Are Rural Markets Complete?
Prices, Profits, and Recursion

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December 2016[†]

Abstract

Under the assumption that markets are complete, the simultaneous production and consumption decisions made by farm households are substantially simplified into a recursive system with production choices preceding consumption decisions. This is a powerful assumption that lies at the heart of many empirical models of farm behavior in the literature. The majority of studies that have assessed the validity of the recursion assumption determine whether there is a link between labor demand on the farm and the demographic structure of the farm household. If markets are complete, there should be no links. Empirical implementation of these tests is complicated by endogenous behavioral responses of farm households and complex measurement challenges. Using extremely rich data that were designed for this research, we develop and implement a new test for market completeness that exploits the fact that, under recursion, farm profits only affect consumption through an income effect. Exploiting plausibly exogenous variation in the local market prices of farm inputs, we test the implication using longitudinal survey data collected over six years from a large sample of farm households in rural Java, Indonesia, by estimating a flexible demand system and taking into account time invariant farm-household heterogeneity. Overall, the assumption that markets are complete is rejected but there is an important sub-group of better off households who behave as if markets are complete.

[†] This paper has benefited from discussions with Peter Arcidiacono, Dwayne Benjamin, Amar Hamoudi, Joe Hotz, Marcos Rangel, John Strauss and Alessandro Tarozzi.

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1. Introduction

The agricultural household model has played a central role in both empirical and theoretical studies in economics. The baseline model incorporates a production process into the standard utility maximization framework, and has been used in a wide array of applications from the study of nutritional decisions (Strauss, 1982, 1984), intrahousehold efficiency (Udry, 1996), agricultural productivity shocks (Jayachandran, 2006), property rights (Field, 2007), technology adoption (Suri, 2011), the impact of microcredit (Kaboski and Townsend, 2011), and many other applications.

Under the baseline assumption of complete markets in the neoclassical model, the simultaneous production and utility maximization problem may be modeled recursively with farm profit maximization occuring in a first stage independent of household characteristics. Families then utilize the profit from their farm business as a source of income in a second stage utility maximization process (Singh et al, 1986). The separation of the joint problem is a powerful simplifying result for both theoretical and empirical applications, as it allows one to analyze production decisions indepenedntly of preferences and household characteristics - input choices depend only on the prices of inputs and characteristics of the farm. Production choices are made without reference to the preferences of household members and, therefore, to consumption allocations.

However, the necessary condition of complete markets is a strong assumption that warrants empirical investigation. The literature testing the validity of the recursive model has focused on the first stage in the two step processes and assesses if production may be treated independently from household characteristics (e.g. Pitt and Rosenzweig, 1986; Benjamin, 1992; Jacoby, 1993; Udry, 1999; Bowlus and Sicular, 2003; Dillon and Barrett, 2015; LaFave and Thomas, 2016).[1] These tests rely on specifying a production process for the household, and often require restrictive assumptions regarding the form of the underlying process. Many of these studies face considerable measurement challenges and are potentially contaminated by unobserved heterogeneity and behavioral responses of farm households. Results of the tests are mixed, but with seminal work failing to find a link between farm labor demand and household demographic composition and, therefore, failing to reject the implications of

[1] An additional set of papers test the separation hypothesis by structurally estimating marginal productivities of agricultural inputs, notably shadow wages of labor, and comparing the estimates to surveyed market prices (wages) for the corresponding factor (e.g. Jacoby, 1993; Barrett et al., 2008).

complete markets (Benjamin, 1992). This work has served as the basis for studies which exploit the advantages of the two-step, recursive structure. More recent evidence overturns this conclusion (LaFave and Thomas, 2016).

This paper extends the existing literature in a number of ways. We define and execute tests of recursion based on the second step of the two-step model - that farm production impacts consumption allocations solely through an income effect. The test relies on plausibly exogenous farm input prices for identification in a modified household demand system. We draw on rich longitudinal consumption and price data from the Work and Iron Status Evaluation (WISE) in Central Java, Indonesia. WISE collected detailed longitudinal data on participating individuals, households, and the communities in which they live. Of particular importance, the data includes transaction prices elicited monthly from local markets, shops, and stalls within each of the 146 WISE communities over a six-year period. The combination of household panel data with market prices offers the unique combination of information on expenditures, consumption prices, and farm input prices necessary to conduct the proposed complementary test of complete markets.

