in each of the first 11 full waves of WISE. The sample consists of households with farm businesses, approximately 75% of households in the survey. All labor measured as unconditional means of person-days over the past 4 months, and assets as January 2002 Rp0,000.

Table 3.10: Labor Demand Regressions - Each Cross Section

	<i>Wave</i>										
	1	2	3	4	5	6	7	8	9	10	11
<i>Number of males [...]</i>											
Birth to 14 years	0.02 (0.02)	0.02 (0.02)	0.03 (0.02)	0.05** (0.02)	0.03* (0.02)	0.00 (0.02)	0.04** (0.02)	0.02 (0.02)	0.01 (0.02)	0.02 (0.02)	0.02 (0.02)
15 to 19	0.09*** (0.03)	0.12*** (0.03)	0.16*** (0.04)	0.12*** (0.03)	0.12*** (0.03)	0.15*** (0.03)	0.10*** (0.03)	0.12*** (0.03)	0.10*** (0.03)	0.05 (0.03)	0.14*** (0.03)
20 to 34	0.16*** (0.03)	0.16*** (0.03)	0.17*** (0.03)	0.20*** (0.03)	0.19*** (0.03)	0.14*** (0.03)	0.15*** (0.03)	0.13*** (0.02)	0.14*** (0.03)	0.14*** (0.03)	0.14*** (0.03)
35 to 49	0.18*** (0.04)	0.19*** (0.04)	0.20*** (0.05)	0.23*** (0.05)	0.22*** (0.05)	0.18*** (0.04)	0.14*** (0.04)	0.16*** (0.04)	0.22*** (0.04)	0.22*** (0.04)	0.13*** (0.04)
50 to 64	0.31*** (0.04)	0.36*** (0.05)	0.24*** (0.06)	0.24*** (0.04)	0.25*** (0.05)	0.29*** (0.05)	0.23*** (0.06)	0.27*** (0.04)	0.33*** (0.05)	0.28*** (0.04)	0.17*** (0.05)
65 and older	0.26*** (0.05)	0.30*** (0.06)	0.22*** (0.07)	0.12** (0.05)	0.17*** (0.05)	0.26*** (0.06)	0.14** (0.06)	0.20*** (0.05)	0.23*** (0.06)	0.17*** (0.05)	0.10* (0.05)
<i>Number of females [...]</i>											
Birth to 14 years	-0.00 (0.02)	-0.03 (0.02)	-0.03 (0.02)	-0.04* (0.02)	-0.02 (0.02)	-0.01 (0.02)	0.00 (0.02)	-0.02 (0.02)	-0.02 (0.02)	-0.04* (0.02)	0.00 (0.02)
15 to 19	-0.01 (0.03)	-0.01 (0.03)	0.02 (0.04)	-0.01 (0.04)	0.04 (0.04)	0.04 (0.04)	0.04 (0.04)	0.05 (0.04)	-0.01 (0.04)	-0.01 (0.03)	0.00 (0.03)
20 to 34	0.01 (0.04)	-0.00 (0.04)	0.07 (0.04)	0.00 (0.03)	0.02 (0.03)	0.02 (0.04)	0.03 (0.04)	0.01 (0.04)	-0.03 (0.04)	-0.03 (0.04)	0.04 (0.04)
35 to 49	0.12** (0.05)	0.06 (0.04)	0.10** (0.05)	0.08* (0.04)	0.05 (0.04)	0.13*** (0.05)	0.02 (0.04)	0.08** (0.04)	0.04 (0.04)	0.06 (0.04)	0.05 (0.04)
50 to 64	0.12** (0.05)	0.13*** (0.05)	0.13*** (0.05)	0.10** (0.04)	0.11*** (0.04)	0.13*** (0.05)	0.08** (0.04)	0.07* (0.04)	0.04 (0.04)	0.11*** (0.04)	0.04 (0.05)
65 and older	-0.02 (0.04)	-0.10** (0.04)	-0.08* (0.05)	-0.02 (0.04)	-0.03 (0.04)	0.01 (0.04)	-0.02 (0.03)	-0.03 (0.04)	-0.07** (0.03)	-0.01 (0.04)	-0.05 (0.04)
<i>Joint tests of demographics (F-stats)</i>											
All Groups	11.64	15.20	8.31	8.66	14.21	8.23	5.83	11.83	8.93	10.69	4.41
<i>p</i> -value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Males	17.22	17.11	9.88	12.87	13.35	10.36	8.00	16.48	13.45	14.76	7.05
<i>p</i> -value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Females	2.81	6.66	3.88	2.941	3.06	2.63	1.60	2.39	2.40	2.82	0.78
<i>p</i> -value	0.01	0.00	0.00	0.00	0.01	0.02	0.15	0.03	0.03	0.01	0.59
Prime age adults 15 to 49	11.02	11.57	13.55	13.66	15.16	10.06	6.07	12.88	8.74	8.83	6.64
<i>p</i> -value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Observations	3421	3475	3302	3557	3610	3527	3536	3570	3486	3420	3273
<i>R</i> <sup>2</sup>	0.39	0.38	0.37	0.43	0.45	0.34	0.38	0.43	0.39	0.41	0.42

*Notes:* Table reports coefficients of interest from estimation of labor demand equations for each of the 11 cross sectional waves with log of total person-days of farm labor the dependent variable. The reported F-statistics and *p*-values are for joint tests of the specified coefficients. Regressions also control for the following: community fixed effects, land ownership status and the size of land owned, whether land is irrigated and size of irrigated land, quintiles of farm and household (real) assets, age and education of the household head and spouse, month of interview and indicators for the farms primary crop. Standard errors in parentheses are calculated accounting for clustering at the community level. \*\*\* Significant at the 1% level, \*\* Significant at the 5% level, \* Significant at the 10% level.

Table 3.11: Comparison with Previous Findings

	(1)	(2)		(3)	(4)	Down-Weighted Household Labor Supply to match 1980 SUSENAS							
	Cross Section	Panel		Cross Section	Panel	Cross Section	Panel	Cross Section	Panel	Cross Section	Panel		
<i>Number of males [...]</i>						<i>Number of males [...]</i>							
Birth to 14 years	0.04* (0.02)	0.04 (0.04)	Household size (log)	0.30*** (0.08)	0.26*** (0.08)	Birth to 14 years	0.08*** (0.03)	0.03 (0.05)	Household size (log)	0.15 (0.09)	0.11 (0.09)		
15 to 19	0.18*** (0.04)	0.08* (0.04)	<i>Share of [...] in Household</i>			15 to 19	0.08** (0.04)	0.03 (0.05)	<i>Share of [...] in Household</i>				
20 to 34	0.14*** (0.03)	0.22*** (0.04)	Males 15 to 54	0.59*** (0.14)	0.21 (0.17)	20 to 34	0.09** (0.04)	0.16*** (0.05)	Males 15 to 54	0.11 (0.17)	-0.07 (0.19)		
35 to 49	0.13* (0.06)	0.14 (0.09)	Males 55 and over	0.48** (0.24)	0.15 (0.23)	35 to 49	0.04 (0.07)	0.03 (0.09)	Males 55 and over	-0.09 (0.27)	-0.37 (0.26)		
50 to 64	0.30*** (0.07)	0.27*** (0.09)	Females 15 to 54	0.19 (0.17)	-0.05 (0.21)	50 to 64	0.16* (0.08)	0.18* (0.11)	Females 15 to 54	-0.16 (0.19)	-0.28 (0.22)		
65 and older	0.27*** (0.08)	0.16* (0.10)	Females 55 and over	0.10 (0.21)	-0.10 (0.23)	65 and older	0.15 (0.10)	0.09 (0.11)	Females 55 and over	-0.07 (0.25)	-0.23 (0.26)		
<i>Number of females [...]</i>						<i>Number of females [...]</i>							
Birth to 14 years	-0.01 (0.03)	-0.05 (0.05)				Birth to 14 years	0.04 (0.04)	0.00 (0.06)					
15 to 19	-0.01 (0.05)	-0.10** (0.05)				15 to 19	-0.01 (0.07)	-0.12** (0.05)					
20 to 34	0.06 (0.06)	0.10* (0.05)				20 to 34	0.03 (0.07)	0.06 (0.06)					
35 to 49	0.15** (0.07)	0.22*** (0.08)				35 to 49	0.07 (0.07)	0.16* (0.09)					
50 to 64	0.19*** (0.06)	0.32*** (0.08)				50 to 64	0.08 (0.08)	0.26*** (0.09)					
65 and older	-0.03 (0.06)	0.12 (0.08)				65 and older	-0.02 (0.07)	0.12 (0.08)					
<i>Joint Test (F-stat)</i>			<i>Joint Test (F-stat)</i>			<i>Joint Test (F-stat)</i>			<i>Joint Test (F-stat)</i>				
All Groups	8.33	5.81	All Groups	8.55	4.39	All Groups	2.96	3.13	All Groups	2.57	2.03		
<i>p-value</i>	0.00	0.00	<i>p-value</i>	0.00	0.00	<i>p-value</i>	0.00	0.00	<i>p-value</i>	0.03	0.07		
Observations	1725	6269	Observations	1725	6269	Observations	1725	6269	Observations	1725	6269		
N. Households	1725	3341	N. Households	1725	3341	N. Households	1725	3341	N. Households	1725	3341		
Overall F-test	10.20	5.70	Overall F-test	10.80	5.43	Overall F-test	12.76	5.50	Overall F-test	14.72	6.14		
<i>R</i> <sup>2</sup>	0.34	0.06	<i>R</i> <sup>2</sup>	0.33	0.05	<i>R</i> <sup>2</sup>	0.35	0.07	<i>R</i> <sup>2</sup>	0.35	0.06		

Notes: Table reports results from labor demand regressions with (log) person-days or farm labor demand as the dependent variable. The sample is restricted to rice farmers interviewed in January, February and March to be consistent with the timing of the Indonesia Socioeconomic Survey (SUSENAS) and data selection in Benjamin (1992). Cross section estimates use households that meet the selection criteria in wave 1 of WISE and panel estimates combine households that satisfy the selection criteria in waves 1, 4 and 7. These waves began data collection in January of 2002, 2003, and 2004 and had the majority of interviews completed by March. Columns 5 through 8 report estimates using a rescaled measure of labor supplied by households to their farms to rectify the inconsistency between WISE and 1980 SUSENAS. WISE families report working an average of 163 person-days per year on their farms while SUSENAS farmers report 26 (Benjamin, 1992 Table II). Labor supply in columns 5 through 8 is defined as original labor supply divided by a factor of 6.27 (163.2/26). Columns 1, 2, 5, and 6 use the preferred specification for household composition, while columns 3, 4, 7, and 8 use an alternative form matching that chosen by Benjamin (1992). Regressions also control for the following: land ownership status and the size of land owned, whether land is irrigated and size of irrigated land, quintiles of farm and household (real) assets, age and education of the household head and spouse, and month of interview indicators. Locality fixed effects are included in the cross sections, and locality-wave and household fixed effects are included in the panel estimates. Indicators for the primary crop are included in the cross section, but are controlled for with the household fixed effect in the panel. Standard errors in parentheses are calculated accounting for clustering at the locality level in the cross section, and the household level in panel models. The R2 for the panel models is for within variation. \*\*\* Significant at the 1% level, \*\* Significant at the 5% level, \* Significant at the 10% level.

Table 3.12: Labor Demand by Farm Tasks - Including Imputed Labor Supply Hours<sup>†</sup>

	Demand for [...] Labor				Differences across coefficients (harvesting as base)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total	Harvesting	Weeding Planting Fertilizing	Land Prep Livestock Dry/Sell/Mill	Total	Harvesting	Weeding Planting Fertilizing	Land Prep Livestock Dry/Sell/Mill
<i>Number of males [...]</i>								
Birth to 14 years	0.00 (0.02)	0.00 (0.02)	0.01 (0.02)	0.03 (0.02)	0.00 (0.02)	-	-0.01 (0.02)	-0.02 (0.03)
15 to 19	0.09*** (0.02)	0.09*** (0.02)	0.08*** (0.02)	0.15*** (0.02)	0.00 (0.02)	-	0.01 (0.02)	-0.06** (0.03)
20 to 34	0.14*** (0.02)	0.14*** (0.02)	0.13*** (0.02)	0.18*** (0.02)	0.01 (0.02)	-	0.01 (0.02)	-0.04 (0.03)
35 to 49	0.16*** (0.03)	0.15*** (0.03)	0.14*** (0.03)	0.23*** (0.04)	-0.01 (0.03)	-	0.01 (0.04)	-0.08* (0.05)
50 to 64	0.21*** (0.03)	0.18*** (0.04)	0.18*** (0.03)	0.26*** (0.04)	-0.03 (0.04)	-	0.00 (0.04)	-0.08 (0.05)
65 and older	0.18*** (0.03)	0.14*** (0.04)	0.14*** (0.03)	0.23*** (0.05)	-0.04 (0.04)	-	0.00 (0.05)	-0.09 (0.06)
<i>Number of females [...]</i>								
Birth to 14 years	-0.03** (0.02)	-0.02 (0.02)	-0.04*** (0.02)	0.00 (0.02)	0.02 (0.02)	-	0.03 (0.02)	-0.02 (0.03)
15 to 19	-0.00 (0.02)	-0.01 (0.02)	0.01 (0.02)	-0.01 (0.02)	-0.01 (0.02)	-	-0.02 (0.02)	0.00 (0.03)
20 to 34	0.05*** (0.02)	0.02 (0.03)	0.06*** (0.02)	0.05* (0.03)	-0.03 (0.03)	-	-0.04 (0.03)	-0.02 (0.03)
35 to 49	0.14*** (0.02)	0.07* (0.04)	0.13*** (0.02)	0.09** (0.04)	-0.07* (0.04)	-	-0.06 (0.04)	-0.02 (0.05)
50 to 64	0.10*** (0.03)	0.06 (0.04)	0.11*** (0.03)	0.10*** (0.04)	-0.04 (0.04)	-	-0.04 (0.04)	-0.04 (0.05)
65 and older	0.02 (0.03)	0.01 (0.04)	0.02 (0.03)	-0.01 (0.04)	-0.01 (0.04)	-	-0.01 (0.04)	0.02 (0.05)
<i>Joint tests of demographics (F-stats)</i>								
All Groups	13.98	6.50	12.18	11.46				
p-value	0.00	0.00	0.00	0.00				
Males	19.62	10.67	15.21	17.36				
p-value	0.00	0.00	0.00	0.00				
Females	7.00	0.92	6.92	3.15				
p-value	0.00	0.48	0.00	0.00				
Prime age adults 15 to 49	24.09	11.43	20.89	18.75				
p-value	0.00	0.00	0.00	0.00				
Mean person-days of labor	72.45	18.73	45.78	28.66				
Observations	38189	27498	34926	36847				
N. of Households	4452	4193	4270	4434				
F-test of All Regressors	25.55	12.89	17.99	10.90				
Within R <sup>2</sup>	0.05	0.03	0.03	0.02				

Notes: Notes: Columns 1 through 4 report estimates of labor demand equations for all types of labor and specific farm tasks. Column 1 matches results in Table 3.2, while columns 2 through 4 divide person-days of labor into the tasks listed in each column. Labor demand for each type is calculated as the sum of person days hired to perform the task and labor supplied by household members who are listed performing the task. Joint tests of coefficient groups and p-values appear below. Along with locality-wave and household fixed effects, additional controls include land ownership status and the size of land owned, whether land is irrigated and size of irrigated land, quintiles of farm and household (real) assets, age and education of the household head and spouse, and the month of interview. Columns 5 through 8 report the differences across coefficients for each task and harvesting with standard errors appearing below. All standard errors are calculated allowing for clustering at the household level.

† Family labor hours were imputed for those individuals who were reported to have worked on a farm task but did not report the task in their employment history. Imputation was based on the number of hours the individual spends doing the task in surrounding waves or the age-gender average hours spent on the task.

\*\*\* Significant at the 1% level, \*\* Significant at the 5% level, \* Significant at the 10% level