Relative to the prior testing strategy, the approach illustrated here is robust to an array of functional forms of the production process, less subject to biases from measurement error of farm inputs, and less likely to be contaminated by behavioral responses of farm households. It is an effective strategy that may be used in a variety of settings as a preliminary step to testing for the validity of models based on the recursion form of household-decision making and related policy analysis.

The results of this new test in our setting reject the implications of separation for the full sample of Indonesian farm households. In an effort to understand what particular market imperfections may be driving these results and the consequences of incomplete markets for household well-being, we show that the rejections of complete markets are concentrated in households at the bottom of the socioeconomic status distribution, while those with larger landholdings and access to credit are able to operate as if complete markets exist.

The next section presents a dynamic version of the neoclassical agricultural household model appropriate for our longitudinal data and focuses on the implications of complete markets for consumption allocations. The empirical demand system is outlined in Section 3, and the survey and price data is discussed in Section 4. Section 5 presents the results rejecting complete markets, and Section 6 concludes with a discussion of the implications of our findings.

2. A Dynamic Agricultural Household Model

This section presents a dynamic agricultural household model with a focus on the implications of complete markets for consumption allocations.

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

$$\max E\left[\sum_{t=0}^{\infty} \beta^t u(x_{mt}, x_{ct}, \ell_t; \mu_t, \varepsilon_t)\right] \tag{1}$$

subject to:

$$C_t = C_t(L_t, V_t, A_t; \nu_t) \tag{2}$$

$$E_t^L = L_t^F + L_t^O + \ell_t \tag{3}$$

$$W_{t+1} = (1 + r_{t+1})[W_t + \{w_t(E_t^L - \ell_t)\} + \{p_{ct}C_t - w_tL_t - p_{vt}V_t - p_{At}A_t\} - \{p_{mt}x_{mt} + p_{ct}x_{ct}\}] \tag{4}$$

where x_{mt} is a vector of market consumption goods, x_{ct} is consumption of agricultural goods (i.e. food, some of which may be grown by the household), and ℓ_t is a vector of household members' leisure. Preferences are captured by μ_t and ε_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.[2, 3] Household members may work on the family farm, L^F_t, or off, L^O_t.

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[2] 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.

[3] Capital is not explicitly included in the production function, as farms in the study 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 capital in the output function and specifying a law of motion for capital over time does not change the empirical predictions tested in this paper.

The intertemporal budget constraint describes the evolution of wealth over time. In the presence of credit markets or some other mechanism for inter-temporal smoothing, farmers can borrow resources in period t to be repaid with interest rate r_{t+1}; a parallel market exists for savings that earn the same interest rate. Wealth in period $t+1$ is equal to the interest earned on wealth in t plus net savings that period. Net savings in period t are the sum of net income from work (in the first pair of braces) and farm profits (in the second pair of braces), less expenditure (in the third pair of braces). Wealth is negative if a household is in debt. The household earns wage income from off-farm labor at the market wage, w_t, which, under the assumption of complete markets, is also the shadow wage for work on the farm. Thus, the imputed value of labor supply is $w_t(E_t^L - \ell_t)$. Net profits is the output C_t evaluated at the market price, p_{ct} , less the imputed value of labor demand (at the market price), w_tL_t , and the costs of variable and fixed inputs, $p_{vt}V_t$ and $p_{at}A_t$, respectively. The value of consumption, in the final pair of braces, is total spending on goods purchased in the market, $p_{mt}x_{mt}$, and the value of consumption of own production evaluated at the market price, $p_{ct}x_{ct}$.

As has been shown in the literature (e.g. Singh et al, 1986; Benjamin, 1992), 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 greatly simplifies the dual decision making problem and implies the joint problem may be formulated recursively as a two-step process.[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 π_t represent farm profits, households solve the following problem in the

[4] 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.

first stage:

$$\max \pi_t = p_{ct} C_t(L_t, V_t, A_t; \nu_t) - w_t L_t - p_{vt} V_t - p_{At} A_t \quad (5)$$

Note that 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).

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

$$\pi_t^* = \pi_t^*(p_{vt}, p_{ct}, w_t, p_{At}) \quad (6)$$

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). Where profit maximization was imbedded in the previous budget constraint, $\boldsymbol{\pi}^*$ now takes the place of the production choices:

$$W_{t+1} = (1 + r_{t+1})[W_t + \{w_t(E_t^L - \ell_t)\} - \{p_{mt}x_{mt} + p_{ct}x_{ct}\} + \pi_t^*(p_{vt}, p_{ct}, w_t, p_{At})\,] \quad (7)$$

Equation (7) exhibits the basis for the complementary test of separation. Under the assumption of complete markets, the farm business influences utility maximization and consumption allocations only by shifting the budget constraint by π^*, the amount of income provided by farm profits.

Having made optimal production choices, 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 without production, 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 demand functions being augmented by farm profits in a particular way. The demand for consumption good *i* in period *t* is the following:

$$x_{it} = x_{it}(p_{mt}, p_{ct}, w_t, r_{t+1}, \pi_t^*(p_{vt}, p_{ct}, w_t, p_{At}), y_t, \lambda_t; \mu_t, \varepsilon_t) \quad (8)$$

where consumption depends on market and agricultural prices, p_{mt} and p_{ct}, wages, interest rates, farm profits, π_t^*, income, y_t, and expected future prices through the marginal utility of wealth, λ_t. The key feature of the recursive framework is visible in equation (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 appear only in the profit function will impact consumption allocations in a similar way. In particular, the prices of variable inputs, p_{vt}, are weakly separable from consumption demand. A change in the price of a farm input such as fertilizer or insecticide impacts demand only through its effect on profits.

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

2.2 Recursion and Consumption Allocations

Previous work in the literature has focused exclusively on the predictions of complete markets for the first stage of the recursive formulation of the agricultural household model. As noted, in order to execute these tests, additional restrictive assumptions are made regarding the functional form of the production function and labor inputs.[5] 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 (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 that are used only in farm production but not consumed on their own, impact consumption solely

[5] Benjamin (1992) specifies a Cobb-Douglas production function and a single homogeneous type of labor. A number of works following this seminal paper continue with this specification.

through profits.[6]

The test is derived by considering the marginal effect of a change in an input price, p_{vt}, on the demand for a given consumption good *i*. Based on the form of (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:

$$\frac{\partial x_{it}}{\partial p_{vt}} = \frac{\partial x_{it}}{\partial \pi_t^*}\frac{\partial \pi_t^*}{\partial p_{vt}} \tag{9}$$

The proposed test exploits this recursive property under the null of separation. Suppressing *t* subscripts for simplicity, consider the marginal effect of a change in two different input prices, e.g. fertilizer (*f*) and insecticide (*s*), on demand for good *i*:

$$\frac{\partial x_i}{\partial p_f} = \frac{\partial x_i}{\partial \pi^*}\frac{\partial \pi^*}{\partial p_f} \tag{10}$$

$$\frac{\partial x_i}{\partial p_s} = \frac{\partial x_i}{\partial \pi^*}\frac{\partial \pi^*}{\partial p_s} \tag{11}$$

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

$$\frac{\frac{\partial x_i}{\partial p_f}}{\frac{\partial x_i}{\partial p_s}} = \frac{\frac{\partial x_i}{\partial \pi^*}\frac{\partial \pi^*}{\partial p_f}}{\frac{\partial x_i}{\partial \pi^*}\frac{\partial \pi^*}{\partial p_s}} = \frac{\frac{\partial \pi^*}{\partial p_f}}{\frac{\partial \pi^*}{\partial p_s}} \tag{12}$$

This relationship provides the basis for a test of separation: any variable that is a part of the second-stage utility maximization problem only through π^* must impact all demands in a similar way through profits. Empirically, when separation holds, the ratio of marginal effects of input prices is the same across all consumption goods.