Table 3.13: First Stage Results: 1 and 2 Period Lagged Composition as IVs

	Dependent Variable											
	Number of males [...]						Number of females [...]					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Birth to 14 years	15 to 19	20 to 34	35 to 49	50 to 64	65 and older	Birth to 14 years	15 to 19	20 to 34	35 to 49	50 to 64	65 and older
<i>Number of males [...] in previous period</i>												
Birth to 14 years	0.63*** (0.01)	-0.01 (0.01)	-0.02* (0.01)	0.02** (0.01)	-0.01* (0.01)	0.00 (0.01)	-0.00 (0.01)	-0.02*** (0.01)	0.01 (0.01)	0.01 (0.01)	-0.01 (0.01)	-0.00 (0.01)
15 to 19	-0.02** (0.01)	0.60*** (0.01)	0.01 (0.01)	0.02** (0.01)	-0.01 (0.01)	-0.00 (0.01)	0.01 (0.01)	-0.02*** (0.01)	-0.02** (0.01)	0.02*** (0.01)	-0.01 (0.01)	-0.01* (0.01)
20 to 34	-0.00 (0.01)	-0.01 (0.01)	0.53*** (0.02)	-0.01 (0.01)	-0.00 (0.01)	-0.01* (0.01)	0.00 (0.01)	0.00 (0.01)	0.02* (0.01)	0.01 (0.01)	0.00 (0.01)	-0.00 (0.01)
35 to 49	0.01 (0.01)	-0.00 (0.01)	-0.07*** (0.02)	0.60*** (0.02)	-0.04*** (0.01)	-0.02** (0.01)	0.02* (0.01)	0.01 (0.01)	-0.01 (0.02)	0.02* (0.01)	-0.00 (0.01)	-0.02 (0.01)
50 to 64	-0.01 (0.02)	-0.00 (0.01)	-0.05*** (0.02)	0.01 (0.02)	0.54*** (0.02)	-0.06*** (0.01)	0.02 (0.02)	-0.01 (0.02)	0.01 (0.02)	-0.02 (0.01)	0.04*** (0.01)	-0.03*** (0.01)
65 and older	-0.01 (0.02)	-0.01 (0.01)	-0.04** (0.02)	0.01 (0.02)	-0.05*** (0.02)	-0.49*** (0.02)	0.01 (0.02)	-0.01 (0.02)	0.02 (0.02)	-0.02* (0.01)	0.01 (0.01)	-0.01 (0.01)
<i>Number of females [...] in previous period</i>												
Birth to 14 years	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	0.04*** (0.01)	-0.02** (0.01)	-0.00 (0.01)	0.62*** (0.02)	-0.02** (0.01)	-0.01 (0.01)	0.02** (0.01)	-0.01 (0.01)	0.01 (0.01)
15 to 19	0.01 (0.01)	-0.01 (0.01)	0.01 (0.01)	0.02*** (0.01)	-0.00 (0.01)	-0.01* (0.00)	-0.03** (0.01)	0.58*** (0.01)	-0.00 (0.01)	0.02** (0.01)	-0.01 (0.01)	0.01 (0.01)
20 to 34	0.02 (0.01)	-0.00 (0.01)	0.03*** (0.01)	-0.00 (0.01)	0.01 (0.01)	-0.01 (0.01)	-0.00 (0.01)	-0.00 (0.01)	0.53*** (0.02)	-0.03*** (0.01)	-0.00 (0.01)	0.01 (0.01)
35 to 49	0.02 (0.01)	0.02** (0.01)	0.01 (0.01)	0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.03* (0.01)	0.05*** (0.01)	-0.07*** (0.02)	0.58*** (0.02)	-0.07*** (0.01)	0.03*** (0.01)
50 to 64	-0.00 (0.01)	0.02 (0.01)	-0.01 (0.01)	0.01 (0.01)	0.00 (0.01)	-0.03*** (0.01)	-0.02 (0.01)	0.03*** (0.01)	-0.03** (0.01)	-0.02 (0.02)	0.51*** (0.01)	0.02* (0.01)
65 and older	0.02 (0.01)	0.02* (0.01)	-0.01 (0.01)	0.02* (0.01)	-0.01 (0.01)	-0.02** (0.01)	0.01 (0.01)	0.01 (0.01)	0.00 (0.01)	0.01 (0.01)	-0.00 (0.02)	0.52*** (0.02)
<i>Number of males [...] 2 period ago</i>												
Birth to 14 years	-0.06*** (0.01)	0.05*** (0.01)	-0.02** (0.01)	0.01 (0.01)	-0.00 (0.01)	-0.00 (0.01)	0.00 (0.01)	0.01 (0.01)	-0.03*** (0.01)	0.02*** (0.01)	-0.01 (0.01)	0.01 (0.01)
15 to 19	-0.01* (0.01)	-0.03** (0.01)	-0.01 (0.01)	-0.00 (0.01)	0.00 (0.01)	0.00 (0.00)	-0.01 (0.01)	0.01 (0.01)	-0.01 (0.01)	0.01 (0.01)	0.00 (0.01)	-0.00 (0.01)
20 to 34	-0.02* (0.01)	-0.00 (0.01)	-0.06*** (0.01)	-0.01 (0.01)	0.01 (0.01)	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	0.00 (0.01)	-0.01 (0.01)	0.01 (0.01)	-0.01** (0.01)
35 to 49	0.01 (0.01)	-0.00 (0.01)	-0.04** (0.02)	-0.04*** (0.01)	0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	0.01 (0.01)	-0.03** (0.01)	0.02** (0.01)	-0.00 (0.01)	-0.01 (0.01)
50 to 64	-0.03* (0.02)	0.01 (0.01)	-0.02 (0.02)	-0.03** (0.01)	0.02 (0.01)	-0.02** (0.01)	-0.02 (0.01)	-0.01 (0.01)	-0.00 (0.02)	-0.02* (0.01)	0.04*** (0.01)	-0.03*** (0.01)
65 and older	-0.01 (0.02)	0.00 (0.01)	-0.01 (0.02)	-0.02 (0.01)	0.04** (0.01)	-0.05*** (0.01)	-0.01 (0.01)	-0.02* (0.01)	-0.00 (0.02)	-0.01 (0.01)	0.02 (0.01)	-0.02* (0.01)
<i>Number of females [...] 2 periods ago</i>												
Birth to 14 years	-0.00 (0.01)	0.00 (0.01)	-0.01 (0.01)	0.00 (0.01)	-0.00 (0.01)	0.00 (0.01)	-0.03 (0.02)	0.04*** (0.01)	0.00 (0.01)	0.01 (0.01)	-0.01* (0.01)	0.01 (0.01)
15 to 19	0.01 (0.01)	-0.02** (0.01)	-0.01 (0.01)	0.00 (0.01)	-0.00 (0.01)	-0.00 (0.00)	0.00 (0.01)	-0.05*** (0.01)	0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	0.01* (0.01)
20 to 34	0.01 (0.01)	-0.02** (0.01)	-0.01 (0.01)	-0.00 (0.01)	0.01 (0.01)	-0.01 (0.01)	0.02* (0.01)	-0.02** (0.01)	-0.03** (0.01)	-0.00 (0.01)	-0.01 (0.01)	0.01 (0.01)
35 to 49	-0.02 (0.01)	0.01 (0.01)	0.00 (0.01)	-0.01 (0.01)	0.03*** (0.01)	-0.03*** (0.01)	0.02 (0.01)	-0.00 (0.01)	-0.02 (0.01)	-0.01 (0.02)	0.02* (0.01)	-0.01 (0.01)
50 to 64	-0.00 (0.01)	-0.03** (0.01)	0.01 (0.01)	-0.02** (0.01)	0.01 (0.01)	-0.00 (0.01)	0.01 (0.01)	-0.02 (0.01)	-0.00 (0.01)	0.00 (0.01)	-0.01 (0.01)	-0.01 (0.01)
65 and older	0.01 (0.01)	-0.02* (0.01)	-0.00 (0.01)	-0.02 (0.01)	0.01 (0.01)	-0.00 (0.01)	0.01 (0.01)	-0.02 (0.01)	-0.01 (0.01)	0.00 (0.01)	-0.00 (0.01)	-0.02 (0.01)
<i>Joint Test of IVs</i>												
F-stat	154.1	112.9	103.2	130.7	127.9	72.71	142.4	107.8	102.5	125.1	101.8	51.85
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Observations	30,150	30,150	30,150	30,150	30,150	30,150	30,150	30,150	30,150	30,150	30,150	30,150
N. Households	3,888	3,888	3,888	3,888	3,888	3,888	3,888	3,888	3,888	3,888	3,888	3,888
Overall F-stat	76.01	54.30	48.76	71.72	65.68	74.64	70.36	50.76	54.15	69.21	53.68	38.52
R <sup>2</sup>	0.33	0.27	0.24	0.31	0.29	0.39	0.32	0.26	0.27	0.31	0.27	0.28

Notes: Table reports coefficients of interest from the 1st stage of labor demand regressions using 1 and 2 period lagged household composition as instruments for the number of household members in the contemporaneous demographic group in each column. A joint F-test of the IVs is included below the point estimates. Along with locality-wave and household fixed effects, additional controls include land ownership status and the size of land owned, whether land is irrigated and size of irrigated land, quintiles of farm and household (real) assets, age and education of the household head and spouse, and the month of interview. Standard errors calculated allowing for clustering at the household level.

\*\*\* Significant at the 1% level, \*\* Significant at the 5% level, \* Significant at the 10% level

## Are Rural Markets Complete? Prices, Profits, and Recursion

### 4.1 Introduction

The agricultural household model under complete markets allows the simultaneous production and consumption decisions faced by farm households to be modeled recursively. This is an incredibly useful result for both theoretical and empirical applications. However, as established in the previous chapter, complete markets is a strong condition that requires empirical investigation. To assess the validity of the recursive framework, a number of previous papers have tested if production may be treated independently from consumption (e.g. Pitt and Rosenzweig, 1986; Benjamin, 1992; Jacoby, 1993; Bowlus and Sicular, 2003; LaFave, 2011). Results are mixed. These papers, including the baseline analysis in Chapter 3 of this dissertation, rely on specifying a production process for the household, and often require restrictive assumptions regarding the homogeneity of labor inputs.

The final section of the previous chapter established that a more appropriate test of the agricultural household model would be one that could allow for heterogeneous

types of labor, and abstract from the restrictions imposed by previous studies. This chapter defines and executes a complementary test of recursion and complete markets from the consumption allocations of households that is free of potentially confounding assumptions regarding farm production.

While the literature has focused on the implications of complete markets for production decisions, there is a second stage of household decision making that has been ignored. The two stage recursive agricultural household model implies production and consumption are linked only through an income effect from the farm business. After farmers make optimizing production decisions independently of their households, they effectively return with farm profits that is taken as given in the second stage utility maximization. This chapter empirically assesses a restriction of complete markets on consumption choices that results from this recursive relationship.

When markets are complete and recursion holds, there are variables that influence optimal production decisions that only affect second stage consumption demand through the income from farm profits. In particular, prices of farm inputs are weakly separable from the second stage demands for food, household items, human capital, and other goods as the price effects operate only through profits. This weak separability implies an empirically testable restriction on the marginal effects of the input prices on consumption allocations.

In order to test this prediction, this chapter estimates a household demand system drawing on rich longitudinal consumption and price data from the Work and Iron Status Evaluation (WISE). WISE offers the unique combination of data on expenditures as well as market prices that makes this analysis possible. Along with the detailed household survey, enumerators collected transaction prices for consumption goods and farm inputs in local shops and markets in each WISE.

The results of this exercise support the findings in Chapter 3, and suggest that household behavior is inconsistent with a world of complete markets. These findings

complement previous work in the literature examining recursion from only the production side, and offer additional evidence on the complexity of markets in developing settings.

The next section revisits the agricultural household model outlined in Chapter 3 and focuses on the implications of complete markets for consumption allocations. The empirical demand system is then outlined in Section 4.3, the unique survey and price data is discussed in 4.4, and Section 4.5 presents results rejecting complete markets.