In order to test this restriction, we estimate a flexible demand system including input prices and examine the ratio of price effects on consumption allocations. Testing this restriction of separation requires detailed data not only on consumption goods but also agricultural input prices. We move next to defining the empirical strategy.

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[6] Note that this is not true of all prices from the production side. Wages and the price of agricultural output, w_t and p_{ct}, directly enter consumption demands.

3. Household Demand Systems and Empirical Implementation

This section presents an empirical specification for a household demand system based on the Working-Leser model that we use to test the ratio restrictions implied by recursion. Budget shares of food and non-food goods are regressed against composite consumption prices, variable input prices, a flexible function of per capita expenditure (PCE), and additional controls. Throughout the analysis we exploit the longitudinal nature of the WISE data to abstract from concerns of unobserved time-invariant heterogeneity at the farm level.

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. The linear 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.[7] 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 community j and wave t be the following:

$$w_{hjt}^{c} = \alpha + \sum_{c=1}^{C} \beta_c \log\left(p_{jt}^{c}\right) + \sum_{v=1}^{V} \gamma_v \log\left(p_{jt}^{v}\right) + f\left(x_{hjt}; \delta\right) + \theta z_{hjt} + \mu_h + \varepsilon_{hjt} \qquad (13)$$

This conditional demand function includes the log of each composite consumption price, 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 $f(.)$ that is parameterized by δ. Here $f(.)$ 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 paper draws upon a rich panel dataset from the Work and Iron Status Evaluation (WISE) including detailed information on prices and expenditure for approximately 3,200 households in rural Indonesia. The panel structure of the WISE

[7] 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).

data allows us to include a household fixed effect, μ_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, and could potentially bias estimates of the input prices in the demand system in a cross-sectional analysis.

Recall from equation (8) that when recursion holds, the ratio of the marginal price effects of any two input prices will be the same regardless of which consumption good one considers. In terms of equation (13), the ratio of two elements of γ 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:

$$\frac{\gamma_{fert}^{food}}{\gamma_{insect}^{food}} = \frac{\gamma_{fert}^{util}}{\gamma_{insect}^{util}} \tag{14}$$

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

$$H_0\colon \frac{\gamma_i^c}{\gamma_j^c} = \frac{\gamma_i^d}{\gamma_j^d} \quad \forall c, d, i, j \tag{15}$$

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.[8] We examine these cross equation restrictions using a non-linear Wald test while allowing for clustering at the household level.

4. Data

While a clear theoretical prediction, the data required to implement the test 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.

[8] Alternatively, one can test the following form of the null: H_0: $\gamma_j^c \gamma_i^d = \gamma_i^c \gamma_j^d$ for all *c, d, i, j*.

Even fewer have the data recorded frequently over a multi-year time horizon. We utilize 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).[9]

Alongside a randomized iron supplement intervention, WISE collected a large-scale longitudinal survey containing detailed information on individuals, households, and the communities in which they live. A major component of the project that makes this paper possible was the collection of transaction price data at the community level from direct visits to local markets, shops, and stalls.

The panel nature of the WISE data allows us to utilizes household fixed effects to sweep away time invariant heterogeneity, and identify the price effects from changes within households over time. These fixed effects also proxy for stable, unobserved farm characteristics such as soil quality and plot topography which have been particularly difficult to measure in household based surveys (e.g. Udry, 1999). In order for such a panel exercise to be valid, however, it is essential to maintain minimal attrition over the course of the survey. Participant households were interviewed every four months beginning in 2002 and continuing through 2005, with a longer-term follow-up conducted five years from the start of the survey in 2007. As a testament to the research team's effort to track respondents over all waves of the survey, ninety-seven percent of the original farm households from the 2002 baseline were interviewed five years later in the 2007 wave.[10]

4.1 Household Expenditure Data

Household expenditure is measured through a questionnaire administered 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 consisting of staple grains, other foods, 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 that are essential for the ratio tests. However, results using an expanded demand system with finer commodity groups are

[9] Purworejo is a rural region located along the southern coast of Java, and home to approximately one million people.
[10] Thomas et al. (2011) reports further on attrition and the tracking scheme used in the WISE study.

consistent with those presented in Section 5.[11] Appendix Table A.1 summarizes the aggregation of the composite consumption goods.