## 4.2 Recursive Agricultural Household Model

Chapter 3 of this dissertation develops a dynamic version of the agricultural household model and defines the testable implications of recursion on the production side of household behavior. This section reiterates the model with a focus on the implications of complete markets for consumption allocations. As will be clear, these testable implications are free of a number of concerns regarding the specification of the production function and a single type of labor input that are relied upon by previous work testing complete markets on the production side.

Farm households face the objective of maximizing expected future utility subject to a production process, endowment of time, and intertemporal budget constraint. Following the notation in Chapter 3, households choose consumption goods, farm inputs, and leisure to:

$$\max E \left[ \sum_{t=0}^{\infty} \beta^t u(x_{mt}, x_{at}, l_t; \mu_t, \varepsilon_t) \right] \quad (4.1)$$

subject to:

$$Q_t = Q_t(L_t, V_t, A_t) \quad (4.2)$$

$$E^L = \ell_t + L_t^F + L_t^O \quad (4.3)$$

$$W_{t+1} = (1+r_{t+1}) [W_t + w_t(E^L - \ell_t) + p_{at}Q_t(t) - w_tL_t - p_{vt}V_t - p_{At}A_t - p_{mt}x_{mt} - p_{at}x_{at}] \quad (4.4)$$

where  $x_{mt}$  is a vector of market consumption goods,  $x_{at}$  is consumption of agricultural goods (i.e. food, some of which may be grown by the household), and  $\ell_t$  is a vector of household members' leisure. Preferences are captured by  $\mu_t$  and  $\varepsilon_t$ , which include observed and unobserved characteristics that parameterize the utility function such as household size and composition. The agricultural production function relates labor,  $L_t$ , variable inputs such as seed and fertilizer,  $V_t$ , and farm land,  $A_t$ , to output.<sup>1,2</sup> Household members may work on the family farm,  $L_t^F$ , or off,  $L_t^O$ , as is done by approximately two-thirds of household members.<sup>3</sup> The budget constraint defines how wealth,  $W_t$ , transitions between periods earning interest at rate  $r_{t+1}$ .

The solution to this joint production-consumption problem when all current and future markets exist and prices are taken as given reveals that the optimal choice of farm inputs is determined as if households operate their farms as stand-alone profit maximizing firms independent of their households. The separation between production and household characteristics implies the joint problem may be formulated recursively as a two-step process.

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<sup>1</sup> As in Chapter 3, land remains a choice variable in the model, but in the rural Indonesian setting of the Work and Iron Status Evaluation, family farms remain generally stable over time.

<sup>2</sup> Capital is not explicitly included in the production function, as farms in the region have small capital stocks, and what capital does exist, such as sickles to harvest rice, can effectively be thought of as variable inputs. Including a capital in the output function and specifying a law of motion for capital over time does not change the empirical predictions tested in this chapter.

<sup>3</sup> See Section 3.7.

### 4.2.1 Two-Step Approach

#### *Profit Maximization*

In the first stage, households maximize profits on their farms as if they are operating independent businesses. Farmers choose farm labor, variable inputs, and land to maximize farm profits. Letting  $\pi_t$  represent farm profits, households solve the following problem in the first stage:

$$\max \pi_t = p_{at}Q_t(L_t, V_t, A_t) - w_tL_t - p_{vt}V_t - p_{At}A_t \quad (4.5)$$

This same profit maximization problem is nested in the joint problem, as the expression for farm profits directly appears in the intertemporal budget constraint in equation (4.4).

Solving this problem results in input demand functions that depend on wages, output prices, and input prices. Optimal choices of farm inputs are determined according to straightforward first order conditions that relate the prices of the inputs to their marginal product. The results of this first stage can be summarized by the following profit function, which is independent of household characteristics or preferences:

$$\pi_t^* = \pi_t^*(p_{vt}, p_{at}, w_t, p_{At}) \quad (4.6)$$

#### *Utility Maximization*

Once optimal production decisions have been made, households take the profits from the farm business as given in the second stage utility maximization process; farmers effectively return to their households with a lump sum of resources to use in maximizing household utility. The budget constraint limiting the utility maximization process in the second stage is now a modified version of equation (4.4). Where profit maximization was imbedded in the previous budget constraint,  $\pi^*$  now takes the place of the production choices:

$$W_{t+1} = (1 + r_{t+1}) [W_t + w_t(E^L - \ell_t) - p_{mt}x_{mt} - p_{at}x_{at} + \pi_t^*(p_{vt}, p_{at}, w_t, p_{At})] \quad (4.7)$$

Under the assumption of complete markets, the farm business influences utility maximization and consumption allocations only by shifting the budget constraint by  $\pi^*$ , the amount of income provided by farm profits.<sup>4</sup>

The result of the second stage utility maximization problem is a set of conditional demand functions. These follow a similar form to those obtained in standard intertemporal models, and depend on prices, income, and the marginal utility of wealth. However, the inclusion of the production component in the agricultural household model and recursion under complete markets results in the functions being augmented by farm profits in a particular way. The demand for consumption good  $c$  in period  $t$  is the following:

$$x_{ct} = x_{ct}(p_{mt}, p_{at}, w_t, r_{t+1}, \pi_t^*(p_{vt}, p_{at}, w_t, p_{At}), y_t, \lambda_t; \mu_t, \varepsilon_t) \quad (4.8)$$

where consumption depends on market and agricultural prices,  $p_{mt}$  and  $p_{at}$ , wages, interest rates, farm profits,  $\pi_t^*$ , income,  $y_t$ , and expected future prices through the marginal utility of wealth,  $\lambda_t$ . The key feature of the recursive framework is visible in equation (4.8). When recursion holds, the family farm only affects consumption demands through the profits determined in the first stage. As a result, changes in variables that only appear in the profit function will impact consumption allocations in a similar way.

This prediction of the model leads to a testable implication of complete markets that assesses whether farm input prices are weakly separable for consumption demand.

#### *4.2.2 Recursion and Consumption Allocations*

Previous work in the literature, including Chapter 3 of this dissertation, has focused exclusively on the predictions of complete markets for the first stage of the recursive formulation of the agricultural household model.<sup>5</sup> As stated in the introduction, in

<sup>4</sup> Strauss (1986) illustrates the recursive form of the model and derives the bordered Hessian matrix for the static version of the farm household's problem under complete markets. The block diagonal form of the bordered Hessian illustrates how production decisions may be modeled as independent of consumption side variables.

<sup>5</sup> See Chapter 3 and references therein.

order to execute these tests, additional restrictive assumptions are made regarding the functional form of the production function and labor inputs.<sup>6</sup> The extended model at the end of Chapter 3 suggests that the homogeneity of labor, either explicitly or implicitly assumed by past work, may not be an accurate representation of rural labor markets. One distinct advantage of the test of complete markets in the second stage of the recursive model is the ability to abstract from a number of these concerns.

A close examination of equation (4.8) shows that the separation between consumption and production imposes a restriction on how factors that only impact profits go on to impact demand. When recursion holds, the prices of variable farm inputs, factors of production that are used only in farm production but not consumed on their own, impact consumption solely through profits.<sup>7</sup> This weak separability restriction provides a test of recursion under complete markets similar to the ratio test utilized in Chapter 2.

The test is derived by considering the marginal effect of a change in an input price,  $p_{vt}$ , on the demand for good  $c$ . Based on the form of (4.8), this derivative can be decomposed into two parts; the effect of a change in the input price on profits, and the impact of a change in profits on consumption:

$$\frac{\partial x_{ct}}{\partial p_{vt}} = \frac{\partial x_{ct}}{\partial \pi_t^*} \frac{\partial \pi_t^*}{\partial p_{vt}} \quad (4.9)$$

The proposed test exploits this recursive property under the null of complete markets. Suppressing  $t$  subscripts for simplicity, consider the marginal effect of a change in two different input prices  $f$  and  $i$ , fertilizer and insecticide for example, on good  $c$ :

$$\frac{\partial x_c}{\partial p_f} = \frac{\partial x_c}{\partial \pi^*} \frac{\partial \pi^*}{\partial p_f} \quad (4.10)$$

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<sup>6</sup> The seminal paper in the literature, Benjamin (1992), specifies a Cobb-Douglas production function and a single homogeneous type of labor. A number of works following this early work continue with this specification.

<sup>7</sup> Note that this is not true of all prices from the production side. Wages and the price of agricultural output,  $w_t$  and  $p_{at}$ , directly enter consumption demands.

$$\frac{\partial x_c}{\partial p_i} = \frac{\partial x_c}{\partial \pi^*} \frac{\partial \pi^*}{\partial p_i} \quad (4.11)$$

In both derivatives, the first term is independent of the input price, and the second component is independent of the consumption good  $c$ . As a result, the ratio of the two derivatives will be independent of good  $c$ :

$$\frac{\frac{\partial x_c}{\partial p_f}}{\frac{\partial x_c}{\partial p_i}} = \frac{\frac{\partial x_c}{\partial \pi^*} \frac{\partial \pi^*}{\partial p_f}}{\frac{\partial x_c}{\partial \pi^*} \frac{\partial \pi^*}{\partial p_i}} = \frac{\frac{\partial \pi^*}{\partial p_f}}{\frac{\partial \pi^*}{\partial p_i}} \quad (4.12)$$

Any variable that is a part of the second-stage utility maximization problem only through  $\pi^*$  must impact all demands in a similar way through profits. Empirically, when recursion holds, the ratio of marginal effects of input prices should be the same for all consumption goods.