4.2 Community Price Data

Assessing the predictions of the model relies on precisely estimating the price effects of both consumption goods 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 paper 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 is 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 log-linear. 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 the 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 including seeds, fertilizers, and insecticides. 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

[11] The results for a seven-good demand system are included in Appendix tables A.3 through A.5.

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.[12] Appendix Table A.2 summarizes the WISE prices used to construct the composite 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.[13] The agricultural input prices are normalized using the same regional price index, but are not aggregated in any way.

Table 1 reports means and standard errors of household expenditure, demographics, and community price data. While the WISE survey follows movers and split-off households regardless of location, the sample is limited to 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 in the empirical analysis: 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

[12] 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.
[13] 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.

insecticide.[14] 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 conditional on additional covariates in the model, notably locality and time fixed effects. 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 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, suggesting seed and output prices are unrelated.[15]

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

5. Results

5.1 Demand System Estimates

Table 2 reports estimates of the price and income effects from equation (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 visible along the diagonal of the first four rows, 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

[14] The prices of fertilizer and insecticide are particularly valuable, as they should not have any substitution effects in the demand estimation that seed prices may have.

[15] These estimates are from the following regression for community *j* in time *t*:

$$\log(p_{jt}^{rice}) = \alpha + \beta \log(p_{jt}^{riceseed}) + \mu_t + \mu_j + \varepsilon_{jt}$$

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.[16] 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 increases.

The estimated γ 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.

5.2 Separation Tests

Tests of recursion rely on assessing whether the ratios of the coefficients of the input prices in Table 2 are equivalent. These ratios are calculated using the delta method and reported in Table 3, with standard errors again allowing for arbitrary correlation within a household across time. Each ratio reflects a combination of coefficients. For example, -0.85 in column 1 of Table 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 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 low-powered, 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. The table reports the *p*-values for the non-linear Wald tests of the cross equation ratio restrictions defined by equation (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 3 these ratios are -0.85 and -0.37. Values above a critical value suggest that we

[16] This is visible in equation (8). The price of agricultural goods, p_{at}, influences consumption demand through farm profits as well as directly through an own-price effect.

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.

There are 36 pair-wise restrictions to test as well as the overarching tests of equality of all 24 ratios in Table 3. The results of these tests provide 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 a third of the tests rejected at the 5% level, the results are in clear violation of recursion.[17] These findings support those established in LaFave and Thomas (2016); in contrast to seminal work in the literature, household behavior in rural Indonesia appears inconsistent with the predictions of complete markets.

5.3 Do Markets Appear Complete for a Select Few?

Prior work often acknowledges that while the average effect may show that households are unable to smooth consumption or operate as if markets are complete, market sophistication may be a valid characterization for a subset of the population (e.g. Townsend, 1994, Bowlus and Sicular, 2003). This section provides evidence of such heterogeneity by showing that rejections of complete markets are concentrated amongst households at the bottom of the socioeconomic status distribution.

Table 5 reports results of the ratio tests mirroring those in Table 4, but for stratified samples. Based on existing evidence of the plausible market failures that may drive rejections of recursion (e.g. Bowlus and Sicular, 2003), households are divided into those who own more than the within community mean of land ownership versus those who own less than the within community mean of land holdings.[18] Panel A summarizes the key findings: after

[17] These results are corroborated by the disaggregated demand system presented in Appendix Tables A.3 though A.5.
[18] The corresponding demand system estimates for each of the groups are presented in Appendix Table A.6.

dividing the sample, the rejections of complete markets are concentrated amongst the small landowners. Out of the 36 pairwise tests for each group, 14 are rejected at the 10% level for those households at the bottom of the distribution while only 1 is rejected for those households at the top. These households not only have larger farms, but appear significantly more active in local credit and insurance markets as well.