In order to test this restriction, we estimate a flexible demand system and examine the ratio of price effects on consumption allocations. This consumption-side test complements past research examining recursion from the production side and produces results consistent with those rejecting complete markets in Chapter 3.

### 4.3 Household Demand Systems and Empirical Implementation

This section presents the empirical specification for the demand system used to test the ratio restrictions implied by recursion. We estimate a household demand system of composite goods adopting an extension of the Working-Leser model. Budget shares of aggregated food and non-food goods are regressed against composite consumption prices, variable input prices, and a flexible function of per capita expenditure (PCE).

While Working-Leser curves are well grounded in theory, a limitation of the model is its imposition of a linear form for the relationship between the log of per capita expenditure and the budget share for each good. This functional form has the disadvantage of being prone to influential observations in the extreme values of PCE,

and forces a linear relationship where it may not be appropriate.<sup>8</sup> To address this concern, a piece-wise linear function of PCE is used to allow the demand functions to have a more flexible shape and limit the influence of extreme values.

Let the share of expenditure,  $w$ , on composite good  $c$  for household  $h$  in locality  $j$  and wave  $t$  be the following:

$$w_{hjt}^c = \alpha + \sum_{c=1}^C \beta_c \log(p_{jt}^c) + \sum_{v=1}^V \gamma_v \log(p_{jt}^v) + f(x_{hjt}; \delta) + \theta z_{hjt} + \mu_h + \varepsilon_{hjt} \quad (4.13)$$

where  $c$  indexes commodity groups and  $t$  waves. This conditional demand function includes the log of each composite consumption prices,  $p_{jt}^c$ , as well as the log price of variable farm input prices,  $p_{jt}^v$ , such as seeds, fertilizer and insecticide. Household per-capita expenditure,  $x_{hjt}$ , enters through the flexible function  $f(\cdot)$  that is parameterized by  $\delta$ . Here  $f(\cdot)$  is specified as a spline with three knot points to allow expenditure to impact demand in a flexible way. Additional time varying household controls are included in  $z_{hjt}$  including household composition and size, age and education of the household head and spouse, and wave, year, and season indicators.

The empirical analysis in this chapter draws from the same Work and Iron Status Evaluation panel data utilized in Chapter 3. The panel structure of the WISE data allows one to include a household fixed effect,  $\mu_h$ , to capture all additive and time invariant observed and unobserved heterogeneity. The analysis looks within households over time without the concern that stable unobserved factors at the household or farm level are biasing the results. These factors, such as unobserved farm characteristics like soil quality or farm-specific knowledge, may be related to input choices, are could potentially bias estimates of the input prices in the demand system. Coefficients reflect the impact of a change in the right hand side variables relative to their within household averages.

Recall from equation (4.8) that when recursion holds, the ratio of the marginal

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<sup>8</sup> This issue is true for other parametric demand specifications including the Almost Ideal Demand System (Deaton and Muelbauer, 1980), and Quadratic Almost Ideal Demand System (Banks et al., 1997).

price effects of any two input prices will be the same regardless of which consumption good one considers. In terms of equation (4.13), the ratio of two elements of  $\gamma$  should be the same regardless of the consumption share on the left-hand side. For clarity, consider two goods, food and utilities, and two input prices, fertilizer and insecticide. Under the null of recursion, the following must hold:

$$\frac{\gamma_{fert}^{food}}{\gamma_{insect}^{food}} = \frac{\gamma_{fert}^{util}}{\gamma_{insect}^{util}} \quad (4.14)$$

This same relationship must hold for each combination of consumption goods and prices. More generally, for composite goods  $c$  and  $d$ , and input prices  $f$  and  $i$ , the null hypothesis under complete markets is:

$$H_0 : \frac{\gamma_f^c}{\gamma_i^c} = \frac{\gamma_f^d}{\gamma_i^d} \quad \forall c, d, f, i \quad (4.15)$$

Alternatively:

$$H_0 : \gamma_f^c \gamma_i^d = \gamma_i^c \gamma_f^d \quad \forall c, d, i, f \quad (4.16)$$

It is important to note that the equivalence of ratios must hold not only jointly across all consumption goods and input prices, but for each combination as well. These cross equation restrictions are tested using a non-linear Wald test allowing for clustering at the household level.

## 4.4 Data

While a clear theoretical prediction, the data required to implement tests of recursion on the consumption side are extensive and difficult to collect. Few surveys contain detailed data on consumption behavior, market consumption prices, as well as agricultural input prices. Even fewer have the data recorded frequently over a multi-year time horizon. As in Chapter 3, I utilize new data from the Work and Iron Status Evaluation (WISE) in Purworejo, Indonesia to implement the tests defined in the previous section (Thomas et al., 2011).

#### *4.4.1 Household Expenditure Data*

Household expenditure is measured through a module given to the household head recording information on goods purchased or produced at home for consumption. The survey contains 14 food groups and 11 non-food groups. For the body of the results, these goods are aggregated to estimate a four good demand system including staple grains, other food, expenditure on home goods such as utilities, rent, and household items, and human capital expenditures including education and health. Aggregating consumption to this level aids in precisely estimating the price effects which is essential for the ratio tests. Results using an expanded demand system with other food further disaggregated are consistent with those presented in the next section and appear in supplemental tables 4.7 and 4.9. Supplemental Table 4.5 summarizes the aggregation of the composite consumption goods.

#### *4.4.2 Community Price Data*

Assessing the predictions of the model relies on precisely estimating the impact of both consumption and variable input prices on consumption demands. Accurately measuring the prices households face in the marketplace is an extremely difficult task, and one not often undertaken by household surveys. This chapter benefits from the efforts of the survey team to explicitly measure prices in each WISE community. In many household studies, the only available measure of prices are from unit-values, the amount of expenditure on a group of goods divided by the quantity purchased. However, a major concern with this approach is that unit-values conflate both price and quality variation, and do not reflect the prices households face in the market.

A common approach in the demand estimation literature when prices are unobserved is to adopt a method developed in Deaton (1988) to estimate both price and quality effects. In order to do so, one must be willing to assume weak separability amongst the defined consumption groups, and that demand functions are loglinear. These are not innocuous assumptions. As discussed in McKelvey (2011), using unit-values may still cloud the analysis with unmeasured quality variation and systematic measurement error. McKelvey rejects the assumptions required of the

Deaton method in the same WISE data used in analysis presented below, highlighting the importance of the transaction price data.

Within each community, WISE enumerators solicited prices from street stalls, shops, markets, and community informants for a large series of commonly purchased goods. In addition, surveyors visited multiple farm stores in each community to obtain information on the prices of agricultural inputs such as seeds, fertilizers, and insecticides. This is an incredible benefit of the WISE survey, as the simultaneous collection of consumption prices, agricultural input prices, and expenditure data presents a unique opportunity to test the implications of recursion on consumption behavior.

Great care was taken by the survey team to ensure that prices were collected for the same quality, brand, and size of each good in the price surveys. In the few cases that a particular size and brand was not available, the price of a pre-specified close substitute good was recorded along with its brand, size, and additional identifying information. This process results in price data with both low quality variation and few missing values. Enumerators followed the same procedure to collect transaction prices for farm inputs, including seeds, fertilizers, and insecticides. The price surveys occurred alongside data collection at the household level, resulting in a set of prices with both spatial and temporal variation.

Prices are matched to households by computing community-date medians across sources of price information, and converted to real values using the regional price index available from Statistics Indonesia, Badan Pusat Statistik (BPS). The date a household was interviewed within a wave and in which community it resides determines the set of prices it receives. The consumption prices are then used to create composite prices to match the aggregated consumption goods in the demand system. The weight each price receives is determined by the share of expenditure on the good in the 2002 SUSENAS expenditure survey for households in Purworejo.<sup>9</sup> Supplemental Table 4.6 summarizes the WISE prices used to construct the composite

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<sup>9</sup> The 2002 SUSENAS was given during the same time period as the baseline of WISE, and contains a long-form expenditure module to facilitate calculating the weights for the composite prices.

price of each consumption good in the demand system, whether data from markets (pasars) or stores (tokos) are used, and the weight it receives in the aggregation.<sup>10</sup> The agricultural input prices are normalized using the same regional price index, but are not aggregated in any way.

Table 4.1 reports means and standard errors of household expenditure, demographics, and community prices. Due to the agricultural price surveys beginning in December of 2003 after WISE had already begun, the estimation sample in this chapter uses 8 of the 11 waves used in the previous chapter.<sup>11</sup> The sample is also limited to those households living within WISE communities, as the price surveys were only administered in the communities selected for the WISE study. As the analysis focuses on agricultural households, this poses less of a concern than it may otherwise, as family farms tend to be stable over the four-year period of the data. The estimation sample consists of approximately 3,800 unique farm households and 29,000 household-wave observations.

Households spend approximately 60% of their budget on food, and the remaining 40% on non-food items, with per capita expenditure averaging 200,000Rp per person per month (approximately 20USD). Prices of composite and input goods are recorded in Rp0,000 (approximately 1USD) and appear in column 2. Four input prices are used: the price of IR64 rice seed, a common high-yield variety rice, kangkung seed, a leafy green vegetable similar to spinach, and common varieties of fertilizer and insecticide. The prices of fertilizer and insecticide are particularly valuable as they should not have any substitution effects that seed prices may have. These input goods are frequently purchased, and should impact consumption demands only through a profit effect if markets are complete.

A key condition in the empirical analysis is that the input prices are not related to the composite consumption prices. If the price of rice seed is strongly correlated with the purchase price of rice, for example, this would violate the test relying on the input

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<sup>10</sup> The distinction of markets or stores for the source of price information is determined based on the frequency of purchase and stock of each source.