This result provides support for our findings and the ability of our test to provide reasonable assessments of market completeness. Consistent with past work, the results suggest that those households at the top of the socioeconomic status distribution are able to function as if markets are complete.

6. Conclusion

This paper provides empirical evidence on the inconsistency of complete markets in rural Indonesia from a new test of recursion in the agricultural household model. By exploiting that consumption allocations are made after profit maximization in the recursive form of the model, we are able to test the implications of separation without relying on restrictive assumptions of the production process.

Using longitudinal consumption and transaction price data from the Work and Iron Status Evaluation, the results show a link exists between agricultural production and consumption allocations that is inconsistent with complete markets. These results are inconsistent with seminal papers upholding the recursive model, and offer support to more recent evidence on the complexities of rural markets.

Future work will look to push forward on determining the underlying causes of the failures of complete markets. 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 and policies directed at improving market access and function. Recognizing market complexities is essential in designing and evaluating development policy around the world.

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Table 1
Descriptive Statistics

Household Characteristics	(1) Mean (se)	*Community Prices* (Rp0,000)	(2) Mean (se)
Share of Expenditure on […]		*Price of […]*	
Grain	16.67	Grain	0.22
	(0.05)		(0.0001)
Other Food	43.69	Other Food	0.70
	(0.07)		(0.0002)
Home Goods	19.64	Home Goods	1.79
	(0.05)		(0.001)
Human Capital	20.00	Human Capital	0.23
	(0.08)		(0.0001)
Per Capita Expenditure	203.71	*Input Prices*	
(Rp000/mo)	(0.95)	Rice seed	1.51
Years of Education of […]			(0.001)
Primary Male	5.59		
	(0.02)	Kangkung Seed	1.99
Primary Female	5.09	(water spinach)	(0.002)
	(0.02)		
Age of […]		Insecticide	3.94
Primary Male	54.54		(0.003)
	(0.08)		
Primary Female	49.41	Fertilizer	5.25
	(0.07)		(0.003)
Household Size	3.76		
	(0.01)		
Urban (%)	13.42		
	(0.20)		
Wet Season (%)	47.49	N. Waves	8
	(0.29)	N. Households	3825
		N. Observations	29101

Notes: Table reports means and standard errors for variables of interest over the first 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/mo and all prices in real Rp0,000 with January 2002 as the base (approximately 1USD). See appendix tables 1 and 2 for detailed information on the consumption goods used in creation of the composite expenditure shares and prices.

Table 2
Demand System Estimates

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

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

Notes: Table reports the ratios of coefficients for pairs of inputs prices from the demand system estimates in Table 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

Separation Test Results (*p*-values)

Summary	
N. of Pairwise Ratios	36
N. of Rejections at 5%	11
N. of Rejections at 10%	15

Consumption Goods		*Ratio Test Results*						
		Rice Seed to […]			Kangkung to […]		Insecticide to	
Good A	*Good B*	Kangkung Seed	Insecticide	Fertilizer	Insecticide	Fertilizer	Fertilizer	All 6
Grain	Other Food	0.375	0.867	**0.013**	0.665	**0.007**	0.447	**0.094**
	Home Goods	0.320	0.671	**0.036**	0.316	0.136	**0.086**	0.223
	Human Capital	0.584	0.518	0.123	0.213	**0.031**	0.120	0.239
Other Food	Home Goods	0.533	**0.035**	0.210	**0.037**	0.247	0.570	0.340
	Human Capital	0.820	**0.063**	**0.005**	**0.062**	**0.004**	0.688	**0.058**
Home Goods	Human Capital	0.976	**0.043**	**0.010**	**0.070**	**0.037**	0.121	0.113
	Overall	0.316						

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. The final column 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 3. Tests rejected at a 90% confidence level or above are highlighted in bold.