<sup>11</sup> The results in Chapter 3 remain consistent when limited to the sample used in this chapter.

price only impacting demand through a profit effect. This is an empirical question, and one addressable in the data. There seems to be no evidence of such a connection between seed and market purchase prices. A regression of the log market price of rice on the log price of rice seed while controlling for locality and time effects returns a coefficient of 0.003 with a standard error of 0.039 on rice seed prices, suggesting seed and output prices are unrelated.<sup>12</sup>

The next section presents results from estimating the composite demand system and tests of recursion. The findings complement those in Chapter 3 suggesting that household behavior is inconsistent with a world of complete markets.

## 4.5 Results

### 4.5.1 Demand System Estimates

Table 4.2 reports estimates of the price and income effects from equation (4.13) where budget shares are measured 0 to 100. Standard errors appearing below the point estimates are clustered at the household level.

Before presenting tests of the model, it is informative to examine the price and income effects from the modified Working-Leser Engel curves. As is expected, the uncompensated own-price elasticity estimates, the coefficients on the composite price for its corresponding good, are negative and precisely estimated for home and human capital goods. In contrast, the own-price elasticity for grain is positive and statistically significant, implying that a one percent increase in the composite price of grain is related to a two percent increase in the share of expenditure spent on staple grains. The agricultural household model provides a theoretical justification for this result as an increase in the price of the farm's output good includes a profit effect that is absent from standard demand systems.<sup>13</sup> It is possible that the positive own-price elasticity of grain is the result of the increase in farm revenue when the price of rice

<sup>12</sup> These estimates are from the following regression:  $\log(p_{jt}^{rice}) = \alpha + \beta \log(p_{jt}^{riceseed}) + \mu_t + \mu_j + \varepsilon_{jt}$ , where  $j$  indexes communities and  $t$  waves.

<sup>13</sup> This is clear in the model in Section 4.2 and equation (4.8). The price of agricultural goods,  $p_{at}$ , influences consumption demand through farm profits in the conditional demand function in equation (4.8).

increases.

The estimates on the spline of log per capita expenditure highlight the importance of allowing for nonlinearities in the estimation. The coefficients are reported so as the estimate reflects the slope within the specified part of the PCE distribution. For example, grain begins with a positive expenditure elasticity and then transitions to negative, suggesting differing patterns of staple consumption with differing expenditure levels. The estimates reflect that expenditure is allocated toward non-staples and human capital and away from grain and home goods as the level of PCE within a household rises.

The estimated  $\gamma$  coefficients on the farm input prices are jointly significant for each composite good. The precision of these estimates is essential in testing the equivalence of their ratios across equations. While these input prices are allowed to affect consumption goods, they must do so in a way that reflects the separation between production and consumption in order to be consistent with complete markets.

#### *4.5.2 Separation Tests*

Tests of recursion rely on assessing whether the ratios of the coefficients of the input prices in Table 4.2 are equivalent. These ratios are calculated using the delta method and reported in Table 4.3, with standard errors again allowing for arbitrary correlation within a household. Each ratio reflects a combination of coefficients. For example, -0.85 in column 1 of Table 4.3, is the ratio of the coefficient on kangkung seed to rice seed in the grain demand function (the ratio of 0.73 to -0.62 from Table 4.2). The ratios are generally small, although a number are imprecisely estimated and statistically indistinguishable from zero. This imprecision may lead toward failing to reject complete markets, as ratios that are imprecisely estimated will be indistinguishable from each other in the cross-equation, nonlinear Wald test even if the point estimates are quite different. As the Wald test is notoriously weak, rejections of the equivalence of these ratios should therefore be seen as clear violations of recursion.

The results of the ratio tests of complete markets appear in Table 4.4. The table

reports the  $p$ -values for the non-linear Wald tests of the cross equation ratio restrictions defined by equation (4.15). Each cell represents the  $p$ -value for the pairwise test between the two prices listed in the column and the two goods listed in the row. For example, the value of 0.375 in column 1 is the  $p$ -value for the test that the ratio of the price coefficients for rice seed and kangkung seed are the same when estimating demand for grains and other food. From Table 4.3 these ratios are -0.85 and -0.37. Values above a critical value suggest that we fail to reject the null that recursion holds.

In contrast, the value of 0.013 in column 3 rejects that the ratios for rice seed to fertilizer are the same across grain and other food demand functions (whether 3.11 is equal to -0.22). This test and others that reject the predictions of complete markets at the 10% level or below are highlighted in bold.

In the aggregated demand system estimated in this chapter, there are 36 pairwise restrictions to test as well as the overarching tests of equality of all 24 ratios in Table 4.3. The results of these tests provide clear evidence to reject recursion and complete markets. Of the 36 pair-wise tests, 11 reject the equality imposed by recursion at the 5% level, and 15 at the 10% level. In order for the demand system to be consistent with complete markets, *all* of the  $p$ -values must be above a reasonable range of rejection, a condition that is clearly violated.

With 36 tests, one could certainly expect to statistically detect a small number of false rejections purely out of chance. However, with nearly 33% of tests rejected at the 5% level, the results are in clear violation of recursion.<sup>14</sup> These finding supports those established in Chapter 3; in contrast to seminal work in the literature, household behavior in rural Indonesia appears inconsistent with the predictions of complete markets.

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<sup>14</sup> These results are corroborated by the disaggregated demand system presented in supplemental tables 4.7 through 4.9.

## 4.6 Conclusion

This chapter provides evidence on the rejection of complete markets in rural Indonesia consistent with the results in the previous chapter. Using new, longitudinal consumption and price data from the Work and Iron Status Evaluation and a novel test of complete markets from the consumption decisions of households, the results show a link exists between agricultural production and consumption allocations that is inconsistent with complete markets. This is in direct contrast to seminal findings in the literature that have upheld the predictions of complete markets and currently serve as a motivating foundation for large bodies of work in the microeconomics of development.

The analysis benefits from a test of recursion that relies on the way input prices influence consumption demands. While this test allows one to relax a number of assumptions required for the production side approach presented in Chapter 3, the easing of assumptions comes at a cost. The results of the test rely on comparing nonlinear combinations of coefficient estimates across conditional demand functions. This presents a potential challenge, as these coefficient estimates are often imprecisely estimated. Future efforts will work to determine the cost of this imprecision and further refine the estimation strategy. As is stands, the results strongly suggest that one can reject the validity of the recursive model.

The results of this chapter highlight the importance of utilizing appropriate models of household decision making in theoretical and empirical applications. The approach also presents the opportunity to quantify the welfare loss from failures of separation. By specifying the household utility function and structurally estimating the decision problem, future work will build upon these results to provide evidence on the cost of departing from the neoclassical baseline.

The question of separation and complete markets is not only important as a technical matter, but for what it reveals about the market environment in developing settings. Recognizing such market complexities is essential in the design and evaluation of development policy around the world.

## 4.7 Primary Tables

Table 4.1: Descriptive Statistics

<i>Household Characteristics</i>		<i>Community Prices</i>	
	(1)		(2)
<i>Share of Expenditure on [...]</i>	<b>Mean (se)</b>	<i>Price of [...]</i>	<b>Mean (se)</b>
Grain	16.67 (0.05)	Grain	0.22 (0.0001)
Other Food	43.69 (0.07)	Other Food	0.70 (0.0002)
Home Goods	19.64 (0.05)	Home Goods	1.79 (0.001)
Human Capital	20.00 (0.08)	Human Capital	0.23 (0.0001)
Per Capita Expenditure	203.71 (0.95)	<i>Input Prices</i>	
<i>Years of Education of [...]</i>		Rice Seed	1.51 (0.001)
Primary Male	5.59 (0.02)	Kangkung Seed	1.99 (0.002)
Primary Female	5.09 (0.02)	Insecticide	3.94 (0.003)
<i>Age of [...]</i>		Fertilizer	5.25 (0.003)
Primary Male	54.54 (0.08)		
Primary Female	49.41 (0.07)		
Household Size	3.76 (0.01)		
Urban (%)	13.42 (0.20)		
Wet Season (%)	47.49 (0.29)	N. Waves	8
		N. Households	3825
		N. Observations	29101

*Notes:* Table reports means and standard errors for variables of interest over the 8 waves of WISE used in the demand system estimation. Column 1 reports household level characteristics and column 2 community level prices. The sample consists of households with farm businesses, approximately 75% of households in the survey. Per capita expenditure is in real Rp000/month and all prices in real Rp0,000 with January 2002 as the base (approximately 1USD). See supplemental tables 4.5 and 4.6 for detailed information on the consumption goods used in creation of the composite expenditure shares and prices.

Table 4.2: Demand System Estimates

	<i>Share of Household Expenditure on</i>			
	(1)	(2)	(3)	(4)
	<b>Grain</b>	<b>Other Food</b>	<b>Home Goods</b>	<b>Human Capital</b>
<i>log of Composite Prices</i>				
Grain	2.14** (0.92)	-1.00 (1.30)	-0.44 (0.68)	-0.70 (1.24)
Other Food	-0.20 (1.66)	2.00 (2.47)	0.41 (1.32)	-2.21 (2.30)
Home Goods	-1.30 (0.82)	2.64** (1.22)	-0.45 (0.64)	-0.88 (1.19)
Human Capital	1.97** (0.87)	0.36 (1.21)	1.21* (0.62)	-3.54*** (1.15)
<i>log of Farm Input Prices</i>				
Rice Seed	0.73 (0.86)	-4.47*** (1.24)	2.43*** (0.71)	1.31 (1.15)
Kangkung Seed	-0.62** (0.31)	1.64*** (0.45)	-0.65** (0.26)	-0.37 (0.44)
Insecticide	0.03 (0.79)	-0.97 (1.14)	-1.19** (0.59)	2.12** (1.06)
Fertilizer	2.28*** (0.72)	0.99 (1.07)	0.34 (0.56)	-3.61*** (1.01)
<i>Spline of log(PCE)</i>				
0-25th Percentile	2.27*** (0.61)	11.38*** (0.66)	-14.93*** (0.38)	1.28** (0.55)
25th-50th Percentile	-4.11*** (0.67)	11.30*** (0.90)	-11.51*** (0.44)	4.33*** (0.79)
50th-75th Percentile	-3.27*** (0.61)	7.33*** (0.98)	-11.35*** (0.47)	7.29*** (0.98)
75th-100th Percentile	-0.93*** (0.36)	2.03*** (0.78)	-8.81*** (0.29)	7.71*** (0.92)
Household Fixed Effects	Yes	Yes	Yes	Yes
<i>Joint Test of Input Prices</i>				
F-statistics	3.69	6.18	5.00	3.98
p-value	0.005	0.0001	0.001	0.003
Observations	29101	29101	29101	29101
N. of Households	3825	3825	3825	3825

*Notes:* Outcomes are shares of household expenditure on the composite good in each column, and all prices are expressed in real terms as the log of 2002 Rp0,000. Knots in the log PCE distribution are placed at the 25%, 50% and 75% percentile. Additional controls include the education and age of the primary male and female within the household, an indicators for whether or not the household is in an urban area, household composition, and indicators for the wave, year, and season. Standard errors appear below the point estimates and are calculated allowing for clustering at the household level. \*\*\* Significant at the 1% level, \*\* Significant at the 5% level, \* Significant at the 10% level.

Table 4.3: Ratios of Input Price Effects

	<i>Share of Household Expenditure on [...]</i>			
	(1)	(2)	(3)	(4)
<i>Coefficient Ratio of [...] to [...]</i>	<b>Grain</b>	<b>Other Food</b>	<b>Home Goods</b>	<b>Human Capital</b>
Kangkung Seed to Rice Seed	-0.85 (1.02)	-0.37*** (0.13)	-0.27** (0.14)	-0.28 (0.40)
Insecticide to Rice Seed	0.04 (1.07)	0.22 (0.26)	-0.49* (0.29)	1.62 (1.63)
Fertilizer to Rice Seed	3.11 (3.74)	-0.22 (0.25)	0.14 (0.24)	-2.76 (2.53)
Insecticide to Kangkung Seed	-0.05 (1.27)	-0.59 (0.72)	1.82 (1.12)	-5.75 (7.56)
Fertilizer to Kangkung Seed	-3.67* (2.12)	0.60 (0.69)	-0.52 (0.86)	9.78 (12.23)
Insecticide to Fertilizer	0.01 (0.35)	-0.97 (1.28)	-3.51 (5.47)	-0.59** (0.29)
Observations	29101	29101	29101	29101
N. of Households	3825	3825	3825	3825

*Notes:* Table reports the ratios of coefficients for pairs of input prices from the demand system estimates in Table 4.2. The ratios are calculated using the delta method with standard errors allowing for clustering at the household level. \*\*\* Significant at the 1% level, \*\* Significant at the 5% level, \* Significant at the 10% level.

Table 4.4: Separation Ratio Test Results ( $p$ -values)

<i>Consumption Goods</i>		<i>Ratio Test Results</i>						
<i>Good A</i>	<i>Good B</i>	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Kangkung Seed	Rice Seed to [...] Insecticide	Fertilizer	Kangkung to [...] Insecticide	Fertilizer	Insecticide to Fertilizer	All 6 Ratios
Grain	Other Food	0.375	0.867	<b>0.013</b>	0.665	<b>0.007</b>	0.447	<b>0.094</b>
	Home Goods	0.320	0.671	<b>0.036</b>	0.316	0.136	<b>0.086</b>	0.223
	Human Capital	0.584	0.518	0.123	0.213	<b>0.031</b>	0.120	0.239
Other Food	Home Goods	0.533	<b>0.035</b>	0.210	<b>0.037</b>	0.247	0.570	0.340
	Human Capital	0.820	<b>0.063</b>	<b>0.005</b>	<b>0.062</b>	<b>0.004</b>	0.688	<b>0.058</b>
Home Goods	Human Capital	0.976	<b>0.043</b>	<b>0.010</b>	<b>0.070</b>	<b>0.037</b>	0.121	0.113
Joint Test All Ratios		0.316						
<b>Summary</b>								
N. of Pairwise Ratios	36							
N. of Rejections at 5%	11							
N. of Rejections at 10%	15							

*Notes:* Table reports  $p$ -values from pairwise and joint tests of the ratio restrictions implied by separation in the agricultural household model. Each value represents the test for the pair of input prices in the column and consumption goods in the row. Column 7 tests equivalence across all pairs of price ratios for the goods in the corresponding row (6 restrictions). The overall joint test examines equality of all ratios reported in Table 4.3. Tests rejected at a 10% level or below are highlighted in bold.

## 4.8 Supplemental Tables

Table 4.5: Expenditure Categories and Budget Shares

Disaggregated Good	Detail	Composite Good
Rice	Hulled, uncooked	Grain
Staples	Corn, sago/flour, cassava, tapioca, dried cassava, sweet potatoes, potatoes, yams	Grain
Dried Food	Noodles, rice noodles, uncooked noodles, macaroni, shrimp chips, other chips	Grain
Meat and Fish	Beef, mutton, goat, chicken, duck, salted meat and canned meat, fresh fish, salted fish, smoked fish	Other Food
Vegetables	Kangkung, cucumber, spinach, mustard greens, tomatoes, cabbage, katuk, green beans, string beans and the like, beans like mung-beans, peanuts, soya-beans	Other Food
Fruits	Papaya, mango, banana and the like	Other Food
Tofu, Tempe		Other Food
Milk, Eggs	Eggs, fresh milk, canned milk, powdered milk, cheese	Other Food
Sugar	Javanese (brown) sugar, granulated sugar	Other Food
Oil	Coconut oil, peanut oil, corn oil, palm oil	Other Food
Spices	Sweet and salty soy sauce, salt, shrimp paste, chili sauce, tomato sauce, shallot, garlic, chili, candle nuts, coriander	Other Food
Beverages and Other Drinks/Consumer Products	Drinking water, coffee, tea, cocoa, soft drinks like Fanta, Sprite, etc., alcoholic beverages like beer, wine	Other Food
Tobacco	Cigarettes, tobacco, betel nut	Other Food
Prepared food		Other Food
Utilities and Transportation	Electricity, water, fuel, transportation, including bus fare, cab fare, vehicle repair costs, gasoline	Home Goods
Household Items	Laundry soap, cleaning supplies, personal toiletries, domestic servants	Home Goods
Household Equipment and Repair	Tables, chairs, kitchen tools, bed sheets, towels, repairs	Home Goods
Rent you do pay		Home Goods
Rent would pay if renting		Home Goods
Clothing for Children & Adults	Shoes, hats, shirts, pants, clothing for children	Human Capital
Education	Fees, tuition, books, school supplies, transport, meals and housing expenses	Human capital
Medical Costs	Hospitalization costs, clinic charges, physician's fee, traditional healer's fee, medicines	Human capital
Ritual Ceremonies, Charities, and Gifts	Weddings, circumcisions, tithe, charities, gifts	Human capital

*Notes:* Table provides a guide to the disaggregated goods in the WISE consumption module that are included in each of the composite goods used in the demand system estimation.

Table 4.6: Composite Prices: Sources and Weights

Composite Good	Price of [...]	Source	Weight in Composite Price
Grain	Cassava	Pasar	0.01
	Cassavachip	Pasar	0.07
	Cassava leaves	Pasar	0.02
	Corn	Pasar	0.03
	Flour	Toko	0.09
	Noodle	Toko	0.17
	Potato	Pasar	0.16
	Rice	Toko	0.41
	Sweet Cassava	Pasar	0.04
Other Food	Apple	Pasar	0.04
	Beef	Pasar	0.09
	Cabbage	Pasar	0.01
	Carrot	Pasar	0.01
	Chicken	Pasar	0.04
	Chili	Toko	0.01
	Cigarettes	Toko	0.14
	Coconut	Pasar	0.002
	Coffee	Toko	0.01
	Cucumber	Pasar	0.01
	Eggs	Toko	0.02
	Garlic	Toko	0.01
	Green Bean	Pasar	0.01
	Kangkung	Pasar	0.01
	Lima Bean	Pasar	0.01
	Milk Powder	Pasar	0.12
	Mineral Water	Pasar	0.07
	Mujair	Pasar	0.03
	Nuts	Pasar	0.01
	Oil	Toko	0.02
	Onions	Toko	0.01
	Oranges	Pasar	0.04
	Papaya	Pasar	0.0002
	Pindang	Pasar	0.03
	Salak	Pasar	0.02
	Salt	Toko	0.003
	Spinach	Pasar	0.005
	Sugar	Toko	0.02
	Sweet Milk	Toko	0.07
	Tea	Toko	0.01
Tempe	Toko	0.02	
Teri	Pasar	0.01	
Tobacco	Pasar	0.03	
Tofu	Pasar	0.02	
Tomato	Pasar	0.01	
Tongkol	Pasar	0.04	
Home Goods	Detergent	Toko	0.09
	Gas (LPG)	Pasar	0.50
	Kerosene	Toko	0.19
	Soap	Toko	0.22
Human Capital	Cotton	Pasar	0.02
	Dresses	Pasar	0.02
	Notebook	Toko	0.90
	Pants	Pasar	0.02
	Slippers	Toko	0.03

*Notes:* Table summarizes the individual prices that are utilized in constructing composite prices. Weights are determined using the 2002 SUSENAS detailed expenditure survey, restricting the sample to Purworejo.