Table 5

Separation Ratio Test Results - Sample Stratified by Household Land Holdings (p-values)

Panel A: Summary

	Household Land Holdings Relative to Community Mean: Below	Above
N. of Pairwise Ratios	36	36
N. of Rejections at 5%	7	0
N. of Rejections at 10%	14	1

Panel B: Households with land holdings below their community mean

Consumption Goods		*Ratio Test Results*						
		Rice Seed to […]			Kangkung to […]		Insecticide to	
Good A	*Good B*	Kangkung Seed	Insecticide	Fertilizer	Insecticide	Fertilizer	Fertilizer	All 6
Grain	Other Food	0.798	0.283	**0.020**	0.310	**0.018**	0.397	0.210
	Home Goods	0.932	0.894	0.107	0.859	0.175	0.229	0.589
	Human Capital	0.624	0.142	**0.096**	0.185	**0.054**	0.157	0.318
Other Food	Home Goods	0.614	**0.080**	0.644	**0.091**	0.576	0.638	0.609
	Human Capital	0.556	**0.045**	**0.028**	**0.049**	**0.018**	0.380	0.143
Home Goods	Human Capital	0.536	**0.053**	**0.045**	**0.066**	**0.093**	0.474	0.267
	Overall	0.544						

Panel C: Households with land holdings above their community mean

Good A	*Good B*	Kangkung Seed	Insecticide	Fertilizer	Insecticide	Fertilizer	Fertilizer	All 6
Grain	Other Food	0.182	0.349	0.868	0.668	0.105	0.289	0.546
	Home Goods	0.151	0.557	0.385	0.194	0.594	0.575	0.674
	Human Capital	0.671	0.490	0.546	0.647	0.165	0.189	0.687
Other Food	Home Goods	0.694	0.321	0.164	0.311	0.352	0.250	0.739
	Human Capital	0.397	0.977	0.349	0.756	**0.073**	0.767	0.584
Home Goods	Human Capital	0.499	0.590	0.133	0.889	0.292	0.258	0.679
	Overall	0.930						

Notes: Table reports p-values from pairwise and joint tests of the ratio restrictions implied by separation in the agricultural household model after stratifying the sample based on land holdings. Results for those households who own less than the within community mean appear in Panel B (n=19711). Results for those households with greater than the witin community mean appear in Panel C (n=9390). Each value represents the test for the pair of input prices in the column and consumption goods in the row. The final column tests equivalence across all pairs of price ratios for the goods in the corresponding row (6 restrictions). Demand system results for the stratified groups are available in Appendix Table A.6. Tests rejected at a 90% confidence level or above are highlighted in bold.

Appendix Table A.1
Expenditure Categories and Budget Shares

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

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.

Appendix Table A.2
Composite Price Sources and Weights

Composite Good	Individual Good	Price 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.

Appendix Table A.3
Expanded Demand System Estimates

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

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

Appendix Table A.4
Expanded Demand System Input Price Ratios

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

Notes: See Table 3.

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

Appendix Table A.5

Separation Ratio Test Results for Expanded Demand System (*p*-values)

Summary	
N. of Pairwise Ratios	126
N. of Rejections at 5%	18
N. of Rejections at 10%	28

Consumption Goods		*Ratio Test Results*						
		Rice Seed to […]			Kangkung to […]		Insecticide to	All 6
Good A	*Good B*	Kangkung Seed	Insecticide	Fertilizer	Insecticide	Fertilizer	Fertilizer	Ratios
Grain	Protein	0.489	0.689	0.210	0.512	0.572	0.455	0.804
	Fruit and Vegetables	**0.075**	0.469	**0.088**	0.663	**0.015**	0.190	0.130
	High Calorie Food	0.323	0.514	**0.006**	0.267	**0.039**	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	**0.054**	0.536	**0.092**	**0.088**	0.284
	Human Capital	0.802	0.253	0.113	0.237	**0.042**	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	**0.007**	0.664	0.106	**0.048**	0.371	0.129	**0.015**
	Tobacco	0.946	0.173	0.200	0.155	0.184	0.755	0.379
	Home Goods	**0.002**	**0.034**	0.643	0.647	0.428	0.411	**0.054**
	Human Capital	0.254	0.183	**0.013**	**0.031**	**0.014**	**0.060**	**0.042**
High Calorie Food	Tobacco	**0.095**	0.164	0.466	0.941	0.129	0.138	0.328
	Home Goods	0.248	**0.009**	0.200	**0.038**	0.140	0.320	0.139
	Human Capital	0.360	**0.054**	**0.002**	0.438	0.144	0.369	**0.048**
Tobacco	Home Goods	**0.095**	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	**0.047**	**0.011**	**0.042**	**0.035**	**0.080**	**0.095**
	Overall	0.521						

Notes: See Table 4.