Table 4.7: Expanded Demand System Estimates

	<i>Share of Household Expenditure on [...]</i>						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	<b>Grain</b>	<b>Protein</b>	<b>Fruit and Vegetables</b>	<b>High Calorie Food</b>	<b>Tobacco</b>	<b>Home Goods</b>	<b>Human Capital</b>
<i>log of Composite Prices</i>							
Grain	2.70*** (0.97)	-0.98 (0.85)	-0.44 (0.52)	-0.30 (1.15)	0.00 (0.62)	-0.12 (0.73)	-0.87 (1.32)
Protein	-1.81 (1.56)	0.73 (1.37)	-1.07 (0.85)	5.70*** (1.92)	-1.18 (1.02)	0.36 (1.25)	-2.74 (2.18)
Fruit and Veg	-0.12 (0.80)	0.82 (0.73)	1.20*** (0.44)	-2.77*** (0.94)	-0.93* (0.53)	0.03 (0.62)	1.77 (1.10)
High Calorie	0.97 (0.60)	-0.46 (0.54)	0.32 (0.32)	-0.45 (0.73)	1.08*** (0.39)	-0.49 (0.48)	-0.97 (0.86)
Tobacco	0.84 (1.03)	-2.22** (0.90)	1.15** (0.55)	-1.04 (1.24)	-0.77 (0.69)	1.03 (0.82)	0.99 (1.39)
Home Goods	-1.33 (0.84)	-2.15*** (0.76)	-0.98** (0.44)	5.88*** (1.02)	-0.39 (0.55)	-0.21 (0.65)	-0.81 (1.21)
Human Capital	2.16** (0.88)	1.24* (0.75)	-0.62 (0.47)	-0.89 (1.01)	1.36** (0.54)	0.94 (0.65)	-4.20*** (1.19)
<i>log of Farm Input Prices</i>							
Rice seed	1.15 (0.87)	-0.96 (0.81)	1.44*** (0.48)	-5.24*** (1.06)	0.63 (0.57)	2.27*** (0.72)	0.70 (1.17)
Kangkung Seed	-0.49 (0.32)	0.08 (0.28)	0.58*** (0.17)	0.73** (0.35)	0.28 (0.20)	-0.68** (0.27)	-0.51 (0.45)
Insecticide	-0.18 (0.80)	0.54 (0.70)	0.70 (0.45)	-1.68* (0.92)	-0.58 (0.51)	-1.21** (0.60)	2.41** (1.06)
Fertilizer	2.21*** (0.74)	0.43 (0.67)	0.37 (0.41)	1.56* (0.89)	-0.56 (0.47)	0.16 (0.57)	-4.17*** (1.03)
<i>Spline of log(PCE)</i>							
0-25th Percentile	2.25*** (0.61)	3.75*** (0.36)	0.29 (0.24)	5.11*** (0.54)	2.22*** (0.30)	-14.93*** (0.38)	1.31** (0.55)
25th-50th Percentile	-4.12*** (0.67)	3.98*** (0.54)	0.05 (0.33)	5.51*** (0.76)	1.74*** (0.42)	-11.52*** (0.44)	4.35*** (0.79)
50th-75th Percentile	-3.28*** (0.61)	2.56*** (0.57)	-1.26*** (0.29)	5.02*** (0.75)	1.01*** (0.38)	-11.34*** (0.47)	7.29*** (0.98)
75-100 Percentile	-0.92** (0.36)	1.73*** (0.43)	-1.05*** (0.19)	1.67*** (0.52)	-0.34 (0.24)	-8.81*** (0.30)	7.72*** (0.92)
Household Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Joint Test of Input Prices</i>							
F-statistic	3.18	0.72	7.30	7.96	1.87	4.86	4.98
p-val	0.01	0.58	0.00001	0.000002	0.11	0.0007	0.0005
Observations	29101	29101	29101	29101	29101	29101	29101
N. Households	3825	3825	3825	3825	3825	3825	3825

Notes: See Table 4.2.

Table 4.8: Expanded Demand System Price Coefficient Ratios

	<i>Share of Household Expenditure on [...]</i>						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
<i>Ratio of [...] to [...]</i>	<b>Grain</b>	<b>Protein</b>	<b>Fruit and Vegetables</b>	<b>High Calorie Food</b>	<b>Tobacco</b>	<b>Home Goods</b>	<b>Human Capital</b>
Kangkung Seed to Rice Seed	-0.42 (0.40)	-0.09 (0.29)	0.40** (0.19)	-0.14** (0.07)	0.44 (0.54)	-0.30** (0.15)	-0.73 (1.32)
Insecticide to Rice Seed	-0.15 (0.70)	-0.56 (0.87)	0.48 (0.35)	0.32* (0.19)	-0.92 (1.15)	-0.53 (0.32)	3.46 (5.99)
Fertilizer to Rice Seed	1.92 (1.57)	-0.45 (0.80)	0.26 (0.30)	-0.30* (0.18)	-0.89 (1.11)	0.07 (0.25)	-5.98 (10.09)
Insecticide to Kangkung Seed	0.36 (1.65)	6.50 (23.05)	1.19 (0.83)	-2.30 (1.70)	-2.07 (2.35)	1.77 (1.08)	-4.76 (4.77)
Fertilizer to Kangkung Seed	-4.54 (3.32)	5.20 (19.53)	0.63 (0.74)	2.13 (1.67)	-2.02 (2.27)	-0.24 (0.83)	8.23 (7.74)
Insecticide to Fertilizer	-0.08 (0.35)	1.25 (2.91)	1.88 (2.77)	-1.08 (0.71)	1.02 (1.45)	-7.38 (24.69)	-0.58** (0.25)
Observations	29101	29101	29101	29101	29101	29101	29101
N. of Households	3825	3825	3825	3825	3825	3825	3825

*Notes:* See Table 4.3.

Table 4.9: Expanded Demand System Separation Test Results ( $p$ -values)

Consumption Goods		Ratio Test Results						
<i>Good A</i>	<i>Good B</i>	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Kangkung Seed	Rice Seed to [...] Insecticide	Fertilizer	Kangkung to [...] Insecticide	Fertilizer	Insecticide to Fertilizer	All 6 Ratios
Grain	Protein	0.489	0.689	0.210	0.512	0.572	0.455	0.804
	Fruit and Vegetables	<b>0.075</b>	0.469	<b>0.088</b>	0.663	<b>0.015</b>	0.190	0.130
	High Calorie Food	0.323	0.514	<b>0.006</b>	0.267	<b>0.039</b>	0.194	0.105
	Tobacco	0.183	0.565	0.169	0.372	0.532	0.277	0.623
	Home Goods	0.760	0.659	<b>0.054</b>	0.536	<b>0.092</b>	<b>0.088</b>	0.284
	Human Capital	0.802	0.253	0.113	0.237	<b>0.042</b>	0.180	0.270
Protein	Fruit and Vegetables	0.318	0.258	0.381	0.571	0.596	0.884	0.753
	High Calorie Food	0.865	0.287	0.847	0.457	0.794	0.284	0.905
	Tobacco	0.370	0.795	0.729	0.475	0.508	0.940	0.962
	Home Goods	0.556	0.969	0.472	0.648	0.511	0.481	0.974
	Human Capital	0.438	0.266	0.273	0.578	0.913	0.256	0.789
Fruit and Vegetables	High Calorie Food	<b>0.007</b>	0.664	0.106	<b>0.048</b>	0.371	0.129	<b>0.015</b>
	Tobacco	0.946	0.173	0.200	0.155	0.184	0.755	0.379
	Home Goods	<b>0.002</b>	<b>0.034</b>	0.643	0.647	0.428	0.411	<b>0.054</b>
	Human Capital	0.254	0.183	<b>0.013</b>	<b>0.031</b>	<b>0.014</b>	<b>0.060</b>	<b>0.042</b>
High Calorie Food	Tobacco	<b>0.095</b>	0.164	0.466	0.941	0.129	0.138	0.328
	Home Goods	0.248	<b>0.009</b>	0.200	<b>0.038</b>	0.140	0.320	0.139
	Human Capital	0.360	<b>0.054</b>	<b>0.002</b>	0.438	0.144	0.369	<b>0.048</b>
Tobacco	Home Goods	<b>0.095</b>	0.712	0.257	0.137	0.375	0.321	0.474
	Human Capital	0.336	0.247	0.397	0.546	0.133	0.109	0.406
Home Goods	Human Capital	0.620	<b>0.047</b>	<b>0.011</b>	<b>0.042</b>	<b>0.035</b>	<b>0.080</b>	<b>0.095</b>
	Joint Test All Ratios	0.521						
<b>Summary</b>								
N. of Pairwise Ratios	126							
N. of Rejections at 5%	18							
N. of Rejections at 10%	28							

Notes: See Table 4.4.

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