Appendix Table A.6
Demand Systems for Stratified Samples

	Household Land Holdings Less than the Community Mean				Household Land Holdings Greater than the Community Mean			
	Share of Household Expenditure on [...]				*Share of Household Expenditure on [...]*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Grain	**Other Food**	**Home Goods**	**Human Capital**	**Grain**	**Other Food**	**Home Goods**	**Human Capital**
log of Composite Prices								
Grain	1.85*	-0.89	-0.57	-0.39	1.98	0.17	-1.30	-0.85
	(1.04)	(1.45)	(0.75)	(1.33)	(1.30)	(2.11)	(1.16)	(2.11)
Other Food	-0.75	5.45*	-1.47	-3.23	0.06	1.00	1.70	-2.76
	(2.10)	(2.91)	(1.50)	(2.67)	(2.65)	(4.30)	(2.37)	(4.29)
Home Goods	-0.46	2.31*	-0.62	-1.23	-3.16***	3.56*	-0.48	0.08
	(0.98)	(1.36)	(0.70)	(1.25)	(1.22)	(1.98)	(1.09)	(1.97)
Human Capital	3.26***	0.64	0.28	-4.19***	-0.87	1.45	2.67**	-3.25
	(0.99)	(1.38)	(0.71)	(1.26)	(1.26)	(2.05)	(1.13)	(2.04)
log of Farm Input Prices								
Rice Seed	1.87*	-5.17***	2.38***	0.92	-1.23	-2.98	2.60**	1.61
	(1.01)	(1.41)	(0.73)	(1.29)	(1.30)	(2.11)	(1.16)	(2.10)
Kangkung Seed	-0.56	1.89***	-0.65**	-0.67	-0.82*	1.00	-0.54	0.36
	(0.37)	(0.51)	(0.26)	(0.47)	(0.47)	(0.76)	(0.42)	(0.75)
Insecticide	2.73***	-0.28	0.47	-2.92***	1.20	4.04**	-0.03	-5.21***
	(0.88)	(1.23)	(0.63)	(1.12)	(1.13)	(1.84)	(1.01)	(1.83)
Fertilizer	-0.65	-1.03	-1.04	2.72**	1.72	-0.86	-1.38	0.51
	(0.91)	(1.26)	(0.65)	(1.15)	(1.17)	(1.90)	(1.05)	(1.90)
Splines in log(PCE)								
0-25th Percentile	2.29***	11.46***	-15.10***	1.34**	2.02***	11.03***	-14.58***	1.52
	(0.45)	(0.63)	(0.32)	(0.57)	(0.77)	(1.25)	(0.69)	(1.25)
25th-50th Percentile	-3.37***	11.33***	-11.64***	3.68***	-5.92***	11.26***	-11.25***	5.91***
	(0.70)	(0.97)	(0.50)	(0.89)	(0.97)	(1.57)	(0.86)	(1.56)
50th-75th Percentile	-2.71***	7.95***	-12.08***	6.84***	-4.54***	5.93***	-9.97***	8.58***
	(0.66)	(0.91)	(0.47)	(0.83)	(0.79)	(1.28)	(0.70)	(1.28)
75th-100th Percentile	-0.09	2.70***	-8.93***	6.31***	-1.89***	1.27**	-8.74***	9.36***
	(0.34)	(0.48)	(0.25)	(0.44)	(0.34)	(0.55)	(0.30)	(0.54)
Household Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	19,711	19,711	19,711	19,711	9,390	9,390	9,390	9,390

Notes: Table reports demand system estimates similiar to those in Table 2, but for stratified sample. Households are divided by whether they are small or large landowners, where small is defined as owning less than or equal to the within community mean. The majority of households fall within the small category. As before, 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 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